AEEC
Together "We Set the Standard."

| | | | |
|---|---|---|---|
| **To** | Internet Protocol Suite (IPS) Subcommittee | **Date** | February 2, 2016 |
| **From** | P. J. Prisaznuk<br>pjp@sae-itc.org<br>tel 1-240-334-2579 (o)<br>tel 1-410-212-0913 (c) | **Reference** | 16-012/IPS-001 lth |

**Subject** **Strawman Circulation**
**ARINC Project Paper 658:** *Internet Protocol Suite (IPS) for Aeronautical Safety Services – Roadmap Document*

**Summary** The ARINC staff prepared the attached strawman document as the starting point for ARINC Project Paper 658 describing a roadmap for developing IPS standards and services.

The strawman is organized as follows:

1.0 Introduction
2.0 Air/Ground Communications Overview
3.0 Requirements for IPS
4.0 IPS Architectures
5.0 Deployment Roadmaps
6.0 Standardization Roadmap
7.0 Summary and Conclusions
Appendix A – List of Acronyms
Appendix B – Glossary

**Action** This strawman document will be reviewed by the IPS Subcommittee on February 23-25, 2016 in Washington, DC. All comments should be in writing and directed to Paul Prisaznuk before February 22, 2016.

**cc** AGCS, AMX, DLK, NIS, SAI



SAE ITC
An SAE International Affiliate
16701 Melford Blvd., Suite 120, Bowie, Maryland 20715 USA
http://www.aviation-ia.com/aeec

SAE Industry Technologies Consortia (SAE ITC)
16701 Melford Blvd., Suite 120
Bowie, Maryland 20715 USA

# STRAWMAN

# FOR

# ARINC PROJECT PAPER 658

# INTERNET PROTOCOL SUITE (IPS) FOR AERONAUTICAL SAFETY SERVICES

# ROADMAP DOCUMENT

This draft dated: February 2, 2016

TABLE OF CONTENTS

APPENDICES

# 1.0 INTRODUCTION

## 1.1 Purpose

This document provides a roadmap for the development of an Internet Protocol Suite (IPS) for Aeronautical Safety Services. This document recognizes the broad use of the existing datalink infrastructure components and protocols. It describes the steps necessary to transition to IPS. The recommendations are intended to be evolutionary. They are expected to be implemented in a step-wise fashion.

This document describes data communication services necessary for operation in the evolving Communications Navigation Surveillance/Air Traffic Management (CNS/ATM) environment expected for the FAA NextGen program, Single European Sky ATM Research (SESAR) program and considerations of the Japan Collaborative Actions for Renovation of Air Traffic Systems (CARATS). These capabilities are intended to satisfy the industry's long-term objectives.

The International Civil Aviation Organization (ICAO) is developing an Aviation System Block Upgrade (ASBU) plan to harmonize the Air Traffic Management (ATM) improvement programs across the globe. The ASBU defines target implementation timelines organized in four five-year blocks: Block 0 – 2013, Block 1 – 2018, Block 2 – 2023, and Block 3 – 2028 onward. Each Block addresses four aviation performance areas:

- Airport operations
- Globally-interoperable systems and data
- Optimum capacity and flexible flights
- Efficient flight paths

The Blocks contains Modules which define the Communication, Navigation, and Surveillance (CNS) information management functions required for the aircraft and ground components. Descriptions of the ASBU Blocks and Modules can be found in the ICAO Working Document for the Aviation System Block Upgrades, The Framework for Global Harmonization, Issued 28 March 2013.

ATM modernization plans emphasize broad use of datalink communication, GNSS navigation and the various surveillance capabilities to improve flight deck situational awareness and enhance performance-based operations. This document assesses the impact of airspace modernization plans to airborne avionics equipment and architectures, recognizing that the benefit from equipping aircraft may depend on coordinated changes to regulations, procedures, ground infrastructure, etc. The equipage analyses contained herein are intended to represent a high level system view that can be broadly disseminated to airlines, airspace planners, Air Navigation Service Providers (ANSPs), airframe manufacturers, avionics suppliers and others who participate in the development process. This document represents the consensus of industry.

This document refers to **ARINC Report 660B:** *CNS/ATM Avionics Architectures Supporting NextGen/SESAR Concepts.* In some cases the content from ARINC Report 660B is included here for emphasis.

The challenges to the industry set forth by this document require an unprecedented degree of cooperation. The working relationships and the deliverables to be produced are summarized in Section 6 of this document.

1.0 INTRODUCTION

## 1.2 Scope

This document describes airline objectives toward the development and introduction of advanced data communication protocols and services that meets the safety and performance requirements of aviation for the year 2020 and beyond.

The existing ACARS network and the Aeronautical Telecommunication Network (ATN) infrastructure is aviation-unique and can be improved. The industry desires a modern, off-the-shelf, efficient, and robust network infrastructure common to both Air Traffic Services (ATS) and Aeronautical Operational Communications (AOC) safety services. The International Telecommunication Union (ITU) defines a “safety service” as any radio communication service used for the safeguarding of human life and property. ICAO Annex 10 refines that definition to a “service reserved for communications relating to safety and regularity of flights”, specifically ATS and AOC “safety communications” as defined in ICAO Doc 9718.

A new network infrastructure for safety services based on the Internet Protocol Suite (IPS) will meet this need. Accordingly, the industry is preparing ARINC Standards that will define the IPS for aeronautical safety services. The resulting documents are expected to be based upon ICAO Doc 9896 IPS definition and on prevalent commercial IP network technology (e.g., IETF RFC 2460 for IPv6) with the modifications necessary to support aeronautical safety services.

It is anticipated that IPS will use multiple line-of-sight and beyond-line-of-sight subnetworks that operate in the protected spectrum allocated by ITU and ICAO for safety services, including Inmarsat SwiftBroadband, Iridium NEXT, AeroMACS, future Satcom and LDACS systems, and possibly VDL Mode 2. It is targeted that IPS will also provide backward compatibility with traditional ACARS ATS (e.g., FANS) and AOC (e.g., ARINC 702A flight plans) as well as Link 2000+ (ATN B1) and ATN B2 applications, so the applications will remain unchanged.

This calls for two steps as outlined below.

### 1.2.1 Step 1 Roadmap for Standardization and Main Architecture Impacts of IPS

This document, ARINC Report 658, describes the roadmap for the standardization of IPS (air-to-ground and end-to-end) and the timeline for elements to be standardized. It will also identify the proper Standards Development Organization (SDO), e.g., ARINC, RTCA, EUROCAE, ICAO. This will include an identification of IPS requirements (performance, information security) and a description of the avionics architecture impacts.

### 1.2.2 Step 2 Development of an ARINC Standard for IPS

An ARINC Standard will be prepared to define the avionics architecture, functions, and an IPS profile which 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 CMU (or equivalent avionics) by defining its ability to act as an IP router.

## 1.3 Objectives

This section describes the top-level objectives for NextGen/SESAR data communication services. Due to the far-reaching impact of each of these objectives, it is important that each one be fully considered when designing avionics equipment for the CNS/ATM operating environment.

### 1.3.1 Fleet-Wide Application

A wide range of aircraft must be equipped with CNS/ATM avionics equipment that will operate within the NextGen/SESAR airspace. The CNS/ATM architecture should enable the use of common retrofit components for all aircraft types. The regulatory approval processes and the ATM system should acknowledge and account for the varying levels of integration between the airborne CNS elements and existing aircraft equipment. This requires a clear relationship between benefits and system performance.

### 1.3.2 Common Crew Interfaces

The avionics equipment is expected to provide a user-friendly interface to the crew for all CNS/ATM functions. This document does not attempt to define a common crew interface for fleet-wide application across many aircraft types because of the different flight deck design philosophies embraced by the respective airframe manufacturers.

### 1.3.3 Flight Simulators

Flight simulators are recognized as an important part of the aviation industry. Airlines depend upon simulators for flight crew and maintenance training. Airlines typically desire simulators to be available as early as possible to allow for crew training prior to system introduction into revenue service. The guidelines of **ARINC Report 610C:** *Guidance for Use of Avionics Equipment and Software in Simulators*, apply.

### 1.3.4 Airframe Manufacturer Support

The role of the avionics system integrator is of paramount importance. The system integrator is responsible for balancing user needs with the practical and economic realities of installing and certifying equipment. Airframe manufacturers are often requested to provide engineering and program management expertise to support enhancements to current production aircraft and as well as those requiring retrofit.

### 1.3.5 User Control of Aircraft System Certification

As the CNS/ATM infrastructure develops using IPS, airline operational desires will influence aircraft equipage. Software configuration will be influenced by aircraft type and aircraft route structure. Therefore, it is desired that airlines, airframe manufacturers and avionics suppliers share the responsibility for selected software changes.

Airlines desire a high-degree of cooperation between the airlines, airframe manufacturers and avionics suppliers in the specification of new or modified avionics. Significant cost reductions can occur if a large degree of software commonality is achieved across multiple fleet types. This can be achieved through the development of common functional and operational standards.

### 1.3.6 Flexibility

It is clearly recognized by the industry that NextGen/SESAR functionality will be evolving over time. Therefore, the CNS/ATM architecture, hardware and software must support this change in a manner that minimizes not only the initial acquisition cost but also the on-going cost of ownership associated with the evolving NextGen/SESAR environment.

#### 1.3.7 Growth

The CNS/ATM equipment must balance initial acquisition costs with built-in growth capacity to accommodate and support the anticipated CNS/ATM capabilities. It is recognized that high upgrade costs may preclude support of some advanced avionics applications and corresponding ATM operations. That said, it is widely viewed that IPS services represent the desired end state.

#### 1.3.8 Supplier Competition

It is the desire of the airlines to ensure supplier competition by defining ARINC Standards for many individual components and functions of the CNS/ATM architecture. Interoperability, common operating procedures, and compliance with minimum performance and safety standards are required.

#### 1.3.9 Software Reliability

The CNS/ATM software should support optimal dispatch reliability and availability to reduce life cycle costs. Fault tolerant design and redundant configurations should be considered in the design process.

#### 1.3.10 Maintainability

The CNS/ATM functions must support design and integration standards that facilitate simplified maintenance. These standards should provide a similar level of system maintainability for aircraft with or without a central maintenance system.

#### 1.3.11 Information Security

The trend toward aircraft connectivity is well established in air transport and general aviation. The need for information security is based on the presumption that aircraft may be exposed to data sources and sinks that are not part of the traditional Aircraft Control Domain (ACD). Information security requirements pertinent to IPS are further defined in Section 3.3 of this document.

### 1.4 Desired Benefits of IPS

There are a number of benefits primarily related to operational improvements of the NextGen/SESAR airspace system and individual airline operations. They vary according to geographic region, depending on the level of ATM capability and approved method of operation. The airborne CNS equipment should provide the flexibility needed to take advantage of regional benefits.

The benefits of the Internet Protocol Suite (IPS) are to introduce an efficient protocol stack that will enable CNS/ATM applications to be developed for the airline community and to be updated as necessary for the life of the airplane.

### 1.5 Document Organization

This document is organized as follows:

- Section 1 – Introduction
- Section 2 – Air/Ground Communications Overview
- Section 3 – Requirements for IPS
- Section 4 – IPS Architectures
- Section 5 – Deployment Roadmaps
- Section 6 – Standardization Roadmap

- Section 7 – Summary and Conclusions
- Appendix A – List of Acronyms
- Appendix B – Glossary

This roadmap was prepared for the airline community and all aviation stakeholders. It presents the scope and the level of detail necessary to achieve IPS standardization. It defines the long-term needs for IPS for aeronautical safety services including:

- The users IPS datalink services (ATC, AOC)
- The functional, performance and safety and information security requirements
- The desired applications and means of communication

This document provides deployment roadmaps including the transition phase during which ACARS, ATN/OSI, and IPS will co-exist. It describes how aircraft equipped with ACARS, ATN/OSI and aircraft with IPS will be accommodated.

## 1.6 Related Documents

The following documents pertain to the development of data communication services intended to be operating in the NextGen/SESAR airspace environment:

**ARINC Specification 618:** *Air-Ground Character-Oriented Protocol*

**ARINC Specification 620:** *Data Link Ground System Standard and Interface Specification (DGSS/IS)*

**ARINC Specification 622:** *ATS Data Link Applications over ACARS Air-Ground Network*

**ARINC Specification 623:** *Character-Oriented Air Traffic Service (ATS) Applications*

**ARINC Specification 631:** *VHF Digital Link (VDL) Mode 2 Implementation Provisions*

**ARINC Report 660B:** *CNS/ATM Avionics Architectures Supporting NextGen/SESAR Concepts*

**ARINC Specification 664:** *Aircraft Data Network (Parts 1 to 8)*

**ARINC Characteristic 702A:** *Advanced Flight Management Computer System*

**ARINC Characteristic 724B:** *Aircraft Communication Addressing and Reporting System (ACARS)*

**ARINC Characteristic 750:** *VHF Data Radio*

**ARINC Characteristic 753:** *HF Data Link System*

**ARINC Characteristic 758:** *Communications Management Unit (CMU) Mark 2*

**ARINC Characteristic 761:** *Second Generation Aviation Satellite Communication System, Aircraft Installation Provisions*

**ARINC Project Paper 766:** *AeroMACS Transceiver and Aircraft Installation Standards*

**1.0 INTRODUCTION**

**ARINC Project Paper 771:** *Low Earth Orbiting Aviation Satellite Communication System*

**ARINC Characteristic 781:** *Mark 3 Aviation Satellite Communication Systems*

**ARINC Report 811:** *Commercial Aircraft Information Security Concepts of Operation and Process Framework*

**ARINC Specification 841:** *Media Independent Aircraft Messaging (MIAM)*

**EANPG COG Metrological/Air Traffic Management Taskforce:** MET Strategy in supporting the Global ATM Operational Concept for the EUR Region, January 2012

**FAA AC 20-140B:** Guidelines for Design Approval of Aircraft Data Link Communication Systems Supporting Air Traffic Services (ATS)

**FAA AC 20-165A:** Airworthiness Approval of Automatic Dependent Surveillance –

**FAA AC 25-1309:** System Design and Analysis

**FAA AC 120-70B:** Operational Authorization Process for Use of Data Link Communication System

**FAA Order 8260.52:** United States Standard for Required Navigation Performance (RNP) Approach Procedures with Special Aircraft and Aircrew Authorization Required (SAAAR)

**FAA:** NextGen Implementation Plan, June 2013

**ICAO Annex 10 Volume III:** International Standards and Recommended Practices, Aeronautical Telecommunications, Annex 10 to the International Civil Aviation, Volume III) Part I – Digital Data Communications Systems; Part II Voice Communication System

**ICAO Document 7030/4:** Regional Supplementary Procedures

**ICAO Document 8168OPS/611**: Aircraft Operations (PANS OPS)

**ICAO Document 9705-AN/956:** Manual of Technical Precision for the Aeronautical Telecommunication Network (ATN)

**ICAO Document 9750:** Global Air Navigation Capacity & Efficiency Plan, 2013-2028, Draft 2014-2016 Triennium Edition

**ICAO Document 9869:** Manual on Required Communication Performance (RCP)

**ICAO:** Global Operational Data Link Document (GOLD)

**ICAO** Working Document for the Aviation System Block Upgrades, The Framework for Global Harmonization, Issued 28 March 2013

**RTCA DO-232:** Operations Concepts for Data Link Applications of Flight Information Services

**RTCA DO-250:** Guiding Principles for Air Traffic Services Provided via Data Communications Utilizing the ATN, Builds I and IA

**RTCA DO-251:** U.S. National Airspace System (NAS) Plan for Air Traffic Services Data Link (Phase 1, En Route CONUS Implementation)

**RTCA DO-262A:** Minimum Operational Performance Standards for Avionics Supporting Next Generation Satellite Systems (NGSS)

**RTCA DO-267A:** Minimum Aviation System Performance Standards (MASPS) for Flight Information Services-Broadcast (FIS-B) Data Link

**RTCA DO-269:** Concepts for Services Integrating Flight Operations and Air Traffic Management Using Addressed Data Link

**RTCA DO-281A:** Minimum Operational Performance Standards for Aircraft VDL Mode 2 Physical, Link and Network Layer

**RTCA DO-290:** Safety and Performance Requirements Standard for Air Traffic Data Link Services in Continental Airspace (Continental SPR Standard)

**RTCA DO-296:** Safety Requirements for Aeronautical Operational Control (AOC) Data Link Messages

**RTCA DO-305:** Future Air Navigation System 1/A (FANS 1/A) – Aeronautical Telecommunications Network (ATN) Interoperability Standard

**RTCA DO-306:** Safety and Performance Standard for Air Traffic Data Link Services in Oceanic and Remote Airspace (Oceanic SPR Standard)

**RTCA DO-308:** Operational Services and Environment Definition (OSED) for Aeronautical Informational Services (AIS) and Meteorological (MET) Data Link Services

**RTCA DO-324:** Safety and Performance Requirements (SPR) for Aeronautical Information Services (AIS) and Meteorological (MET) Data Link Services

**SESAR Consortium:** European ATM Master Plan, October 2012

# 2.0 AIR/GROUND COMMUNICATIONS OVERVIEW

## 2.1 Introduction

One of the cornerstones of NextGen and SESAR is improved data communication to the aircraft and the flight deck crew. Datalink services enable a multitude of capabilities and functions on the airplane. These services include:

- Controller Pilot Data Link Communication (CPDLC)
  - Taxi Clearance
  - Departure Clearance
  - Route Clearance
  - Oceanic Clearance
- Out, Off On, In (OOOI)
- ATS Facilities Notification (AFN)
- Automatic Terminal Identification Service (ATIS)
- Weather Awareness Information
- Trajectory Based Operations
- System Wide Information Management
- Airborne Information Management
- Others

## 2.2 Air Traffic Services Datalink Communications

Air Traffic Services (ATS) datalink employs several subnetworks to provide services. The Line of Sight (LOS) subnetworks are Very High Frequency (VHF) Data Link Mode 0/A (VDL M0/A) and VHF Data Link Mode 2 (VDLM2). The Beyond Line of Sight (BLOS) subnetworks are High Frequency Data Link (HFDL), and mobile satellite system communications (Satcom). Voice communications are not covered in this section, but will continue to be needed for time critical situations.

Current datalink modernization programs for ATS data communications include EUROCONTROL's Link 2000+, FAA's Data Comm Program and those in the NextGen and SESAR concepts. The Future Air Navigation System (FANS 1/A) was the first operational ATS datalink program transmitting datalink messages over the Aircraft Communications Addressing and Reporting System (ACARS) network employing Aviation VHF Link Control (AVLC) called ACARS over AVLC (AOA). AVLC mediates between the native binary VDLM2 and Satcom communications and the character oriented ACARS. FANS 1/A is used primarily in oceanic and remote regions. FANS 1/A+ is an extension to FANS 1/A with a small set of additional functions. ACARS with VDL M0/A is in common use. It is referred to as Plain Old ACARS or simply POA.

The FAA and EUROCONTROL have been developing the Aeronautical Telecommunications Network Baseline1 and Baseline 2 (ATN B1 and ATN B2). The EUROCONTROL Link 2000+, a subset of ATN B1, is the first fully binary ATS datalink and is used exclusively in Europe. Regardless of the technology, the aircraft architectural implementation consists of the radios, the router or Communications Management Function (CMF), and the services on the aircraft as is shown in Figure 2-1.

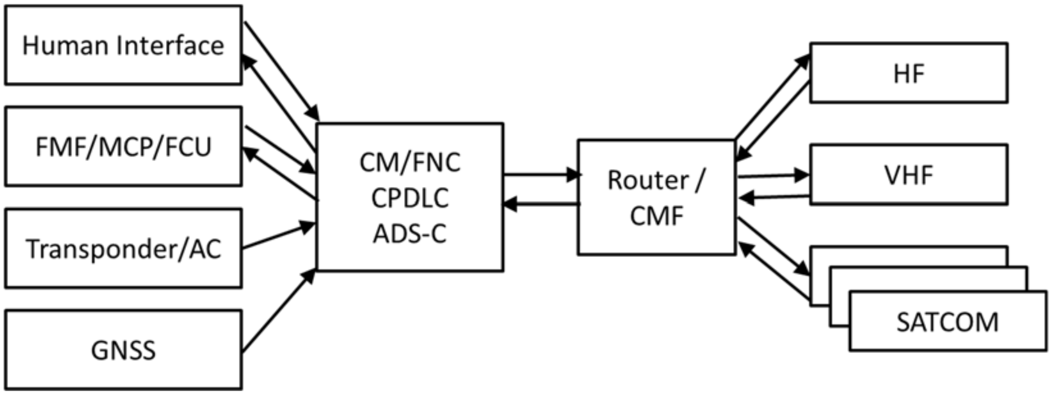


**Figure 2-1 – ATS Datalink High-Level Functional Break-Down**

Both the FAA NextGen and European SESAR plan an evolution to the ATN Baseline 2 applications and services.

### 2.2.1 Subnetworks of ATS Datalink Communications

This section addresses the LOS (coverage range of about 200 NM) and BLOS subnetworks. The radios and routers will evolve to support greater communications loads over larger areas as NextGen and SESAR influence new procedures and systems. Table 2-1 lists the ATS datalink sub networks. Figure 2-2 shows the general ATS datalink network. In this network the Communications Service Providers (CSP) are companies that provide services to the aviation customers. Service is obtained by subscription.

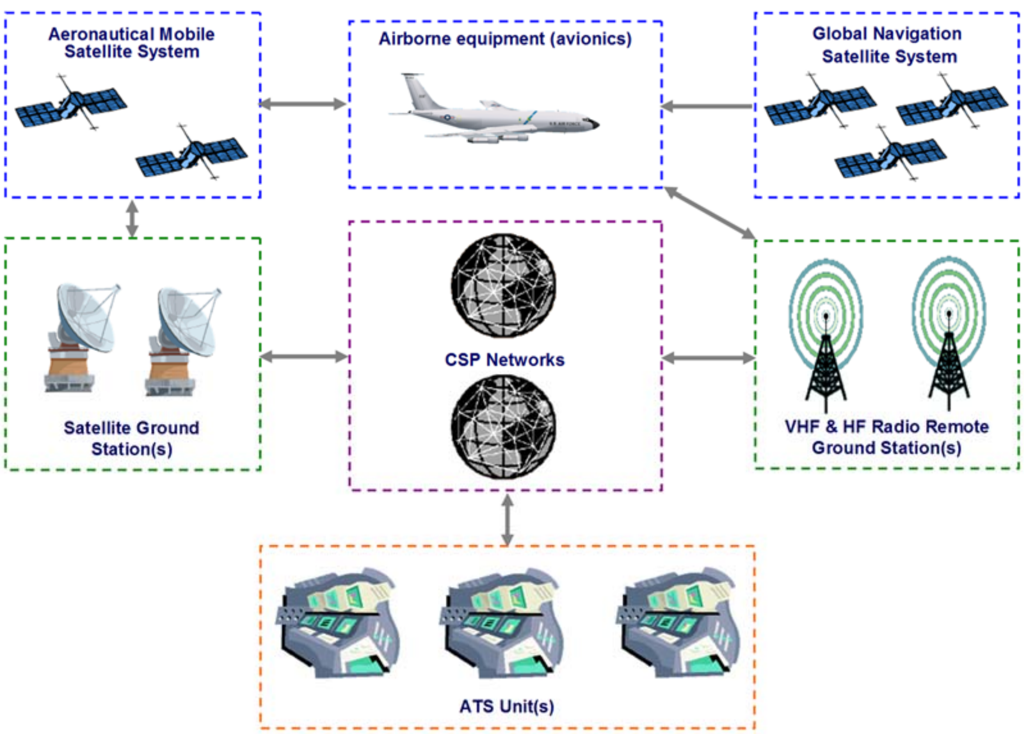


**Figure 2-2 – ATS Datalink Air-Ground Network (ICAO GOLD 6/14/2010-Fig 2-1)**

**Table 2-1 – AST Datalink Sub Networks (ICAO GOLD 6/14/2010 – Table 2-2)**

| Link | Description | Applicable Standard(s) |
|---|---|---|
| VDL M0/A | LOS: Very High Frequency Data Link – mode 0/A. Analog VHF link with a data rate of 2.4 kbps. | ARINC 618 (INTEROP) for air/ground protocol |
| VDLM2 | LOS: Very High Frequency Data Link. This is a D8PSK digital datalink operating at 136.975 MHz with a channel bandwidth of 25 kHz and a data rate of 31.5 kbps. | a) ICAO Annex 10, Vol III<br>b) ICAO Doc 9776, Manual on VDL Mode 2<br>c) RTCA DO-224 (MASPS)<br>d) ARINC 631 (INTEROP) |
| HFDL | BLOS: High Frequency Data Link. This link provides world-wide coverage. It operates at 2-30 MHz with TDMA or FDMA providing 300 to 800 bps. | a) ICAO Annex 10, Vol III<br>b) ICAO Doc 9741, Manual on HF Data Link<br>c) RTCA DO-265 (MASPS)<br>d) ARINC 753 (INTEROP) |
| Satcom (Inmarsat) | BLOS MSS: Inmarsat or MT-SAT – aero classic satellite communications. Coverage is world-wide but is not available in polar regions. | a) ICAO Annex 10, Vol III<br>b) ICAO Doc 9925, AMS(R)S Manual<br>c) RTCA DO-270 (MASPS)<br>d) ARINC 741, 761, or 781 (INTEROP) |
| Satcom (Iridium) | BLOS MSS: Iridium satellite communications using a short burst data modem. Coverage is worldwide.<br>Iridium NEXT is a new capability with increased capacity. Satellite launch is expected to start in 2015. | a) ICAO Annex 10, Vol III<br>b) ICAO Doc 9925, AMS(R)S Manual<br>c) RTCA DO-270, Change 1 (MASPS)<br>d) ARINC 761 (INTEROP) |

### 2.2.1.1 LOS – VDL 0/A and VDLM2

LOS communications are applicable to operations within VHF coverage from ground stations. The two links used are VDL M0/A and VDLM2; see Table 2-2. Most modern aircraft are forward fit with ARINC 750 radios and are therefore capable of operations over voice, VDL M0/A and VDLM2. Many legacy aircraft (e.g., those delivered in the 1970 decade) and military aircraft are not equipped for VDL Mode 0/A or VDLM2. Operations in areas which are not within VHF coverage (e.g., Oceanic operations) depend on BLOS communications capability. ACARS uses both LOS and BLOS to mediate communications.

**Table 2-2 – Very High Frequency Data Links Technical Summary**

| VDL Mode | Mod-ulation | Channel Spacing | Protocol | Data Rate | Typical Use | Radio Interface |
|---|---|---|---|---|---|---|
| VDL M0/A | DSB AM MSK | 25 kHz | CSMA | 2.4 kbps | ACARS | ARINC 429 |
| VDLM2 | D8PSK | 25 kHz | CSMA | 31.5 kbps | ACARS and ATN | ARINC 429 |

Notes:

1. DSB AM MSK – Double Side Band Amplitude Modulation with Minimum Shift Keying (MSK)
2. CSMA – Carrier Sense Multiple Access
3. D8PSK – Differential 8-Phase Shift Keying (D8PSK)

VDL M0/A was developed by the airlines to coordinate with the aircraft through the Airline Operational Control (AOC) center. VDL M0/A modulation of the voice VHF link on multiple frequencies with 25 kHz channel bandwidth and Audio Frequency Shift Keying (AFSK) modulation. Specifically, VDL M0/A uses DSB AM MSK modulation with CSMA protocol. There is interest from the airlines to include the VDL M0/A subnetwork in the future ATS data communications programs. However, neither NextGen nor SESAR have acknowledged the possibility. VDLM2 is used by both ATN B1 and FANS 1/A. It operates at 136.975 MHz, top of the aeronautical VHF band, with a channel width of 25 kHz using D8PSK modulation and data rate of 31.5 kbps. Work continues in both the US and Europe to identify an alternative for VDLM2. Until new communication means are identified and deployed, it has been decided to increase the number of VHF carrier frequencies for VDLM2 known as Multi-Frequency. ATN Baseline 2 (ATN B2) is expected to initially operate over VDL Mode 2. A study between the FAA and EUROCONTROL ended in 2004 with the Future Communications Study, Communications Operating Concept and Requirements (COCR) document. The study identified subnetworks for communications growth, including the L Band Digital Aviation Communication System or (L DACS).

Figure 2-3 shows the LOS communications using ACARS and ATN B1.

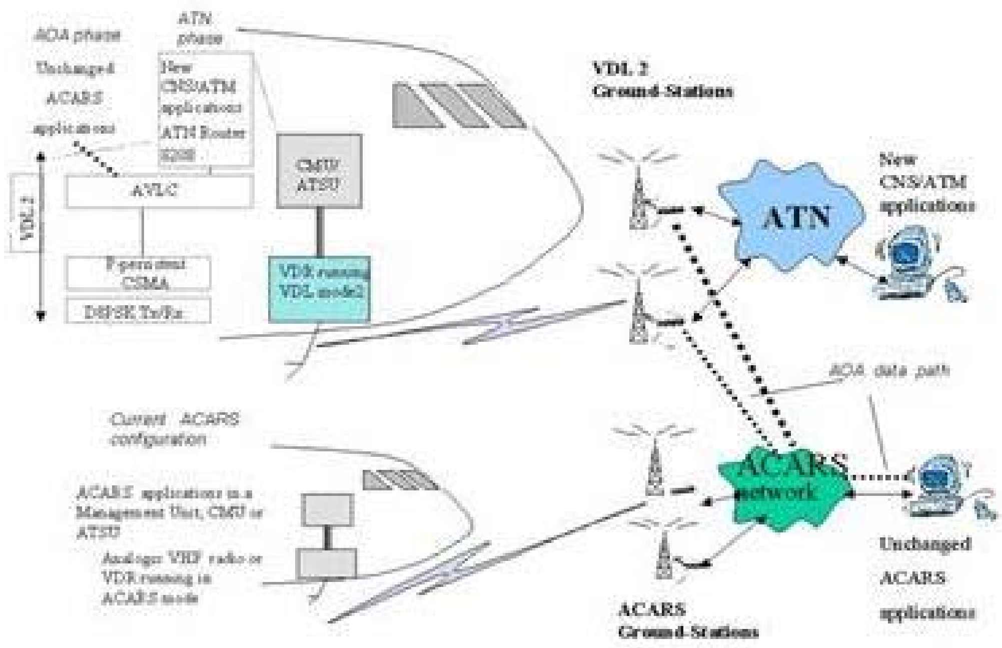


**Figure 2-3 – ATN and ACARS Network**

## 2.2.1.2 BLOS – HFDL and Satcom

### High Frequency Data Link (HFDL)

High Frequency Data Link (HFDL) transmissions have effective bit rates of 300, 600, 1200 or 1800 bps depending on the modulation.

The advantage of HFDL is its worldwide availability. However, link availability and reliability are affected by solar and geo-magnetic disturbances and storms. As a result, the use of HFDL for ATS is limited to standard separation procedures and is not approved for reduced separation procedures.

### Satcom

Satcom for ATS is provided by Inmarsat and Iridium. Both provide oceanic datalink communications between aircraft and ground.

### Iridium and Iridium NEXT

The Iridium constellation uses 66 cross-linked satellites plus spares which create a network of global coverage. Iridium supports Short Burst Data (SBD) service and ACARS. It provides High-availability, low latency, satisfies GOLD RCP240, and is authorized by the FAA and ICAO for CPDLC Communications. The ICAO Global Operational Data Link Document (GOLD) Required Communication Performance (RCP) is discussed further in 2.2.1.2.

Iridium NEXT replaces all of the 66 satellites with 81 new satellites to increase the data capacity to 100 kbps for 90% of the orbit. As with Iridium, it will have global pole-to-pole coverage. The initial launch of Iridium NEXT satellites is scheduled for 2015. Iridium and Iridium NEXT have worldwide coverage.

**Inmarsat**

Inmarsat provides land, maritime, and aviation services with geo-synchronous satellites at an altitude of approximately 22,000 NM. Its coverage is from 80° N to 80° S with no polar coverage. The Inmarsat constellation 3 (I-3) operational limit (sunset) is 2018. Constellation I-4 sunset is 2023. Work has started on I-5. There are 4 variants relevant to ATS:

**Aero H (Sunset expected in 2016)**

Multi-channel voice, 10.5 kbps fax and data, delivered via a high-gain antenna within the satellites' global beams. ICAO approved for safety services.

**Aero H+ (I-3 and I-4)**

Multi-channel voice, 10.5 kbps fax and data, delivered via a high-gain antenna within the spot beams of the Inmarsat-3 satellites and the full footprint of the Inmarsat-4 Atlantic Ocean Region (AOR) satellite at a lower cost per connection. It is ICAO approved for safety services.

**Aero I (Sunset expected in 2016)**

Multi-channel voice, 4.8 kbps circuit-mode data and fax, delivered via an intermediate-gain antenna. Available in the spot beams of the Inmarsat-3 satellites. It is ICAO approved for safety services. Also supports low-speed packet data supported in both the Inmarsat-3 spot beams and in the full footprint of the Inmarsat-4 satellites.

**SwiftBroadBand (I-4)**

SwiftBroadBand supports simultaneous voice and broadband data, with IP data at up to 432 kbps, and IP data streaming on demand at 32, 64, and 128 kbps. This is not yet approved for safety services.

#### 2.2.1.3 Common ATS Communications Function

The ATC Communications architectures are ACARS and ATN. ACARS supports FANS 1/A and FANS 1/A+. ATN supports Link 2000+ and ATN Baseline 1 and Baseline 2 (ATN B1 and ATN B2).

FANS 1/A is in broad use with particular value in remote and oceanic areas. FANS 1/A (DO-258) uses an ACARS network which can use VHFDL, HFDL, and Satcom, and is implemented on many of the aircraft that fly internationally to take advantage of the RNP 4 tracks and services. Some aircraft implement FANS 1/A without VDLM2 radios to support oceanic operations. The FAA Data Communications program has chosen FANS 1/A+ for use in domestic operations. FANS 1/A+ is an upgrade to FANS 1/A already in use.

**DLS-IR in Europe**

The European Data Link Services Implementing Rule (DLS-IR European Commission Regulation Number 29/2009 dated 16 January 2009) requires equipage of aircraft for Link 2000+ as early as 1 January 2011 for all newly delivered aircraft flying above FL285.

The DLS IR was amended 26 February 2015 to address technical issues and delays in various European states. The DLS IR is now calling for the completion of the ATN Baseline 1 datalink services in the enroute European space above FL285 by February 2020.

**2.0 AIR/GROUND COMMUNICATIONS OVERVIEW**

In order to provide the time necessary to resolve the performance issues in the infrastructure causing “Provider Aborts”, the EC adopted a new IR (EU) No 310/2015 amending certain timeframes provided for in Regulation (EC) No 29/2009. In particular, the following amendments have been made:

- Zagreb FIR (Croatia) is inserted in Annex I defining the airspace where DLS shall be provided.
- A common applicability date, notably 5 February 2018, is introduced for all FIRs listed in Annex I, i.e. for the airspace of all EU countries above FL 285.
- Aircraft operators shall ensure that all aircraft operating GAT flights in accordance with IFR above FL 285 within the airspace defined in Annex I are capable to operate the DLS defined in Annex II of Regulation 29/2009 as from 5 February 2020, except for:
  a. Aircraft with an individual certificate of airworthiness first issued before 1 January 2014 and fitted with data link equipment certified against the requirements of one of the Eurocae documents specified in point (10) of Annex III.
  b. Aircraft which have an individual certificate of airworthiness first issued before 31 December 2003 and which will cease operation in the airspace before 31 December 2022.
  c. State aircraft
  d. Aircraft flying in the airspace for testing, delivery or for maintenance purposes or with data link constituents temporarily inoperative under conditions specified in the applicable minimum equipment list.

The Link 2000+ requirement has not been espoused outside of Europe. An airline may determine that aircraft already equipped with FANS 1/A need not equip with Link 2000+ because of the automatic European exemption. An airline may, alternatively, determine that it is advantageous to equip with both technologies to take advantage of services in Europe where FANS 1/A is not supported. Note that the federated approach to FANS 1/A plus Link 2000+ creates human-machine interface issues and complexity for the flight crew. Nonetheless, two approaches currently exist to resolve the disparity in technologies.

**Dual Protocol Stacks**

One approach is dual equipage on the ground. The Maastricht Upper Air Center (MUAC) currently has dual equipage. Other ANSPs in Europe are studying the use of FANS 1/A.

A second approach is to use a dual protocol stack on the aircraft to allow both operations in the oceanic/remote regions and domestically. Such capability is required for FANS 1/A (+) aircraft with individual airworthiness certificate after 01/01/2014, which are not automatically exempted from the European mandate. Both Boeing and Airbus have identified dual stack equipage solutions. The approach to FANS evolution identified in the NextGen Master Plan 2012 is:

- FANS-1/A and ATN CMU are mutually exclusive, i.e., only one can be installed/enabled at one time
- FANS B = ATN B1 (for Airbus)
- Dual-stack aircraft:
  - FANS-2 = FANS-1 and ATN B1 (automatic switching) for Boeing

    - FANS A+B = FANS A+ and ATN B1 (automatic switching) for Airbus
- Next generation FANS aircraft:
    - FANS-3 = FANS-1 and ATN B2 for Boeing
- FANS A+C = FANS A+ and ATN B2 (including backwards compatibility with ATN B1) for Airbus

**North Atlantic Regional Data Link Mandate**

Datalink services are required for aircraft operating in the North Atlantic (NAT) Region. The first phase of the NAT mandate began 7 February 2013. As of that date, all aircraft operating on or at any point along two specified tracks within the NAT organized track system (OTS) between FL360 to FL390 were required to be fitted with and using FANS 1/A (or equivalent) CPDLC and ADS-C equipment.

Phase 2A began on 5 February 2015 and was applicable to FL350 to FL390 within the OTS. Phase 2B commencing 7 December 2017 is applicable to FL350-FL390 (inclusive) throughout the ICAO NAT Region. Phase 2C commencing 30 January 2020 is applicable to FL290 and above throughout the ICAO NAT Region.

**ATN B1 and ATN B2**

In the original work on ATN, there were plans for ATN B1, ATN B2, and ATN Baseline 3 (ATN B3). It was internationally agreed that ATN B2 and ATN B3 functionality would be delivered together and referred to as ATN B2. Link 2000+ is a major subset of ATN B1 with a few functions not implemented. EASA has published certification guidance for ATN B1 aircraft installations. In some regions, ATN B2 will be available in 2018. However, the US plans are to have ATN B2 available in 2023. It is expected that the European and US implementations of ATN B2 will differ with the US using trajectory based operations.

The FAA published guidelines for dual stack approval in **AC 20-140B:** *Guidelines for Design Approval of Aircraft Data Communications Systems* in late 2012. Guidelines for installation and operation of ATN B2 (AC 20-140C and AC 120-70C respectively) are expected in 2014. Dual stacking on the aircraft is increasingly recognized as a means to cope with the existence of mixed ground system implementations, and will be the norm in most new commercial aircraft built to support NextGen/SESAR.

### 2.2.2 Required Communications Performance (RCP)

ICAO has published a Global Operational Data Link Document (GOLD) to facilitate global harmonization of existing datalink operations and resolve regional and/or State differences impacting seamless operations. The first release is dated June 14, 2010 and the second April 26, 2013. It includes Required Communication Performance (RCP), surveillance specifications and guidelines on post implementation monitoring and corrective action. The RCP and surveillance specifications are based on RTCA DO-306/EUROCAE ED-122 Oceanic Safety and Performance Requirement (SPR). Table 2-3 lists the Oceanic RCP types. There are currently no RCP standards for FANS 1/A or for FANS 1/A+ over VDLM2. The RCP standards are not applicable to domestic operations.

**Table 2-3 – Oceanic Surveillance Performance Types (AC 20-141A table 4-2)**

| RCP Type | Transaction Time (seconds) | Continuity | Availability | Integrity |
|---|---|---|---|---|
| RCP 240 | 240 | 0.999 | 0.999<br>0.9999 (efficiency) | Malfunction<br>$10^{-5}$ per flt hour |
| RCP 400 | 400 | 0.999 | 0.999 | Malfunction<br>$10^{-5}$ per flt hour |

Note: The navigation Figure of Merit (FOM) is specified on the navigation criteria associate with the specification.

RTCA DO-290/EUROCAE ED-120, Change 2 provides operational, safety, and performance criteria for continental SPR. No RCP types or surveillance specifications have been developed for datalink services in continental airspace. VDLM2 is the only subnetwork that has been prescribed for datalink services in continental airspace.

RCP is an end to end measure of performance which includes allocations to the subnetwork, controller, network, automation and pilot. Recent studies indicate that the stressing factor in RCP is the human performance particularly the pilot. Future architectures must accommodate RCP in the design of avionics and displays, particularly in support of NextGen/SESAR services such as 4D trajectory (4DTRAD).

**FAA AC 20-140B:** *Guidelines for Design Approval of Aircraft Data Link Communications Supporting Air Traffic Services*, dated 9/27/2012 provides a basis for use of RCP in satisfying performance requirements.

### 2.2.3 Aircraft Communications Addressing and Reporting System (ACARS)

The ACARS is a digital air-ground communications system that has evolved into several forms since its initial deployment in 1978 by ARINC. The original variant, referred to as Plain Old ACARS (POA), is based on LOS communications and is expected to continue in use past 2025 in the US and elsewhere except Europe. POA is described in further detail below. FANS 1/A was developed to support a greater communications message set and can use both LOS and BLOS communications. FANS 1/A and its extension FANS 1/A+ are discussed below. The Aeronautical Telecommunications network baseline 1 (ATN B1) and its extension ATN Baseline 2 (ATN B2) do not use ACARS. VHF ACARS is not a candidate for IPS.

#### 2.2.3.1 POA – VDL M0/A

This original form of ACARS operates on the 25 kHz bandwidth VHF voice communication channels used by ATC and AOC to support a digital communication at 2.4 kbps. This link is referred to as VDL M0/A. The primary limitations of POA are low data rate and the dependence on VHF line-of-sight communications. This medium is not expected to be a candidate for IPS.

#### 2.2.3.2 FANS 1/A and FANS 1/A+ – VDLM2 AOA, Satcom, and HFDL

Boeing introduced FANS 1 in the early 1990’s. A similar product called FANS A was developed by Airbus. Collectively the products are known as FANS 1/A. FANS 1/A+ is FANS 1/A together with some additional messages including Message Delivery Delay. New installations typically support FANS 1/A+. However, older installations may not have FANS 1/A+.

The communications subnetworks used include VDLM2, Satcom, and HFDL. The world-wide coverage includes oceanic RNP-4 routes which require data communications. A FANS 1/A or 1/A+ on an aircraft may utilize all of these possible subnetworks. Many of the installations have FANS 1/A to support use of RNP-4 oceanic routes and do not implement the VDLM2 subnet.

The ACARS on the VDLM2 subnetwork uses the ACARS over AVLC (AOA). Aviation VHF Link Control (AVLC) is the Datalink layer of the VDLM2 protocol stack and mediates between the character-based ACARS and the binary-based VDLM2. With AOA, a data rate of 31.5 kbps is achieved.

Primary references for FANS 1/A and 1/A+ are ARINC 622, RTCA DO-258A and EUROCAE ED-100. In addition, there is a large collection of documents that define functions and characteristics of the avionic and ground based systems.

#### 2.2.3.3 ATN B1 – VDLM2

ATN B1 uses VDLM2 exclusively and is not applicable to oceanic regions. The EUROCONTROL Link 2000+ program is the subset of ATN B1 that has been sufficiently validated by the Link 2000+ program, and is required equipage in Europe. ATN implements the native datalink layer that is more efficient than AOA. The European Implementing Rule exempts aircraft with FANS 1/A+ prior to January 1, 2014, from Link 2000+ certification. The ANSPs are not obligated to accommodate FANS 1/A aircraft. Some ANSPs will equip to support (e.g., Maastricht UACC) FANS and will continue to support it. However, it is expected that some ANSPs will not equip to support FANS and will control these aircraft with voice radio.

The interoperability between FANS 1/A and ATN B1 is specified in RTCA DO-305A/EUROCAE ED-154A.

### 2.2.4 Services of ATS Datalink Communications

The Link 2000+ services have been deployed as of 2013 in several locations in Europe and deployment will continue. The NextGen Implementation Plan for 2013 shows plans for ATN B2 but without a firm starting date. SESAR indicates a plan for ATN B2 in European airspace. The definition of ATN B2 continues and implementation is likely starting in mid-2020. Figure 2-4 shows the Boeing/Airbus B2 timeline.

## 2.0 AIR/GROUND COMMUNICATIONS OVERVIEW

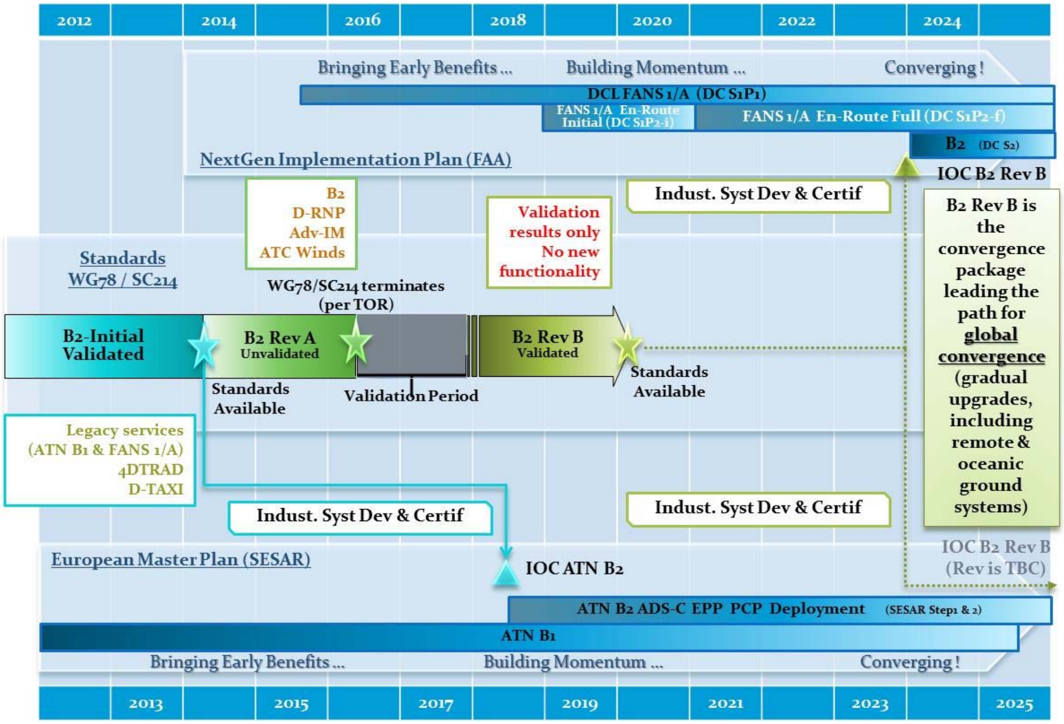


**Figure 2-4 –**

Figure 2-5 shows the FAA roadmap for ATS Data Communications. Figure 2-6 shows the connectivity between ATN B1 and FANS equipped aircraft, and the Air Traffic Service Units (ATSU).

Table 2-4 lists some of the applications and services available with the various links. The column headings list the major equipage capabilities of the fleet and the rows list services and applications. The full list of services is extensive and this is a representative list. Significant portions of the US continental-based aircraft that do not operate in Europe continue to use POA to communicate with the AOC. AOC to ATSU coordination completes the ATS link for domestic services such as Pre-Departure Clearance (PDC). Some aircraft equip with FANS 1/A to take advantage of oceanic services and reduced separation in RNP 4 routes. Many of these do not have VDLM2 radios. Full FANS 1/A, in the US, or ATN B1, in Europe, equipage is becoming common. Equipage for B2 is foreseen in the mid-2020.

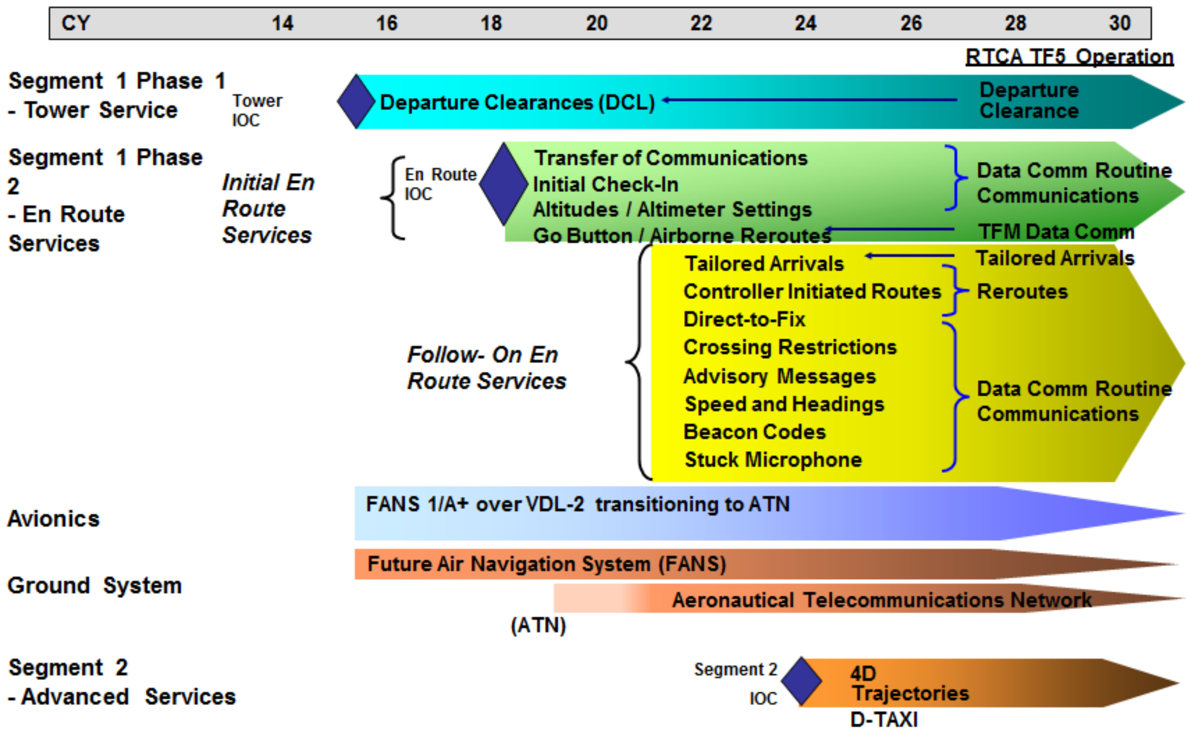


**Figure 2-5 – Data Communications Road Map (FAA March 2013)**

Datalink systems – interoperability designators.

1. Datalink is a generic term that encompasses different types of datalink systems and subnetworks.
2. Figure 2-5 shows various ATSU ground systems and aircraft systems that are interoperable. A designator is associated with each type of ATSU and aircraft datalink system to indicate acceptable interoperable configurations for the datalink applications.

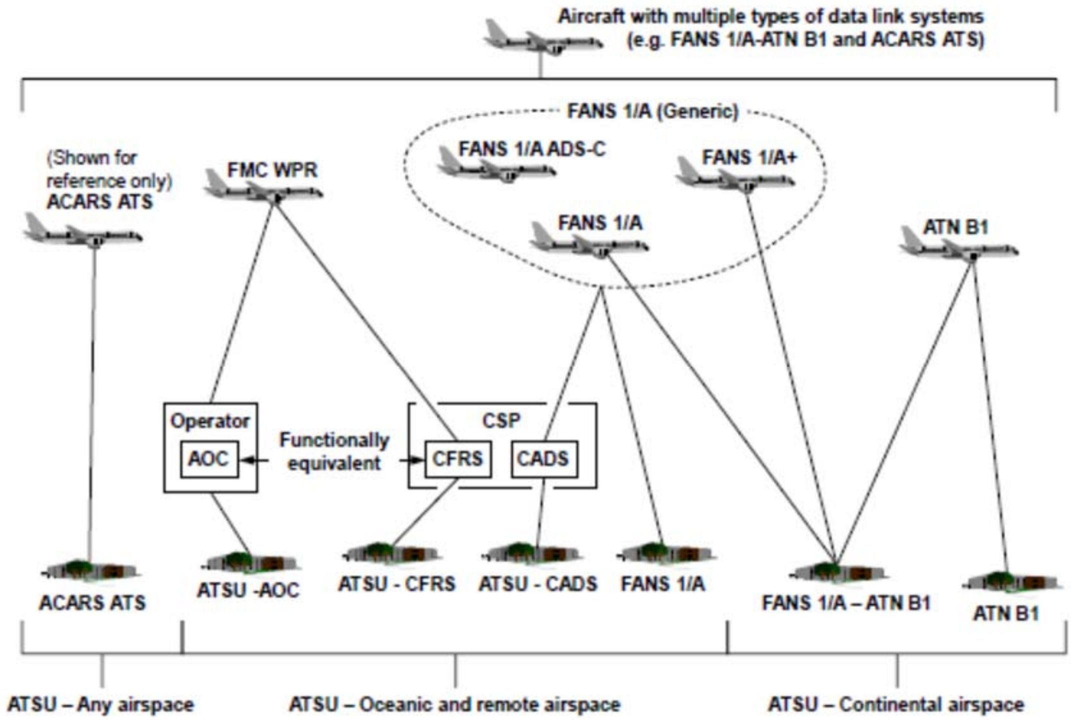


**Figure 2-6 – Various Air Traffic Service Unit (ATSU)/Aircraft Interoperability Connectivity (ICAO GOLD 4/26/2013 – Fig 2-2)**

**Table: 2-4 – Data Link Services – Safety and Performance Specifications (ICAO Gold 4/26/2013, Table 2-2)**

| Designator | Description of Designator | Applicable Interoperability Standard(s) | Applicable System |
|---|---|---|---|
| ACARS ATS | ATS applications, departure clearance (DCL), oceanic clearance (OCL) and Digital – Automatic Terminal Information Service (D-ATIS), supported by aircraft communications addressing and reporting system (ACARS).<br>Note: *ACARS ATS is defined for reference only. Guidance for these applications is not provided in this document.* | a) ED-85A (DCL)<br>b) ED-106A (OCL)<br>c) ED-89A (D-ATIS)<br>d) ARINC 623 | ATSU and Aircraft |
| FMC WPR | Flight management computer waypoint position reporting (FMC WPR) ATS application, generates and sends waypoint position reports, supported by flight management system and ACARS. | ARINC 702A | Aircraft |
| ATSU CFRS | Communication service provider's (CSP's) centralized flight management computer waypoint reporting system (CFRS) enables ATSU to receive waypoint position reports in ICAO format from any FMC WPR aircraft. | a) ARINC 702A<br>b) CFRS Common Specification, Version 2.0, April 2004 (Available from ICAO Regional Office in Paris) | ATSU |
| ATSU AOC | Operator's aeronautical operational control (AOC) facility enables ATSU to receive waypoint position reports in ICAO format from the operator's FMC WPR aircraft. | a) ARINC 702A<br>b) Aeronautical fixed telecommunication network (AFTN) specifications | ATSU |
| ATSU CADS | CSP's centralized ADS-C system (CADS) enables an ATSU without FANS 1/A capability to receive ADS-C reports from any FANS 1/A, FANS 1/A+ or FANS 1/A ADS-C aircraft. | a) DO-258A/ED-100A or previous versions<br>b) CADS Common Specification, Version 2.0, April 2004 (Available from ICAO Regional Office in Paris) | ATSU |

**2.0 AIR/GROUND COMMUNICATIONS OVERVIEW**

| **Designator** | **Description of Designator** | **Applicable Interoperability Standard(s)** | **Applicable System** |
|---|---|---|---|
| FANS 1/A | Initial FANS 1/A ATS applications, ATS Facilities Notification (AFN), CPDLC, and ADS-C, supported by FANS 1/A over ACARS.<br>Note: *FANS 1/A typically involve communication (CPDLC), navigation (RNAV/RNP) and surveillance (ADS-C). This document refers to the FANS 1/A for the datalink system, which includes the CPDLC and ADS-C applications. Refer to ICAO Doc 9613 for guidance material on navigation ( RNAV/RNP) qualification and use.* | a) DO-258A/ED-100A or previous versions<br>b) Boeing document D6-84207, Loading of ATC Clearances into the Flight Management System (FMS), August 2009<br>c) Airbus document X4620RP1133312, FANS A/A+ Function Integration with FMS Technical Report | ATSU and Aircraft |
| FANS 1/A+ | Same as FANS 1/A, except with additional features, such as the message latency monitor function, described in DO-258A/ED-100A, paragraph 4.6.6.9. See also this document, paragraph 3.1.2.6, for procedures on its use.<br>FANS 1/A+ – complies with Revision A of the standard (i.e., not previous versions) | a) DO-258A/ED-100A only<br>b) Boeing document D6-84207, Loading of ATC Clearances into the Flight Management System (FMS), August 2009<br>c) Airbus document X4620RP1133312, FANS A/A+ Function Integration with FMS Technical Report | Aircraft |
| FANS 1/A ADS-C | ATS applications, AFN and ADS-C, supported by FANS 1/A over ACARS.<br>FANS 1/A ADS-C – complies with AFN and ADS-C applications, No CPDLC. | DO-258A/ED-100A | Aircraft |

**2.0 AIR/GROUND COMMUNICATIONS OVERVIEW**

| Designator | Description of Designator | Applicable Interoperability Standard(s) | Applicable System |
|---|---|---|---|
| ATN B1 | ATS applications, CM, and CPDLC, supported by aeronautical telecommunication network – baseline 1 (ATN B1):<br>a) Context management (CM) application for datalink initiation capability (DLIC);<br>b) CPDLC for ATS communications management (ACM), ATS clearance (ACL), and ATC microphone check, except that:<br>1) UM 135 CONFIRM ASSIGNED LEVEL and UM 233 USE OF LOGICAL ACKNOWLEDGEMENT PROHIBITED will not be used by the ATSU and<br>2) DM 38 ASSIGNED LEVEL (level) is not required by the aircraft.<br>*Note: Interoperability for Departure Clearance (DCL), Downstream Clearance (DSC), Digital – Automatic Terminal Information Service (D-ATIS), and flight plan consistency (FLIPCY) datalink services, which are defined in DO-280B/ED-110B, are not supported.* | a) DO-280B/ED-110B<br>b) EUROCONTROL Specification on Data Link Services (EUROCONTROL-SPEC-0116) | ATSU and Aircraft |
| FANS 1/A – ATN B1 | Enables ATSU with ATN B1 ground system to provide datalink service to FANS 1/A aircraft.<br><br>Enables the use of CPDLC along a route of flight where datalink services are provided by FANS 1/A technology in some airspaces and ATN B1 in other airspaces. | a) ATN B1 and FANS 1/A standards are applicable and, in addition,<br>b) DO-305A/ED-154A<br>*Note: Some aircraft implement FANS 1/A and ATN B1 capabilities as separate systems and do not comply with* DO-305A/ED-154A*. Such aircraft do not benefit from automatic CPDLC transfers.* | ATSU Aircraft |

### Table 2-5 – Table of Representative Applications and Services

| | Description | POA* | FANS 1/A not VDLM2# | FANS 1/A & 1/A+ | ATN B1 | ATN B2 |
|---|---|---|---|---|---|---|
| **Sub network** | | | | | | |
| VDL M0/A | | √ | √ | Radio Dependent | | |
| VDLM2 | | | | √ | √ | √ |
| BLOS | | | If oceanic | √ | | TBD |
| **Applications and Services** | | | | | | |
| Context Management (CM) application | CM enables the ATS provider to become aware of the aircraft capabilities and provides for exchange of address information | | | | √ | √ |
| • Data Link Initiation Control (DLIC) service | DLIC is derived from CM to provide the information necessary to provide ATS datalink with the aircraft | | | | √ | √ |
| ATS Facilities Notification (AFN) application | AFN enables the ATS provider to become aware of the aircraft capabilities and provides for exchange of address information | | | √ | | |
| Latency Timer | | | | In 1/A+ | √ | √ |
| Controller Pilot Data Link Communications (CPDLC) application | CPDLC supports digital communications between the Pilot and Controller | | √ | √ | √ | √ |
| • ATC Communications Management (ACM) service | ACM provides automated assistance to flight crew and controller in transfer of ATC communications (voice and CPDLC) | | √ | √ | √ | √ |
| • ATC Clearance (ACL) service | ACL provides a non-time-critical exchanges between flight crews and controllers | | √ | √ | √ | √ |
| • Oceanic Clearance (OCL) | | √ | | | | |
| • Departure Clearance (DCL) and<br>• Pre-departure clearance (PDC) | | √ | FAA Trials starting in 2013 | FAA Trials starting in 2013 | | |
| • Digital Taxi (D-TAXI) | | | | | | √ |

| | Description | POA* | FANS 1/A not VDLM2# | FANS 1/A & 1/A+ | ATN B1 | ATN B2 |
|---|---|---|---|---|---|---|
| • Digital Automatic Terminal Information Service (D-ATIS) | | √ | | | | |
| • Pushback | | | | | | √ |
| • ATC Microphone Check service | A CPDLC message to equipped aircraft to verify voice communication | | Free text | Free text | √ | √ |
| • Uploadable elements | Flight Plans and other information sent to the aircraft and automatically applied in the FMA | | √ | √ | | √ |
| Flight Management Computer Waypoint Reporting (FMC WPR) application | Automatic position reporting at ATC waypoints | √ | | | | |
| Automatic Dependent Surveillance – Contract (ADS-C or ADS) | ADS-C automatically transmits aircraft data to include 3D position | | √ | √ | | √ |
| • Periodic Contract | Normal and emergency in which information is sent at a specified frequency | | √ | √ | | √ |
| • Event Contract | Information is sent upon occurrence of a specified event or sequence of events | | √ | √ | | √ |
| • Demand Contract | Information is sent upon a one-time polling | | √ | √ | | √ |
| Aircraft predicted 4D trajectory data | | | | | | √ |
| Flight Information Service Data Link (FISDL) | FISDL transmits weather and operational status | | | | | |

Note: * POA uses ARINC 623 and ARINC 702A applications and refers to ACARS using VDL M0/A, not FANS 1/A or FANS 1/A+. It was developed and is used to communicate with Airline Operational Control (AOC) centers. Many aircraft are POA equipped only.
# FANS 1/A but not VDLM2 refers to installations that have FANS 1/A with Satcom or HFDL to support oceanic operations, but do not have VDLM2 radios. This equipage is common in a large portion of the fleet.

## 2.3 IPS Applications

The aviation community in concert with NextGen and SESAR programs is expected to negotiate the introduction of IPS in a number of applications and services. The following applications are viewed to be a set of examples for the purpose of generating discussion.

### 2.3.1 CPDLC

Controller Pilot Data Link Communication (CPDLC) is an application that provides air-ground data communication to the ATC service. This includes a set of clearance/information/request message elements which correspond to voice phraseology employed by air traffic control procedures. The pilot may use CPDLC to request clearances that have traditionally been requested by voice. The controller is provided with the capability to issue level assignments, crossing constraints, lateral deviations, route changes and clearances, speed assignments, radio frequency assignments, and various requests for information. A “free text” capability is also provided to exchange information not conforming to defined formats.

The sequence of messages between the pilot and the controller relating to a particular transaction is called a dialogue. There can be several sequences of messages in the dialogue, each of which is closed by means of appropriate messages, usually of acknowledgement or acceptance. Closure of the dialogue does not necessarily terminate the link, since there can be several dialogues between controller and pilot while an aircraft transits the airspace.

The CPDLC application has three primary functions:

- Exchange of controller/pilot messages with the current ATC center
- Transfer from current ATC center to the next ATC center
- Clearance delivery and acknowledgement

The CPDLC application supplements voice communications and, in some airspace regions, CPDLC is likely to supersede voice communication.

### 2.3.2 ADS-C – Automatic Dependent Surveillance-Contract

ADS-C is 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). ADS-C is expected to be used for Trajectory Based Operations (TBO) and Extended Projected Profile (EPP).

### 2.3.3 Weather Awareness

Increasing weather awareness and reducing the disruptive impacts of weather delays are major objectives of NextGen and SESAR. The FAA estimates bad weather causes approximately 75% of air traffic delays and can pose a safety risk to aircraft (Aviation Weather Research website, Lincoln Laboratories, Massachusetts Institute of Technology, 2012). The European SESAR program also depends on better weather forecasting and information dissemination to achieve their European airspace capacity improvement objectives.

Better data sharing of weather information is a key component of NextGen and SESAR. The FAA is planning Common Support Services–Weather (CSS-Wx) to provide the FAA and United States National Airspace System (NAS) users with same-time access to a unified aviation weather picture via the System Wide Information Management network. The CSS-Wx will publish standardized weather information provided by the NextGen Weather Processor, the National Oceanic and Atmospheric Administration's (NOAA) Four-Dimensional Weather Cube and other weather sources. This will enable collaborative and dynamic decision making among all users of the NAS, and give them the flexibility to proactively plan and execute aviation operations ahead of weather impacts.

The SESAR Joint Undertaking (SESAR JU) has established work packages to investigate a similar capability in Europe. According to EUROCONTROL:

"Accurate and timely meteorological information incorporated as an integrated component to the system to support all phases of flight will be provided to the new ATM management. Such information shall be used to determine the optimum route/trajectory for an individual flight or series of flights in all planning phases, and for the execution of a flight. It is expected that the importance of meteorological information for ATM will grow in the next 10 to 15 years; meteorological information from a range of sources (including other aircraft) will be integrated with other data to facilitate trajectory based planning and operations. MET must be provided in an open and interoperable form and incorporated into decision making systems and processes including the development and agreement of contingency plans to mitigate the worst effects of weather." See **EANPG COG Metrological/Air Traffic Management Taskforce**: *MET Strategy in supporting the Global ATM Operational Concept for the EUR Region*, dated January 2012.

Information to improve weather awareness may be shared via SWIM (see Section 2.3.5). When weather forecast result in a trajectory update, the information is processed on ground (e.g., in Airline Operations Control Center) and, if needed, sent to aircraft using classical datalink means (e.g., to update winds data and temperatures for FMS computation).

### 2.3.4 Trajectory Based Operations (TBO)

Trajectory management is a necessary function for both NextGen and SESAR programs to reach the objectives of greater operational efficiency and capacity. Trajectory based operations provide broad and extensive flexibility and adaptability in the creation, definition, and implementation of routes and procedures with reduced separation, and the conduct of ground/flight operations, through a modernized ATM system. The ATM modernization that is required affects both aircraft and ground systems, along with operations policies, air/ground and ground/ground integration, air traffic and flight crew procedures, and systems technologies and integration.

In this concept, airspace users will coordinate a preferred four dimension trajectory (three spatial dimensions, plus time) early in the planning cycle with ANSPs and airport operators. The planning cycle continues to the day of the operation. During this planning process, the various constraints of airspace and airport capacity will have been considered.

In the SESAR concept, this 4D trajectory is called the "Business trajectory." In the case of military aviation, it is referred to as "Mission trajectory." Once the trajectory is agreed upon, it becomes the reference which the airspace user agrees to fly and all the service providers agree to facilitate with their respective services. Subsequently, all stakeholders will then share information on this 4D

Business/Mission trajectory in real time throughout the flight (from preparation through the end of the operation).

The SESAR ConOps establishes that:

The future ATM system will be built around six main pillars:

- Moving from Airspace to 4D Trajectory Management
- Traffic Synchronization
- Network Collaborative Management and Dynamic/Capacity Balancing
- System-Wide Information Management (SWIM)
- Airport Integration and Throughput
- Conflict Management and Automation

### 2.3.5 System Wide Information Management (SWIM)

The transformation to the NextGen and SESAR initiatives requires solutions that provide more efficient operations, including streamlined information access and exchange capabilities. System Wide Information Management (SWIM) is an integral part of that transformation. This capability is a key enabler for many of the proposed NextGen and SESAR operational improvements, particularly for collaborative decision making and shared situational awareness.

In the ICAO Global Air Traffic Management Operational Concept SWIM is described as follows:

"System Wide Information Management aims at integrating the ATM network in the information sense, not just in the systems sense. The fundamental change of paradigm forms the basis for the migration from the one-to-one message exchange concept of the past to the many-to-many information distribution model of the future, that is geographically dispersed sources collaboratively updating the same piece of information, with many geographically dispersed destinations needing to maintain situational awareness with regard to changes in that piece of information."

"SWIM aims to facilitate information-sharing by providing timely data to all relevant ATM stakeholders to reduce the number of interfaces and systems, in order to improve predictability and operational decision-making. In addition, SWIM will support coordination to allow transition from tactical conflict management based on open-loop clearances, to strategic conflict detection and anticipation (trajectory-based operations)."

The foundation for NextGen and SESAR operations is based on having access to near-real time information that is shared among all decisions makers, ground and airborne based, to ensure that collaborative decisions are made with the best, most up to date information.

The SWIM environment will provide an open, flexible, and secure information management service oriented architecture for sharing airspace and user preference advisory data and enabling increased common situational awareness for improved system planning and operation.

As shown in Figure 2-7, SWIM consists of two aspects:

- A ground-to-ground SWIM network interconnecting the different actors such as ANSPs, ATC, flight operations, airport operations and airlines. All share information relative to aircraft flights in order to optimize the airspace and satisfy airline business objectives.

- The air/ground SWIM network interface allows aircraft to exchange information with the ground SWIM network during flight.

From an aircraft perspective, air/ground SWIM is not intended to carry flight critical data. Critical data such as aircraft trajectory will continue to be exchanged via classical air-ground communication means. Air/ground SWIM will enable the exchange of non-safety-critical information such as weather and AIM that can be used on-board the aircraft to enhance the awareness of the crew in some decision cases. The aircraft will also downlink non-critical information through air/ground SWIM infrastructure.

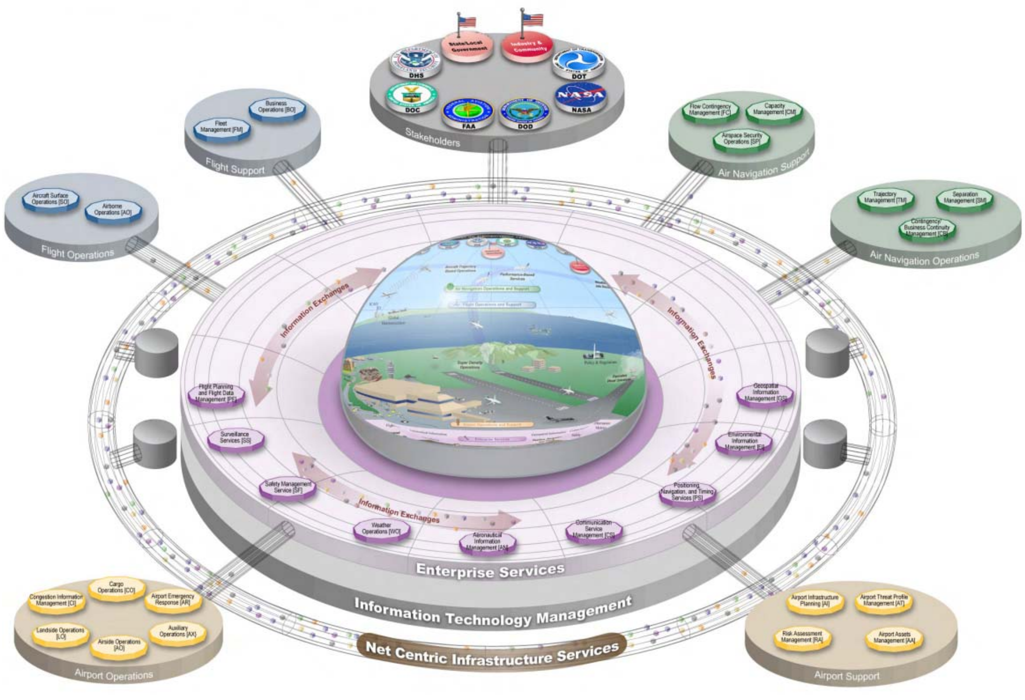


**Figure 2-7 – Net Centric Infrastructure**

### 2.3.6 Airborne Information Management (AIM)

As specified in ICAO Annex 15, Aeronautical Data is a representation of aeronautical facts, concepts, or instructions in a formalized manner suitable for communication, interpretation or processing. It further defines this information as that resulting from the assembly, analysis and formatting of aeronautical data. The management of aeronautical information and aeronautical data is a key part of SESAR and NextGen.

In the context of the NextGen ground infrastructure, generation, distribution and release of SWIM data to the user has been the main focus. While within SESAR, SWIM includes the airborne side as an integral node, special attention had to be given to the ground infrastructure as well due to heterogeneity of the European ATM system. Enhancements in the field of Accuracy, Availability, Non-Redundancy, Completeness and Integrity have been targeted where the main focus is the integrity and quality control process.

Several work packages in SESAR have been assigned for this purpose that could result in rulemaking efforts. Both SESAR and NextGen programs determined that it is important to have a data-centric information management system, and thus the term SWIM (System Wide Information Management) had been established. Today, SWIM does not address the management of data and information in the Airborne Infrastructure, but it appears advantageous that the airborne infrastructure employ some kind of information management that would, whenever practical, use the same quasi approach, thus continuing the data chain from the ground into the aircraft avionics architecture. This logical entity is referred to as the airborne Information Management Service (IMS).

There are a number of advantages in having a centralized IMS in the SESAR and NextGen enabled avionics architecture that will potentially benefit the airframe manufacturer and aircraft operator. Some of these are single load point, pre-processing of data to reduce avionics processing need, data consistency, centralized information security, access to data through single interface, potential for centralized storage of data and information, etc.

There is a trend to remove paper from the aircraft and migrate to digital media using Electronic Flight Bags. Examples are:

- Charting applications
- Airport moving map display
- EFB deployment

The recommended architectures described by this document describe airline preferences for updating the existing aircraft. For existing aircraft it should be possible to get at least some advantage out of those architectural changes (e.g., adaptors for legacy systems connectivity to the IMS).

Standards are being defined today in support of NextGen and SESAR that will increase the need for data and information distribution and use by the aircraft systems. RTCA Special Committee 206 is defining standards for airborne applications to datalink that use Aeronautical Information Services (AIS) and Meteorological (MET) information. RTCA Special Committee 214 is defining applications that will use Air Traffic Services data uplinked to the aircraft via a datalink. Some examples of these applications are: D-TAXI, D-OTIS, D-RVR, 4DTRAD, D-HZWX, etc.

## 2.4 Internet Protocol Suite (IPS) Overview

This section is intended to provide a high-level overview of the role that IPS is expected to have in supporting the applications mentioned above. Details are TBD. The technical requirements for IPS are provided in Section 3, Requirements for IPS, and ARINC Project Paper 8xx: Internet Protocol Suite (IPS) for Aeronautical Safety Services [TBD]

# 3.0 REQUIREMENTS FOR IPS

## 3.1 Introduction

This section describes the requirements for IPS bases on the Air/Ground Communications Overview provided in Section 2 of this document.

## 3.2 Safety Services Datalink Communications

The overall objectives is to enable the use of Internet-based communication protocols in a highly-secure aviation environment.

### 3.2.1 Basic Technical Requirements

#### 3.2.1.1 Naming and Addressing

#### 3.2.1.2 IP Version Usage and Translation (IPv4/IPv6)

#### 3.2.1.3 Quality of Service Requirements

#### 3.2.1.4 Compression Requirements

#### 3.2.1.5 Mobility Requirements

#### 3.2.1.6 Upper Layer Interfaces

- Dialog Service Usage
  - LINK2000+
  - B2/B2A/B2B
- ATNPKT Format Usage
  - FANS-1/A
  - ACARS
- Native IP
- Others?

Lower Layer Interfaces

- Existing transport level
  - SwiftBroadband
  - AeroMACS
- Existing network level
- Existing link/physical
  - VDLM2
  - VDL0/A – Not applicable
- Other (e.g., existing session)?

### 3.2.2 Subnetworks of ATS Datalink Communications

This section addresses any necessary improvements to the subnetworks candidate for IPS services described in Section 2.2.1

#### 3.2.2.1 LOS – VDL 0/A and VDLM2

IPS is not applicable to VDL 0/A. It may be applicable to VDLM2.

#### 3.2.2.2 BLOS – HFDL and Satcom

**High Frequency Data Link (HFDL)**

IPS is not applicable.

**Iridium Basic**

IPS is not applicable

**Iridium NEXT**

TBD

**Inmarsat Aero H (Sunset expected in 2016)**

IPS is not applicable.

**Inmarsat Aero H+ (I-3 and I-4)**

IPS is not applicable.

**Inmarsat Aero I (Sunset expected in 2016)**

IPS is not applicable.

**Inmarsat SwiftBroadBand (I-4)**

TBD

**AeroMACS**

TBD

**LDACS**

TBD

### 3.2.3 Required Communications Performance (RCP)

ICAO has published a Global Operational Data Link Document (GOLD) to facilitate global harmonization of existing datalink operations and resolve regional and/or State differences impacting seamless operations.

The additional requirements pertinent to IPS are unchanged.

### 3.2.4 FANS 1/A and FANS 1/A+ – VDLM2 AOA, Satcom, and HFDL

Boeing introduced FANS 1 in the early 1990’s. A similar product called FANS A was developed by Airbus.

The additional requirements pertinent to IPS are TBD.

### 3.2.5 ATN B1 – VDLM2

ATN B1 uses VDLM2 exclusively and is not applicable to oceanic regions. The EUROCONTROL Link 2000+ program is the subset of ATN B1 that has been sufficiently validated by the Link 2000+ program, and is required equipage in Europe.

The additional requirements pertinent to IPS are TBD.

### 3.2.6 Services of ATS Datalink Communications

The Link 2000+ services have been deployed as of 2013 in several locations in Europe and deployment will continue. The NextGen Implementation Plan for 2013 shows plans for ATN B2 but without a firm starting date. SESAR indicates a plan for ATN B2 in European airspace.

The additional requirements pertinent to IPS are TBD.

## 3.3 Information Security Requirements

All data send over air/ground networks must be completely secure.

The additional requirements pertinent to IPS are TBD.

## 3.4 Safety Requirements

The applicable safety requirements pertinent to IPS are set by the responsible certification authority. ARINC Standards are not intended to be used as a basis of airworthiness certification. The reader should consult the applicable FAA and EASA regulations.

## 3.5 Performance Requirements

This section describes the performance requirements of a variety of applications that will benefit from IPS services.

Performance requirements are TBD.

### 3.5.1 CPDLC

CPDLC is expected to be used extensively in Europe and in the USA starting in 2020.

The additional requirements pertinent to IPS are TBD.

### 3.5.2 ADS-C – Automatic Dependent Surveillance-Contract

ADS-C is a datalink application that provides for contracted services between ground systems and aircraft.

The additional requirements pertinent to IPS are TBD.

### 3.5.3 Weather Awareness

Increasing weather awareness and reducing the disruptive impacts of weather delays are major objectives of NextGen and SESAR.

The additional requirements pertinent to IPS are TBD.

### 3.5.4 Trajectory Based Operations

Trajectory management is a necessary function for both NextGen and SESAR programs to reach the objectives of greater operational efficiency and capacity.

The additional requirements pertinent to IPS are TBD.

### 3.5.5 System Wide Information Management (SWIM)

The transformation to the NextGen and SESAR initiatives requires solutions that provide more efficient operations, including streamlined information access and exchange capabilities. System Wide Information Management (SWIM) is an integral part of that transformation. This capability is a key enabler for many of the proposed NextGen and SESAR operational improvements, particularly for collaborative decision making and shared situational awareness.

The additional requirements pertinent to IPS are TBD.

### 3.5.6 Airborne Information Management

As specified in ICAO Annex 15, Aeronautical Data is a representation of aeronautical facts, concepts, or instructions in a formalized manner suitable for communication, interpretation or processing. It further defines Aeronautical Information as information resulting from the assembly, analysis and formatting of Aeronautical Data. The management of Aeronautical Information and Data became a key part in SESAR and NextGen.

The additional requirements pertinent to IPS are TBD.

# 4.0 IPS ARCHITECTURES

## 4.1 Introduction

This section presents general IPS architecture considerations forming an architectural framework to discuss interoperability goals necessary for NextGen and SESAR. The level of impact to existing avionics is dictated by the generation of aircraft in a given fleet.

The allocation of the data communications functions to the avionics systems is, to some extent, similar on most of the aircraft types of the same generation. Over the years, airlines have come to accept a variety of airframe manufacturers' philosophies. This includes differences in terms of avionics architecture. Also, different updates have occurred during the life of certain aircraft, and this has resulted in a large variance in avionics architectures implemented today on aircraft in production and on aircraft in service.

Figure 4-1 describes a possible IPS architecture.

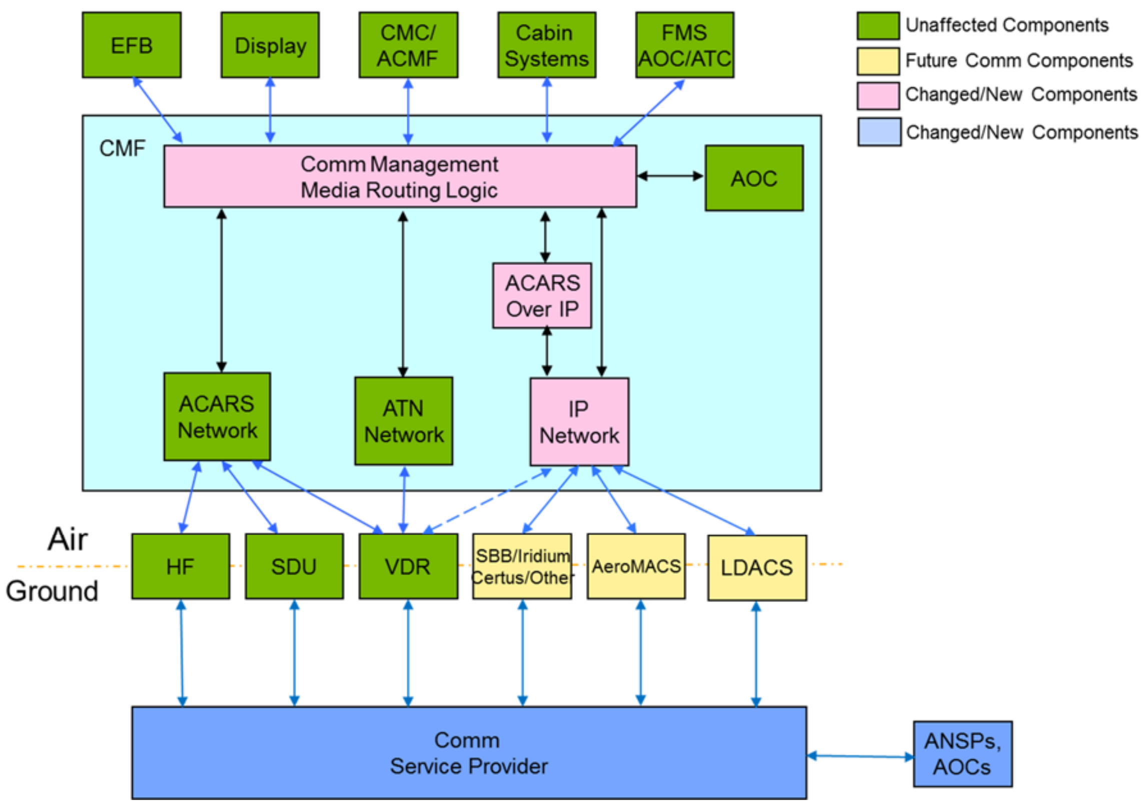


**Figure 4-1 –**

This document describes the general impact of the NextGen/SESAR concepts on the aircraft functions that support data comm services. The reference architectures provide a framework for discussing the impacts and the needs for standardization. It should be understood that each operator will need to evaluate their own fleet in the context of the reference architectures to understand the impact for their particular fleet.

# 4.0 IPS ARCHITECTURES

This section will describe the aircraft architectures using the following themes:

- IPS integration in different types of airborne avionics, ARINC 429 based, ARINC 664 based, and others
- Interfaces with the applications, with the radios, with the other systems
- Impact of information security requirements
- Multi-link considerations and the number of protocol stacks required
- Possible co-existence with ACARS and ATN/OSI datalinks
- Retrofit versus forward fit considerations
- Design Assurance level
- Security Assurance level

## 4.2 Avionics Architecture – 2000's

During the 2000's, required time of arrival, HF and Satcom datalink, 0.15 RNP approach and CAT 1 GPS approach capability emerge along with a more flexible display system and ARINC 750 VHF data radios. The Electronic Flight Bag (EFB) was developed to provide additional, supplementary data to the flight crew with a wide variety of applications ranging from aircraft-related documents to airport moving maps.

Initial ATS datalink (FANS 1/A) capability was expanded to include more aircraft. Once again, aircraft of this vintage likely have a mix of this capability, since emergence of this capability was scattered throughout the 2000's. Further, earlier designed airplanes produced during this time period may have some of this capability as well because these airplanes and systems evolved as technology emerged. Systems such as ATSU and functions such as RNP AR and RTA were brought into the earlier designed airplanes as standard equipment. Therefore, operators may have a wide variety of equipment/capability within a fleet simply due to varying production dates for each airplane type.

Many of these airplanes can support full RNP operations and are provisioned for RTA operations. Though initial FANS 1/A datalink capability was implemented on many airplanes, this capability does not support the European ATS datalink mandate nor does it support the emerging ATS datalink requirements. The first implementations of final approach traffic merging and spacing based on ADS-B emerged as limited local operations using retrofit equipage. By the end of the decade most production airplanes are equipped for ADS-B out equipment, though this equipage will not comply with European or US mandates.

## 4.3 Avionics Architecture – 2010's

During the 2010's, avionics architectures are characterized by broader use of Integrated Modular Avionics (IMA), including high speed networks connecting the IMA elements and other subsystems. These architectures enable greater information sharing between functions. Another characteristic is the introduction of flexible, interactive displays that allow user interface accommodation for new capabilities without major impact to the display system.

Aircraft of this decade are equipped with FANS 1/A and ATN datalink baseline 1 (Link 2000+). Later in the decade, ATN datalink baseline 2 will be implemented enabling 4D trajectory operations and datalink of taxi instructions/clearance. 4D trajectory operations utilize RTA capability to time metered terminal area traffic merging and sequencing. Surface guidance capability will emerge to utilize taxi routing to provide guidance and alerting to the crew to enhance the safety of surface operations. ADS-B mandates are driving transponder and possibly Satellite augmented GNSS equipage in all forward production airplanes and existing fleets. Tactical traffic spacing will utilize ADS-B capability to dynamically enhance traffic separation. Some of the early EFB applications (e.g., airport moving maps) have moved into the forward-field-of-view display systems. With the implementation of Commercial Off The Shelf (COTS) wireless capability, the EFB continues to be a rapidly evolving capability that should be considered when evaluating NextGen/SESAR architectures.

The primary datalink equipage focus for this generation are:

- Flight Management Functions
- Possible addition/enhancement of airport surface operations such as taxi clearance via datalink
- Datalink function (e.g., CMU/ATSU)
- EFB interface (e.g., airport moving map with taxi guidance uplink)
- Airborne information management

Display and control solutions have the capability to further evolve to manage the crew interface requirements associated with the NextGen/SESAR capability.

## 4.4 Integration of IPS in ARINC 429 Avionics Architectures

This section TBD.

## 4.5 Integration of IPS in ARINC 664 Avionics Architectures

This section TBD.

## 4.6 Work to be Done – 2020 and Beyond

As a result of IPS architecture discussions and the material presented in Figure 4-1 several tasks were identified for completion. These include the definition of:

- IPS Communication Management Routing Logic
- ACARS/IPS Profile
- IPS Subnetwork Profiles
- Dialog Services
- Network Services
- Ground Gateway
- Others (TBD)

## 4.7 Overall Architecture - End State

- Ground Systems Impact

# 5.0 DEPLOYMENT ROADMAPS

## 5.1 Introduction

The introduction of the Internet Protocol Suite (IPS) for Aeronautical Safety Services is expected to have broad and long-lasting impact on aviation. This section summarizes typical deployments in the context of the NextGen Implementation Plan and the SESAR Master Plan.

Datalink equipage may be required by mandate or it may be required by incentive (i.e., failure to equip may be punitive to the airlines).

Table 5-1 provides a high level summary of the data comm mandates expected to be in effect in the 2020 timeframe. Airplanes operating in the identified regions will be required to have the designated capabilities. The specific functional requirements for the mandated capabilities may vary in each region, hence it is important for airspace users to consult with the applicable civil aviation authority for the specific equipment and operational requirements. The regional variations for each mandate are as follows:

**ATN CPDLC:** The European Link 2000+ datalink services mandate requires ATN Baseline 1 message set over VDL Mode 2.

**FANS 1/A:** The FANS mandate applies initially to certain flight levels in the North Atlantic Track System (NATS); however, the mandate region is expected to expand to include the entire NATS Organized Track System by 2015.

**Satcom Voice:** China is mandating Satcom equipage in phases beginning in 2013 with full capability by 2017 for Chinese registered aircraft.

**Table 5-1 – Data Comm Mandates by Region**

| | **Region** | | | |
|---|---|---|---|---|
| Mandate | Europe | USA | China | Oceanic |
| ATN CPDLC | √ | | | |
| FANS 1/A | | | | √ |
| Satcom Voice | | | √ | |

## 5.2 ATS Datalink

Air Traffic Systems (ATS) datalink is a component essential to several Air Traffic functions including management of traffic on the ground and in the air. This includes 4D navigation. The long-term approach is to migrate current capabilities, FANS 1/A, and ATN B1 to ATN B2. There are master schedules from NextGen, SESAR, and the ICAO GANIS which generally agree that this migration will start in 2014 with publication of design guidelines.

It will be necessary to integrate a Communications Management Function (CMF) and VDLM2 and Satcom datalink radios in the aircraft to support ATN B1, FANS 1/A (and 1/A+) and growth to ATN B2. The installation of Satcom datalink and possibly HFDL will be needed to support efficient operations in Oceanic and remote airspace. It may be appropriate to select a CMF and radios that satisfy both FANS 1/A+ and ATN B1 (FANS-2B) or ATN B2 (FANS-2/C).

These installations may already have a minimum of FANS 1/A and AOC capability with VDLM2, Satcom datalink, and possibly HFDL. The Satcom radios will require an update to support the Inmarsat SwiftBroadBand or Iridium NEXT formats as the older formats are discontinued or judged to be inadequate. It may be determined that the efficient operations in Europe will require integration of ATN B1. It may be appropriate to select a CMF and radios that satisfy both FANS 1/A+ and ATN B1 or ATN B2.

This generation may have FANS 1/A (or 1/A+) and ATN B1 with VDLM2, Satcom datalink, and possibly HFDL. The Satcom radios will require an update to support the Inmarsat SwiftBroadBand or Iridium NEXT formats as the older formats are discontinued or judged to be inadequate. It may be appropriate to select a CMF or CMF upgrade and radios that satisfy both FANS 1/A+ and ATN B1 (FANS-2B) or ATN B2 (FANS-2/C).

### 5.2.1 NextGen/SESAR Concept Description

Both the NextGen and the Master Plans identify paths to future ATS data communications. The performance-based European ATM system, as defined in the European ATM Master Plan, foresees greater integration and optimum exploitation of the aircraft. NextGen Implementation Plan emphasizes changes that improve safety and efficiency.

The SESAR work plan 9 (WP9 aircraft) addresses aircraft systems. Project WP9.33, Datalink Operational Improvements, applies to ATS data communications avionics. The objectives relative to datalink are:

1. To develop and validate at aircraft level all airborne functions identified in the European ATM Master Plan aircraft Capabilities Levels 2, 3, and 4.
2. To ensure operational and functional consistency across stakeholder airborne segments (Commercial Aircraft, Business Aviation, General Aviation, Military Aircraft, UAS, etc.)
3. To identify technical solutions for different airborne platform types such as mainline aircraft, Regional aircraft, and Business Jets
4. To make proposals and provide inputs to update the European ATM Master Plan

The NextGen plan for data communications, as given in the NextGen Implementation Plan for 2012, calls for two initial segments:

- Segment Alpha: 2010-2015
  - Tower services to enable PDC and ODC using FANS 1/A or FANS 1/A+ to provide the basic capabilities for controllers and flight crews to transfer ATC clearances, requests, instructions, notifications, voice frequency communications transfers and flight crew reports as a supplement to voice communications
  - ATN B1 will not be supported in the US NAS
- Segment Bravo: 2016-2018
  - The details planned for this segment are not final as of 2012

The vision for 2025 and beyond is that data communications is the key for moving from the current voice system to a predominately digital textual mode of communication. Data communications enables more efficient operations, faster revised clearances, trajectory-based routing, optimized profile descents, and automation of routine tasks to improve controller and flight crew productivity. Data communications reduce communication errors, taxi time, fuel use and greenhouse gas emissions, ground delays and operational costs.

### 5.2.2 High Level Requirements for Avionics

Required equipage includes:

**Table 5-2 – ATS Communications Functions**

| Avionics Function | Where and When | Reference Document | Comment |
|---|---|---|---|
| FANS 1/A<br>FANS 1/A+ | RNP 4 Oceanic Routes<br>2012 and beyond | 14 CFR part 121 appendix G<br>ICAO Doc 9750<br>ICAO Doc 7030/4 | The number of oceanic RNP 4 routes supporting 30x30nmi separations will increase significantly |
| Link 2000+ / FANS 1/A | Above FL285 – Current<br>Core Europe – 2015<br>European Union – 2018 | European Commission Regulation # 29/2009 | State aircraft including military aircraft are excluded. Some European ground facilities will only equip for ATN B1 (and ATN B2) |
| ATN B2 | | Document development subject to funding | Concentration on B2 will occur starting in 2014. |

Specific requirements for ATS Datalink are use of RNP-4 oceanic tracks requiring FANS 1/A and the European requirement to equip with either ATN B1 or FANS 1/A. Oceanic operation with 30 nmi x 30 nmi separations requires FANS 1/A. The number of RNP-4 oceanic tracks is increasing making FANS 1/A essential to efficient operations. The current FAA plans for FANS 1/A+ may evolve into a requirement. The dual equipage to support FANS 1/A and ATN B1 will be a decision by the airline. Aircraft that fly exclusively in Europe may equip only with ATN B1. Those with frequent oceanic operation will need FANS 1/A. The European Union exclusion of FANS 1/A equipped aircraft from the ATN B1 requirement allows aircraft to equip with either technology in Europe.

The requirements for ATN B2 and the corresponding FANS variants are identified. State funding will be needed to establish the rules and regulatory documents. Equipage of aircraft will follow based on need. The general approach of “best equipped, best served" may be taken versus equipage mandates. In this case, equipage will be a decision by the airline.

### 5.2.3 High Level Functional Break-Down

The equipment necessary to communicate include HF, VHF, and Satcom systems. The preferential use of a particular communications technology includes consideration of development cost, installation cost, operational costs, and maintenance costs. The router coordinates sending and receiving messages. The router is commonly referred to as the Communications Management Unit (CMU). The host equipment, typically the FMS or ATSU, provides the applications and services.

Figure 5-1 shows the general timeline for ATS data communications. This figure, together with Figure 2-6 from the NextGen program, leads to the following findings:

1. HOST: Software updates will be adequate (except in some older equipment) to the application and services host to maintain currency as the ATS Datalink evolves. Flight Management System/Management Control Processor/Flight Control Processor (FMS/MCP/FCU) will have to be updated to support some applications or services like D-TAXI or 4D navigation in the mid to late 2020's. Again, software upgrades will be adequate in most cases. Displays and Human Interface technologies will also be affected. Technology growth paths are:
    a. FANS 1/A, FANS 1/A+, or ATN B1 will be essential for operation in Europe from 2017 and beyond. Since not all European facilities will be dual equipped, ATN B1 capability will be important for European operations based on the "best equipped, best served" policy.
    b. ACARS based on VDL M0/A will continue to be used. Aircraft not flying in Europe and do not need to take advantage of reduced separation in remote and oceanic regions, may continue to depend on this technology through 2023 and beyond.
    c. FANS 1/A or FANS 1/A+ are needed to take advantage of reduced separation routing in remote or oceanic areas. This will be adequate until the mid-2020 decade when ATN B2 will become useful.
    d. The dual stack equipage of aircraft to accommodate both FANS 1/A or FANS 1/A+ and ATN B1 is based on the operational value to the aircraft in Europe and on remote or oceanic routes. Following the NextGen terminology, the FANS 1 (FANS 1/A+ and ATN B1 supported independently) requires the pilot to manually switch between the two technologies based on location. FANS 2/B (integrated FANS 1/A+ and ATN B1) provides automatic switching between technologies.
    e. Accommodation of B2 will be a consideration as EASA and the FAA establish guidelines for designing and certifying capability. These initial documents are expected in 2012, subject to funding. There is no notable activity by regulatory agencies on B2 (ATN B2 or FANS 3/C) mandates for equipage. The "best equipped, best served" policy is the likely path versus mandates.
2. Router/CMU: In all but the case of older equipment, software upgrade is all that is necessary.

5.0 DEPLOYMENT ROADMAPS

3. Impact on the radios: The retirement of some satellites and introduction of new satellites will impact equipage.
   a. VDLM0/A and VDLM2 radios are stable technology and no changes are anticipated. If additional VDLM2 frequencies are introduced, then it may be desirable to take advantage of these new frequencies. In that case, a modification to the VDLM2 radio will be necessary.
   b. HFDL should not be affected. The antenna size and the limitation of HFDL to standard separation functions may mitigate against continued use. Iridium or Iridium NEXT are alternatives with worldwide coverage.
   c. Inmarsat constellations I2 and I3 will reach end of life (sunset) around 2018. As that date approaches it will be necessary to consider alternatives like SwiftBroadBand, Iridium, or Iridium NEXT. Antenna and radio change will be necessary, depending on the alternatives selected.
4. GNSS: A GNSS is necessary to support the all functions except ACARS over FANS 1/A. Because of the ADS-B mandates internationally, GNSS equipage will be necessary and no special equipage for ATS Datalink is necessary.

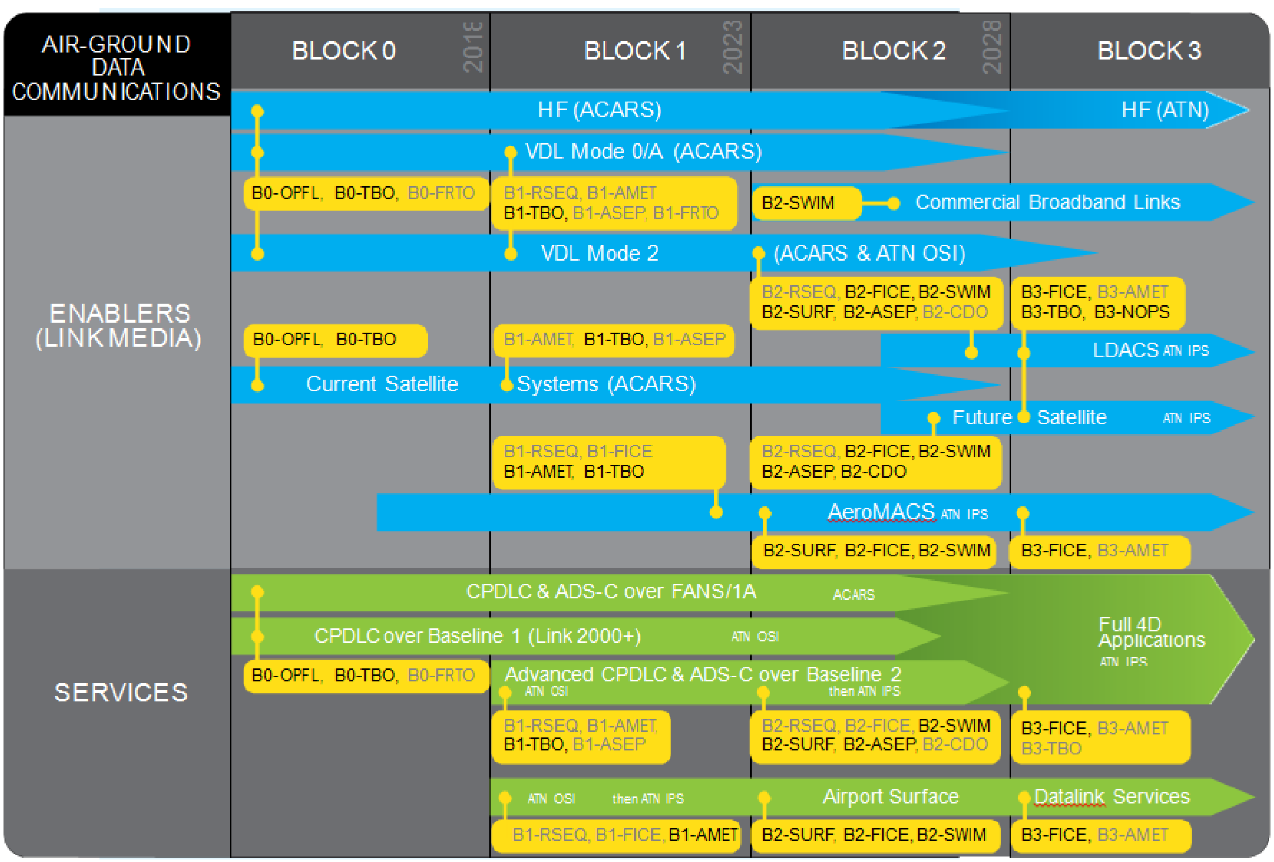


**Figure 5-1 – ICAO GANIS Plan for Data Communications**

### 5.2.4 Communication Management

The Communication Management function will require evolution primarily to support the Initial 4D (I4D) trajectory capability.

An ATC datalink capability will be necessary to exchange clearances for the I4D, ADTRAD operation, including 3D trajectory and time constraint uplink from ATC.

ADS-C will need to be expanded to new contracts for the downlink of Extended Projected Profile and ETA min/max reports.

Also, AOC will require to be modified to request and receive new and more accurate MET data.

## 5.3 Deployment Use Cases

### 5.3.1 CPDLC

Controller Pilot Data Link Communication (CPDLC) is an application that provides air-ground data communication to the ATC service. This includes a set of clearance/information/request message elements which correspond to voice phraseology employed by air traffic control procedures.

Capabilities may extend to taxi route clearances with the appropriate CPDLC messages used for ground operations (e.g., digital taxi clearances). This not only involves the airborne side, but it also requires the ground to provide such capability.

Additionally, the CMU/ATSU will be used for Ground TBO exchanges between the Ground ATC and the aircraft.

The role of IPS services in CPDLC is TBD.

### 5.3.2 Weather Awareness

#### 5.3.2.1 NextGen/SESAR Concept Description

**NextGen:** The FAA is planning Common Support Services–Weather (CSS-Wx) to provide the FAA and United States National Airspace System (NAS) users with same-time access to a unified aviation weather picture via the System Wide Information Management network. The CSS-Wx will publish standardized weather information provided by the NextGen Weather Processor, the National Oceanic and Atmospheric Administration’s (NOAA) Four-Dimensional Weather Cube and other weather sources. This will enable collaborative and dynamic decision making among all users of the NAS, and give them the flexibility to proactively plan and execute aviation operations ahead of weather impacts.

**SESAR:** “Accurate and timely meteorological information incorporated as an integrated component to the system to support all phases of flight will be provided to the new ATM management. Such information shall be used to determine the optimum route/trajectory for an individual flight or series of flights in all planning phases, and for the execution of a flight. It is expected that the importance of meteorological information for ATM will grow in the next 10 to 15 years; meteorological information from a range of sources (including aircraft) will be integrated with other data to facilitate trajectory based planning and operations. MET must be provided in an open and interoperable form and incorporated into decision making systems and processes including the development and agreement of contingency plans to mitigate the worst effects of weather.”

"The information will be derived from a variety of (traditional) sources including the increasing use of remote sensing systems and aircraft derived data based on Global Navigation Satellite System (GNSS). With enhanced digital communications services, the provision of MET information will encompass ground-based and potentially airborne automation systems and human users." See **SESAR Definition Phase:** *The Concepts of Operations at a Glance, SESAR Consortium*.

In both SESAR and NextGen airspace, the airplane is expected to share weather information with the ground to support better weather information consistency amongst all stakeholders in flight planning and execution. This will mean more weather information provided by the airplane to the ground and conversely, additional strategic weather information provided to the airplane from the ground.

SESAR Work Package 9 Aircraft Systems contains two projects related to weather awareness:

- WP 9.30 Weather Hazards/Wake Vortex Sensor
- WP 9.48 AIS/MET Services & Data Distribution

#### 5.3.2.2 High Level Requirements for Avionics

For weather awareness, the avionics will need to support the following requirements:

- Sense real time precipitation and other weather threats proximate to the aircraft
- Sense other metrological data such as temperature, pressure, and winds
- Provide weather indications and alerts to the flight crew
- Provide weather information to the ground
- Receive, process, and display uplink weather

#### 5.3.2.3 High Level Functional Breakdown

The on-board weather sensors include the weather radar and air data sensors. The on-board sensors provide real time weather data to the flight crew via the cockpit display system, including weather precipitation and threats. Weather alerts, such as predictive windshear, are provided to the crew alerting system. The on-board weather sensors also provide downlink weather information to the datalink communications system for transmittal to the ground.

Uplink weather information from the ground is provided to the flight crew via the datalink communications system and the cockpit display system.

The role of IPS services in weather awareness is TBD.

### 5.3.3 Trajectory Based Operations (TBO)

This section addresses TBO as foreseen at the time of this writing by the NextGen and SESAR programs.

#### 5.3.3.1 NextGen Concept

The TBO concept of operation represents a shift from the communications and workload intensive aspects of ATC tactical clearances e.g., vectors, altitudes, holds, etc., to trajectory-based control. Aircraft will fly negotiated trajectories and air traffic control will become trajectory management. The roles of pilots/controllers will evolve due to the increase in automation support. The focus of TBO is primarily enroute cruise. ATC manages trajectories at the local level in support of plans developed by capacity management and flow contingency management, including adjusting trajectories to sequence traffic.

The NextGen “Initial TBO” solution set includes operational improvements that focus on enroute applications during the near-term and mid-term. These improvements include In-trail separation, ADS-B separation, oceanic climb/descent, flexible entry times for oceanic tracks, and increased use of RNP and RNAV routes. The mid-term will also include trajectories that transition from RNP or RNAV to an ILS final approach. NextGen far-term operational improvements will include TBO for all phases of flight and will include the gate-to-gate TBO concept.

Aircraft technologies include RNAV, RNP, ADS-C, ADS-B (Out and In), voice and data communication, and on-board conflict detection and alerting. The role of voice communication will diminish as datalink becomes more predominant in the far-term.

Additional information about TBO can be found in the respective segments of the National Airspace System Enterprise Architecture (NAS EA).

#### 5.3.3.2 SESAR Concept

SESAR concept is defined in B.04.02: SESAR Trajectory Management Document.

“This document provides a high level description of Trajectory Management (TM) in SESAR with the purpose to bring about a better understanding of Trajectory Management focusing in concept story board step 1. It aims to describe the high level aspects of TM, relating them to the SESAR Story Board steps and their target times.”

SESAR Step 1 includes Initial 4D trajectory: “The following extract can be made regarding TBO during the flight phase.

Specialized glossary terms used in this section:

- TMR: Trajectory Management Requirement
- NOP: Network Operations Plan
- EPP: Extended Projected Profile
- RBT/SBT: Required/Shared Business Trajectory
- RMT/SMT: Required/Shared Mission Trajectory

At AMAN horizon, before TOD, the Flight crew prepares the descent and logs on Flight Information Services to get the last up to date parameters using e.g., D-OTIS (runway in use, QNH, weather warning, NOTAM, etc.) and he requests the last up to date winds and temperatures on the arrival profile.

Before beginning the descent (to avoid busy approach phases), the Flight crew agrees with ATC on the runway exit and receives the taxi route information via datalink (e.g., CPDLC). After updating wind/temperature data in the aircraft system, the 3D profile may now be deviating from the previously shared profile more than the delta pre-defined by ATC (TMR). The downlink of the trajectory predictions computed onboard is therefore automatically triggered to update the NOP (e.g., ADS-C EPP).

Taking into account the ETA min/max report automatically provided by the aircraft system on ATC request specifying the metering point, the Arrival Management (AMAN) system calculates a CTA based on the position of the aircraft in the current optimized sequence. Additionally, the AMAN computes a prediction of the modified trajectory, should the CTA be implemented. Through SWIM, all concerned Air Traffic Service Units (ATSU) are made aware of the potential effect in their airspace. Once coordinated with them the CTA is transmitted to the Flight Crew who loads the CTA within the aircraft system to check its feasibility using the RTA function and if acceptable, activates the resulting trajectory onboard leading to a revision followed by an automatic update of the RBT shared through datalink and SWIM to the NOP. Consecutively to CTA allocation, the Flight crew confirms the runway exit previously agreed.

Just before Top of Descent, the Flight crew requests clearance to start descent and flies the descent profile of the RBT which ideally is a Continuous Descent Approach based upon the most optimum engine and aircraft control surface settings possible integrating the CTA. The aircraft system continuously monitors the compliance to the RBT, providing speed adjustments to meet the CTA with the required precision.

To synchronize all inbound flights, the ATM Ground system at the destination airport builds and tactically updates a common sequence of arrivals and departures integrating data from all relevant RBT/SBT, RMT/SMT and taking into account airport configuration, taxi route and other constraints.

The arrival sequence is constructed by the AMAN through the allocation of CTA (absolute time) to ensure the synchronization of the traffic converging to the merge initiation point (on IAF). The Controller monitors the converging traffic and takes action if needed to ensure separation. Before reaching the merge initiation point and within ADS-B range of the preceding aircraft (target aircraft), the Flight crew initiates the ASAS Sequencing & Merging function. The Controller advises the Flight crew of the relative position of the target aircraft and sends the ATC instruction to allow the Flight crew to identify the target aircraft on the cockpit display. The Flight crew confirms the identification to the Controller. The Flight crew then receives the ATC instruction for the Sequencing and Merging maneuver (e.g., Merge behind with the required spacing defined in time versus the target aircraft) and loads the data within the aircraft system and uses the ASPA-FIM application.

The Controller, with tool support, monitors the flow of traffic ready to take action should any of the aircraft have problem maintaining the ASAS procedure. The Flight crew executes the ASAS maneuver until the controller requests the Flight crew to stop the maneuver, e.g., at least before the final approach fix.

The Flight crew then receives instructions for the final approach. The controller may instruct aircraft to maintain visual separation to the preceding aircraft during the final approach. The Flight crew flies the approach while maintaining visual separation from the target aircraft. The CDTI helps the flight crew to more accurately and efficiently monitor the distance between the two aircraft." (SESAR Trajectory Management Document)

Step 1 of Trajectory Based Operations considers the current capabilities of the Flight Management System to manage one CTA. It is expected that Step 2 (to be defined), will no longer consider this constraint. It is assumed that the aircraft will be able to manage several CTA in series.

The long-term concept of 4D Trajectory Management is not yet clearly defined in SESAR or NextGen programs and therefore will not be addressed in the following sections.

However, the short to medium-term concepts are defined in SESAR as Initial 4D trajectory “I4D”, and by RTCA as “4DTRAD.” Their definitions are very similar and based on the negotiation between ATC and the aircraft for a flight trajectory, including one (1) time constraint at a waypoint in the trajectory. The following sections provide information on the I4D/4DTRAD concepts and their impact on the aircraft avionics systems.

### 5.3.4 System Wide Information Management (SWIM)

#### 5.3.4.1 NextGen/SESAR Concept Description

SWIM as paradigm change in the information sharing enables the concept of net-centric ATM operation. In the ATM network, almost every participant is a producer as well as a consumer of information. It is not ideal to decide in advance who will need what information, obtained from whom and when. SWIM decouples producers of information from the possible consumers in such a way that the number and nature of the consumers can evolve over time. Information sharing is enabled by a service oriented approach to SWIM where interoperable services can be used in a flexible way within multiple separate systems from several business domains.

Given the transversal nature of SWIM, which is to go across all ATM systems, data domains, business trajectory phases and the wide range of ATM stakeholders, it is not expected that one solution and certainly not one single technology fits all. Nevertheless, it is recognized that global interoperability through standardization is essential.

SWIM concept presents some differences in the NextGen and SESAR approaches.

**NextGen**

SWIM is anticipated to facilitate greater sharing of airspace user and Air Traffic Management (ATM) system information, such as airport operational status, navigation system status, notices to airmen, weather information, flight data, status of special use airspace, and Temporary Flight Restrictions.

SWIM is intended to typically use commercial off-the-shelf hardware and software to support a loosely coupled service-oriented architecture that allows for easier addition of new systems and connections. However, it is expected to require some customization of hardware and software for system adapters.

The architecture will establish, publish and retrieve structures for the warehousing of information that is expected to be available to a variety of air and ground users. SWIM is anticipated to be evolutionary and will support current and evolving airspace programs by providing flexible and secure information management architecture for sharing all available information. Complementary information management architecture with similar requirements to SWIM can be advantageous when developed on the airborne side (see Section 4.6)

NextGen recognizes that aircraft currently have limited access to NAS information and services from a number of issues such as no consolidated data source for information, no dedicated ground-to-air channel for pilots to obtain and share information, and the over-reliance of voice-only communications. In an effort to remedy this, the FAA believes that Aircraft Access to SWIM (AAtS) can alleviate these constraints by utilizing a digital link between the services and information provided within SWIM and the aircraft, allowing users (e.g., pilots, AOC, WOC, ANSP) to make dynamic and strategic decisions.

**5.0 DEPLOYMENT ROADMAPS**

Within the NextGen framework, communications between aircraft is accomplished via three major data exchange systems: DataComm, ADS-B, and AAtS. DataComm and ADS-B are primarily responsible for the trajectory management, whereas AAtS will only support these operations by providing decision support information and is not intended to carry direct trajectory and flight critical data.

It is anticipated that this capability will be via non-specified (e.g., customer preferred) datalink, similar to the way information is shared within the ground-based infrastructure today. This ensures that the aircraft systems and the pilots are part of the information gathering and sharing structures.

Figure 5-2 shows a notional architecture for the aircraft access to the SWIM network. SWIM information is expected to pass through the NAS Enterprise Security Gateway (NESG) to the operator. The information can also be provided to a value added service provider who has the requisite network connection and functional interface to SWIM to consume NAS Services on behalf of the aircraft operator. The information can be sent to aircraft in a broadcast one-way transmission, or it could be via a connected exchange service to support bi-directional communication, and thus allowing the aircraft to provide its information back to SWIM for consumption by authorized ground users (i.e., AOC).

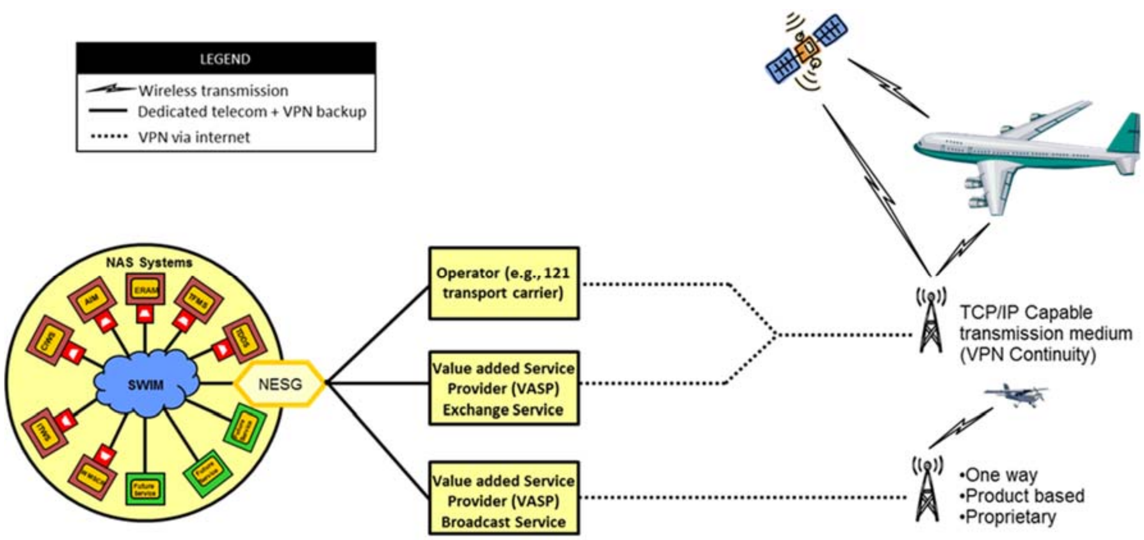


**Figure 5-2 – AAtS Notional Architecture**

There may be differences in how SWIM supports the various operational concepts. These differences will be driven by overall performance of the system in terms of publish and retrieve timing, information latency, communications network performance, etc. This will have an impact on how the planning and near real-time situational awareness is recognized. In addition, the overall network capability will also be dependent upon the timing of the phased rollout described within the National Airspace System Enterprise Architecture Infrastructure Roadmap (*https://nasea.faa.gov* ).

Because of the wide diversity of users desiring access to SWIM there has been collaboration with Communities of Interest (COIs), groups of stakeholders that collectively possess the expertise to accurately describe how information is currently used in the planning and operation of the airspace. COIs currently include Aeronautical Information Management (AIM), Flight and Flow Management (F&FM)

(e.g., the flight object), and Weather; others will form as needed over time. The initial COIs have identified several capabilities to be included in the initial implementation of SWIM. These include:

- AIM
  - Special Use Airspace (SUA) Automated Data Exchange
- Weather
  - Corridor Integrated Weather System (CIWS) Publication
  - Integrated Terminal Weather System (ITWS) Publication
  - Pilot Report (PIREP) Data Publication
- Flight and Flow Management
  - Flight Data Publication
  - Terminal Data Distribution
  - Flow Information Publication
  - Runway Visual Range (RVR) Publication
  - Reroute Data Exchange

The introduction of SWIM is also intended to allow ground systems to develop and evolve at a higher pace. Though, usually major operational benefits can only be achieved in conjunction with the aircraft, i.e., changes on the ground often require additional information exchange with and integration on the airborne side. Using a similar approach on the airborne side and on the ground side will allow avionics to evolve concurrently with ground systems.

### SESAR

The concept of SWIM covers a complete change in paradigm of how information is managed along its full lifecycle and across the whole European ATM system. Its implementation enables direct ATM business benefits to be generated by ensuring the provision of commonly understood quality information delivered to the right user at the right time and at the right place.

Ultimate step of SESAR aims at implementing the performance-based concept of operations supported by an advanced implementation of SWIM enabling timely and secured exchange of information between the actors concerned (timeframe 2021-2025).

Figure 5-3 describes the Air-ground SWIM capability. The aircraft is a peer node of the net-centric EATM SWIM network, to support SWIM operational aspects.

## 5.0 DEPLOYMENT ROADMAPS

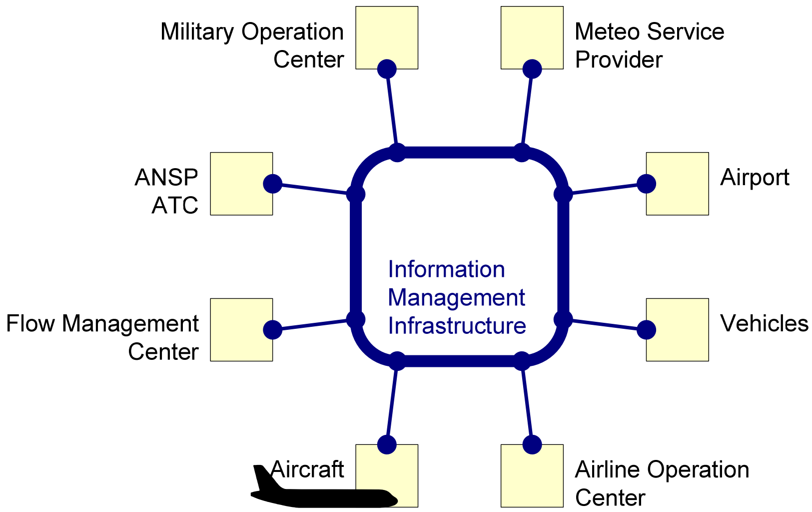


**Figure 5-3 – Aircraft as a SWIM Node**

The SWIM concept allows describing all exchanges of information between ATM actors including the Aircraft. Air-Ground SWIM services are limited to data for information (non-safety critical, e.g., aeronautical and meteorological information). Figure 5-4 shows that data for avionics (safety critical, e.g., some ATC clearances or instructions), i.e., legacy air ground datalink applications (CPDLC, ADS-C) remains supported by point-to-point communication (over DATACOM) while network centric applications (AIS/MET) are supported by Air-Ground SWIM technologies (Service Oriented Architecture – Middleware).

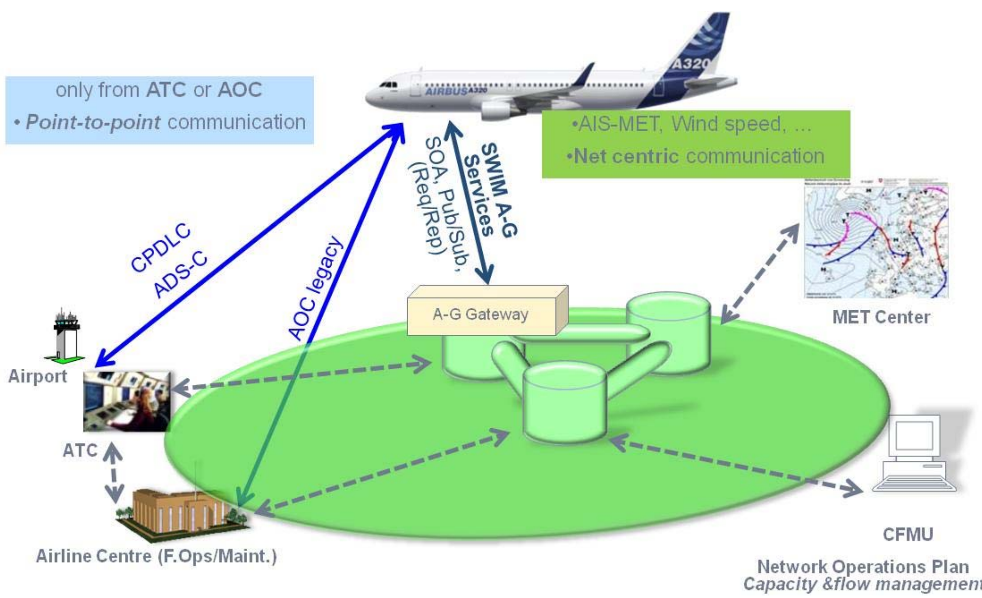


**Figure 5-4 – Aircraft Connection to SWIM**

The following table identifies what is meant by “advisory non safety critical data” and provides a list of information exchange deemed to be enabled through the air/ground SWIM infrastructure:

**Table 5-3 – SESAR Candidate Air-Ground SWIM Data**

| Information Exchange | Exchange Mode |
|---|---|
| Weather and turbulence forecasts | Aircraft requesting information |
| Traffic situation at the destination airport, including expected holdings, slot situation, or a list of connecting flights | Aircraft requesting information |
| Updated information on restricted airspace status published by ground systems | Aircraft requesting information |
| Hazardous weather information from surrounding aircraft | Aircraft requesting and distributing information |
| ATM information and advisories, e.g., Notice to Airmen (NOTAM), airport information, or departure sequence | Aircraft requesting information |
| Aircraft-sourced weather (Outside Air Temperatures (OAT), wind direction/speed, relative humidity or wind shear) | Aircraft distributing information |
| Real-time flight information | Aircraft distributing information |
| Large software/database updates to all (or selected) aircraft | AOC distributing information |
| Maintenance data from aircraft | Aircraft distributing information |

To provide a full air-ground interoperability and to limit the required on-board systems equipage, the Air-Ground SWIM capability needs to be standardized. Different levels to be considered are as follows:

- Service level
- Messaging level

The service level is directly linked to the format and content of the information itself.

At messaging level, the air/ground information management will provide reliable one-to-one, one-to-many and many-to-many exchanges made air-to-ground (downlink), ground-to-air (uplink) and air-to-ground-to-air (crosslink) using push (broadcast), publish-subscribe and request-reply (pull) patterns.

It has to be noted that the air/ground information management technology may be reused as a framework for asynchronous information exchange between aircraft applications and airline ground-based infrastructure.

The underlying protocols providing the Transport level (e.g., IP communications) are out of scope of SWIM.

### 5.3.4.2 High Level Requirements for Avionics

NextGen and SESAR SWIM concepts present significant differences at:

- Air/Ground link level
- And at Network connection level

**Air/Ground Link:**

SESAR includes the Air to Ground datalink management within the SWIM system, while FAA does not specifically include planning for datalink management as part of SWIM, but an access capability (AAtS).

**Network Connection:**

- SESAR SWIM ground architecture is expected to be implemented as a separate Service Oriented Architecture (SOA) network for each state/region with interoperability between them. Discussions are underway regarding the access point for the aircraft.
- Unlike Europe where multiple states are expected to manage their own ground systems, the FAA SWIM is closely managed in a hierarchical framework by a single functional owner (FAA). Access to the SWIM SOA data is through the NESG.

There is a need for harmonization between NextGen and SESAR in order that the aircraft implement one capability which would allow the connection with the two SWIM systems, rather than having two different capabilities to be developed and installed on-board the aircraft, in the case where the two concepts would remain very different.

### 5.3.5 Airborne Information Management

#### 5.3.5.1 NextGen/SESAR Concept Description

The ICAO describes SWIM as: “System Wide Information Management aims at integrating the ATM network in the information sense, not just in the systems sense. The fundamental change of paradigm forms the basis for the migration from the one-to-one message exchange concept of the past to the many-to-many information distribution model of the future.”

The benefits realized by SWIM in the ground infrastructure can also be realized by similar next generation architectural concepts in the airborne system. Thus, as the new concepts of ICAO, NextGen and SESAR are realized, there is the need to have an airborne information management service that aims at integrating the airborne network in the information sense. This supports the migration from the one-to-one message exchange concept of the past to the many-to-many information collection and distribution model of the future which will enable new modes of decision making as information is more easily accessed and shared on the aircraft.

#### 5.3.5.2 High Level Requirements for Avionics

This section defines the high level requirements for an airborne IMS. This contains two logical components: the Information Services (IS) which manages the access, distribution, authentication, policies, and information security; and the Data Repository (DR), which provides queries to retrieve and store the data and information. In this section, the term “information” refers to either data that is processed into intelligent information, or directly to logical groups of data elements.

#### 5.3.5.3 Information Services (IS)

Information Services (IS) provide the interface between the clients in the communications, navigation, surveillance, other domains (i.e., EFB), and the DR. One possible interface can be based on the publish/subscribe design pattern. Within the context of this document, publish and subscribe means the writing and access of information through the IS on the airborne systems.

The IS should allow configurable policy settings to determine which systems can publish information to the IS. Avionics systems which collect information that may be used by other systems on the aircraft provide information to the IS such that it can be efficiently shared.

The IS should allow configurable policy settings that identifies the systems that have access to information shared by the IS. Avionics systems which require information that is shared by the IS can obtain that information through the IS. There may be an exception if the data is time sensitive beyond the capabilities of the implementation.

The IS should provide the capability for users to subscribe to information, as well as request the information directly (request/response).

The IS should provide a registry of services. This registry will provide the services that are available to interface to the IS. The access to these services is still dependent upon the policy settings of the system

Aircraft of the 2010’s have advanced switched IP routers and network interfaces between most of the aircraft avionics and other systems. They are architected to share information via the networked function. Many of the aircraft also have some form of Network Server System (NSS) on which to store and process data and information.

In the case where an NSS type system is available, it may be possible to add functionality for this system to serve as a simple airborne Information Management System. Connecting avionics systems would need software revisions to make use of this centralized system for updating and retrieving information.

For aircraft that are being architected and designed for the latter half of the 2010’s, there is an opportunity to architect the avionics with an Airborne Information Management System as a centralized component. The specifications of the onboard server, IP router, and centralized data base server would be developed to be accessible by all networked aircraft systems. Likewise the specifications of the networked aircraft systems would be developed to provide information to and retrieve information from the Information Management System. Also, interfaces would be developed to connect the IMS to the airborne communications systems to provide and retrieve information via SWIM.

As a result, IPS services are expected to be used extensively on the airplane using domain separation concepts conceived and developed by aircraft manufacturer guidelines.

# 6.0 STANDARDIZATION ROADMAP

## 6.1 Introduction

This section identifies the Aviation Industry Standards that need to be updated and/or prepared to support the use of IPS services in the NextGen/SESAR airspace initiatives. This section describes the following:

- What shall be standardized (i.e., equipment, interfaces, protocols, performance, profiles, as applicable
- Which body shall support the standardization (AEEC, ICAO, RTCA, EUROCAE)
- When the industry standard is needed
- How the standards will be validated (if applicable)

Figure 6-1 describes how AEEC Subcommittees will interact. It also identifies the connection between AEEC, RTCA, EUROCAE, and ICAO (AEEC Executive Committee level).

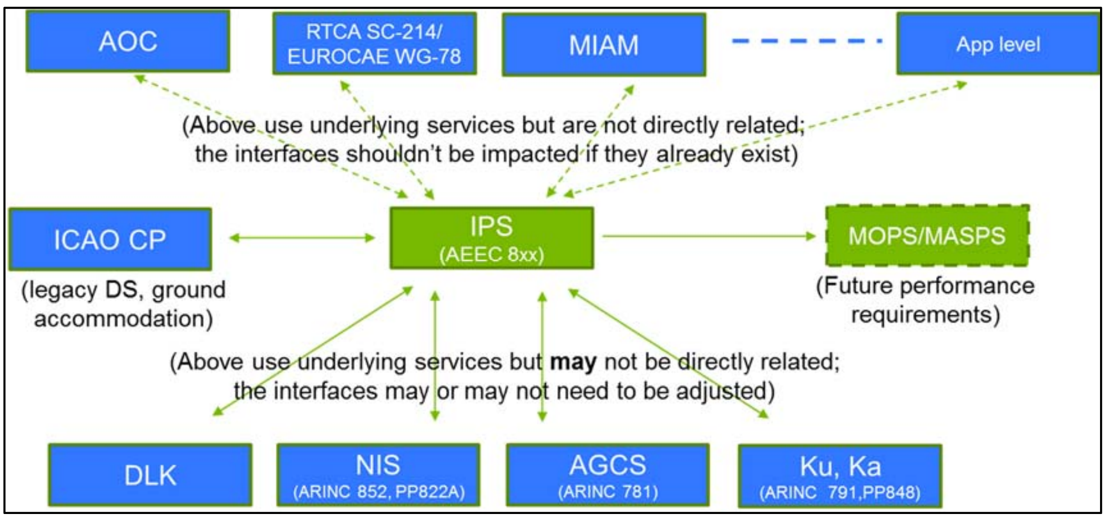


**Figure 6-1 –**

## 6.2 Notional Technology Timelines

Figure 6-2 shows the FAA roadmap for ATS Data Communications.

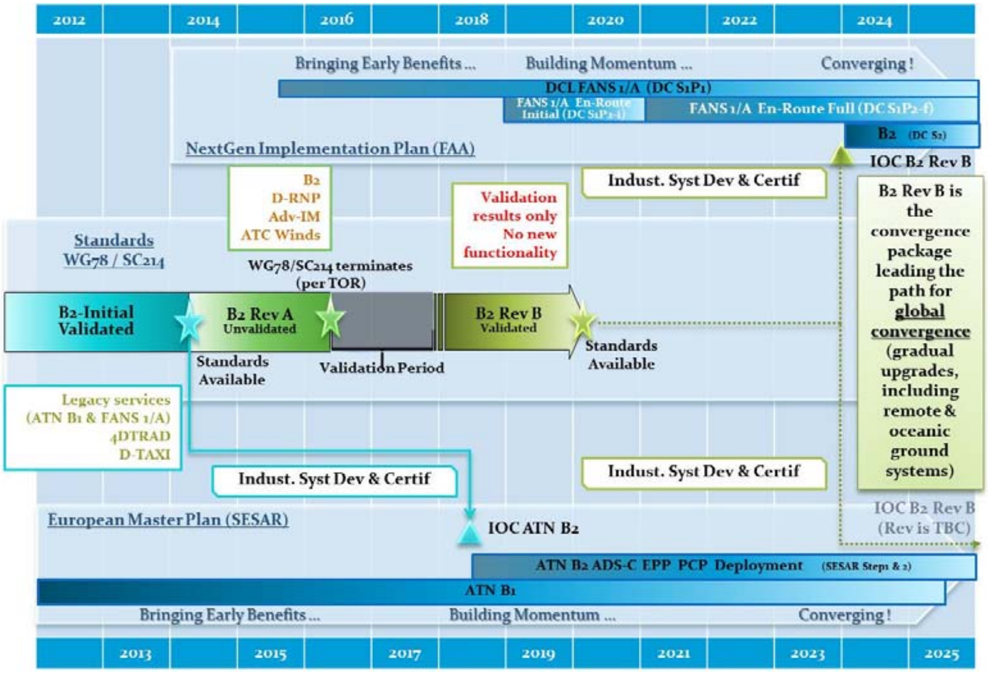


**Figure 6-2 –**

Figure 6-3 shows the Airbus roadmap for ATS Data Communications.

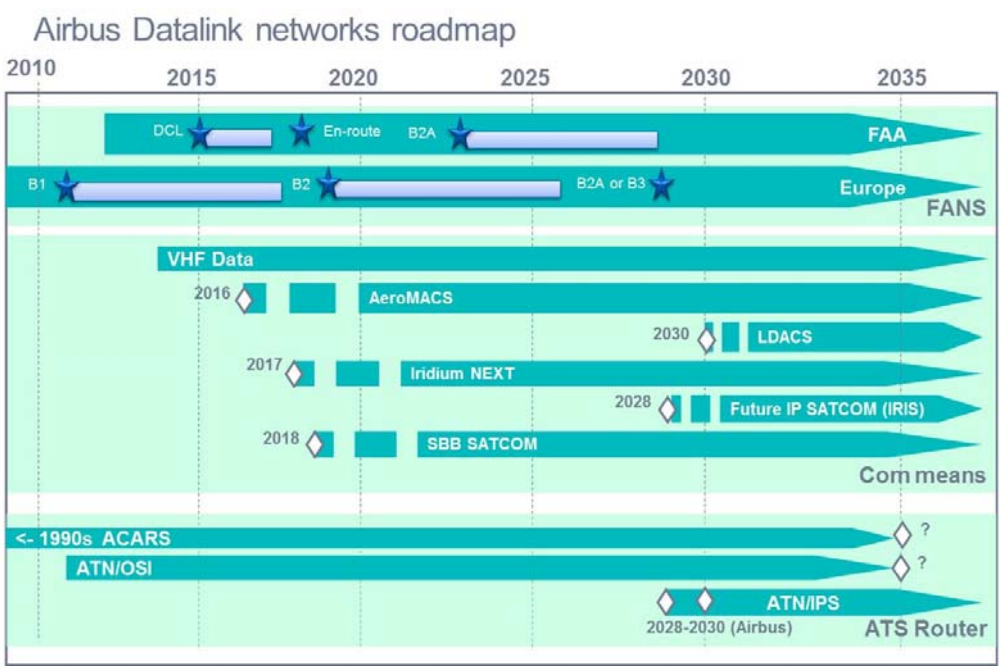


**Figure 6-3 –**

6.0 STANDARDIZATION ROADMAP

Figure 6-4 shows The Boeing roadmap for ATS Data Communications.

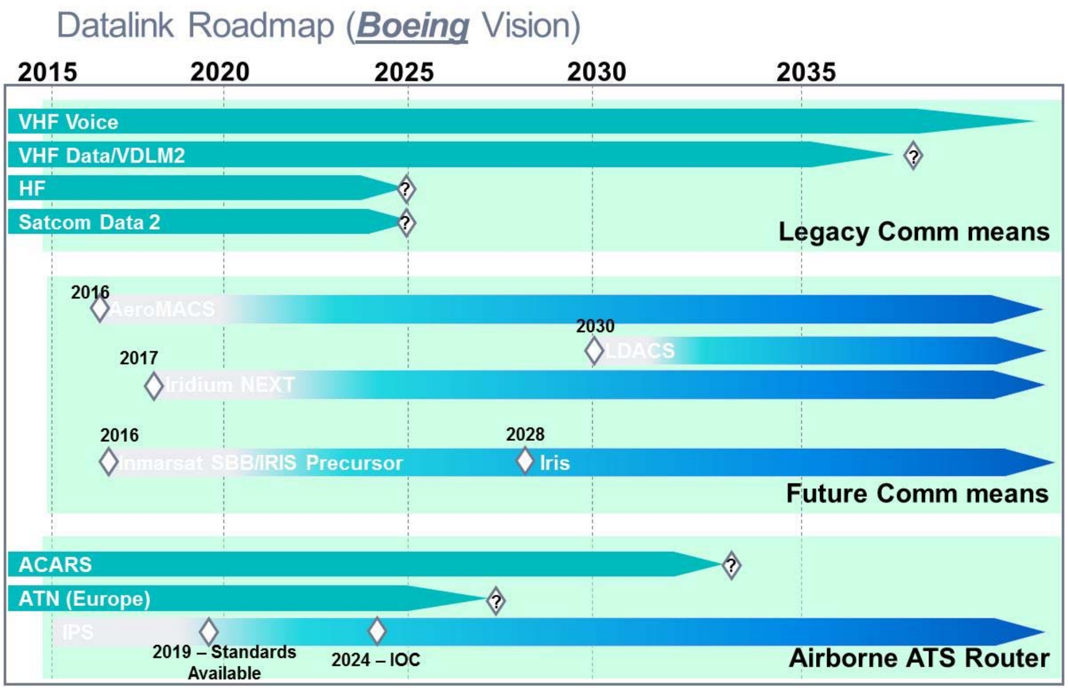


**Figure 6-4 –**

## 6.3 ARINC Standards

**ARINC Specification 618:** Air-Ground Character-Oriented Protocol

**ARINC Specification 631:** VHF Digital Link (VDL) Mode 2 Implementation Provisions

**ARINC Characteristic 702A:** Advanced Flight Management Computer System

**ARINC Characteristic 758:** Communications Management Unit (CMU) Mark 2

**ARINC Characteristic 761:** Second Generation Aviation Satellite Communication System, Aircraft Installation Provisions

**ARINC Project Paper 766:** AeroMACS Transceiver and Aircraft Installation Standards

**ARINC Project Paper 771:** Low Earth orbiting Aviation Satellite Communication System

**ARINC Characteristic 781:** Mark 3 Aviation Satellite Communication Systems

**ARINC Specification 841:** Media Independent Aircraft Messaging (MIAM)

ARINC Project Paper 858: *[pending]*

## 6.4 RTCA Standards

TBD

## 6.5 EUROCAE Standards

TBD

## 6.6 ICAO Standards and Recommended Practices

TBD

# 7.0 SUMMARY AND CONCLUSIONS

## 7.1 Introduction

This section provides conclusions and recommendations for Aviation Industry Standards activities.

More info TBD.

## 7.2 Recommendations for Future Work

- Continued industry investment
- Preparation of ARINC Project Paper 8XX: Internet Protocol Suite (IPS) for Aeronautical Safety Services
- Initial Development and Implementation
- Verification and Validation
- Deployment in TBD subnetworks
- Additional recommendations TBD

## APPENDIX A LIST OF ACRONYMS

| | |
|---|---|
| 4DT | Four Dimensional Trajectory |
| 4DTRAD | Four Dimensional Trajectory Downlink |
| AAtS | Aircraft Access to SWIM |
| ACARS | Aircraft Communications Addressing and Reporting System |
| ACD | Aircraft Control Domain |
| ACL | ATS Clearance |
| ACM | ATS Communications Management |
| ADS-C EPP | ADS-C Extended Projected Profile |
| ADTRAD | Automatic Downlink of Trajectory |
| AEEC | Airlines Electronic Engineering Committee |
| AFN | ATS Facilities Notification |
| AFTN | Aeronautical Fixed Telecommunication Network |
| AIM | Aeronautical Information Management |
| AIS/MET | Aeronautical Information Services/Meteorological |
| ANSP | Air Navigation Service Provider |
| AOA | ACARS Over AVLC |
| AOC | Airline Operational Control |
| AOR | Atlantic Ocean Region |
| ASBU | Aviation System Block Upgrade |
| ATC | Air Traffic Control |
| ATM | Air Traffic Management |
| ATN | Aeronautical Telecommunication Network |
| ATS | Air Traffic Services |
| ATSU | Air Traffic Services Unit |
| AVLC | Aviation VHF Link Control |
| BLOS | Beyond Line Of Sight |
| CADS | Centralized ADS-C System |
| CARATS | Collaborative Actions for Renovation of Air Traffic Systems (Japan) |
| CDU | Control Display Unit |
| CDM | Collaborative Decision Making |
| CDS | Cockpit Display System |
| CFR | Certified Federal Regulation |
| CFRS | Centralized Flight Management Computer Waypoint Reporting System |
| CIWS | Corridor Integrated Weather System |
| CM | Context Management |
| CMF | Communications Management Function |
| CMU | Communications Management Unit |
| CNS/ATM | Communications Navigation Surveillance/Air Traffic Management |
| COCR | Communications Operating Concept and Requirements |

**APPENDIX A**
**LIST OF ACRONYMS**

| | |
|---|---|
| COI | Communities of Interest |
| COTS | Commercial Off The Shelf |
| CPDLC | Controller Pilot Data Link Communications |
| CRT | Cathode Ray Tube |
| CSMA | Carrier Sense Multiple Access |
| CSP | Communication Service Provider |
| CSPR | Closely Spaced Parallel Runway |
| CSS-Wx | Common Support Services-Weather |
| CTA | Constrained (or controlled) Time of Arrival |
| D8PSK | Differential 8-Phase Shift Keying |
| D-ATIS | Digital Automatic Terminal Information Service |
| D-HZWX | Datalink Hazardous Weather |
| D-OTIS | Datalink Operational Terminal Information Service |
| D-TAXI | Digital TAXI |
| DCL | Departure Clearance |
| DLIC | Data Link Initiation Capability |
| DLS-IR | Data Link Services Implementing Rule |
| DM | Downlink Message |
| DoD | Department of Defense |
| DSB | Double Side Band |
| DSC | Downstream Clearance |
| DSP | Data Link Service Provider |
| EASA | European Aviation Safety Agency |
| EATM | European Air Traffic Management |
| EFB | Electronic Flight Bag |
| FAA | Federal Aviation Administration |
| FANS | Future Air Navigation System |
| FDMA | Frequency-Division Multiple-Access |
| FIM | Flight deck Interval Management |
| FIR | Flight Information Region |
| FISDL | Flight Information Service Data Link |
| FLIPCY | Flight Plan Consistency |
| FM | Flight Management |
| FMC | Flight Management Computer |
| FMF | Flight Management Function |
| FMS | Flight Management System |
| FPL | Flight Plan |
| GEO | Geostationary orbit |
| GOLD | Global Operational Data Link Document |
| HFDL | High Frequency Data Link |
| I4D | Initial Four Dimension |

**APPENDIX A**
**LIST OF ACRONYMS**

| | |
|---|---|
| ICAO | International Civil Aviation Organization |
| IFR | Instrument Flight Rules |
| IMS | Information Management Services |
| IP | Internet Protocol |
| IPS | Internet Protocol Suite |
| IS | Information Services |
| ITWS | Integrated Terminal Weather System |
| L DACS | L Band Digital Aviation Communication System |
| LOS | Line of Sight |
| MASPS | Minimum Aviation System Performance Standards |
| MCDU | Multi-purpose Control and Display Unit |
| MEO | Medium Earth Orbit |
| MET | Meteorological |
| MMR | Multi-Mode Receiver |
| MOPS | Minimum Operational Performance Standards |
| MSS | Mobile Satellite System |
| MUAC | Maastricht Upper Air Center |
| NAS | National Airspace System |
| NAS EA | NAS Enterprise Architecture |
| NATS | North Atlantic Track System |
| NESG | NAS Enterprise Security Gateway |
| NextGen | Next Generation Air Transportation System |
| NOP | Network Operations Plan |
| NOAA | National Oceanic and Atmospheric Administration |
| NSS | Network Server System |
| OCL | Oceanic Clearance |
| ODC | Oceanic Departure Clearance |
| OI | Operational Improvements |
| PDC | Pre-Departure Clearance |
| PIREP | Pilot Report |
| POA | Plain Old ACARS |
| RCP | Required Communication Performance |
| RNP | Required Navigation Performance |
| SARPS | Standards and Recommended Practices |
| Satcom | Satellite Communications |
| SBAS | Space Based Augmentation System |
| SBD | Short Burst Data |
| SESAR | Single European Sky Air Traffic Management (ATM) Research |
| SoL | Safety of Life Service |
| SOA | Service Oriented Architecture |
| SPR | Safety and Performance Requirement |

## APPENDIX A
## LIST OF ACRONYMS

| | |
|---|---|
| STC | Supplemental Type Certificate |
| SUA | Special Use Airspace |
| SWIM | System Wide Information Management |
| TBO | Trajectory Based Operations |
| TDMA | Time Division Multiple Access |
| TMR | Trajectory Management Requirement |
| UM | Uplink Message |
| VDL | VHF Data Link |
| VHF | Very High Frequency |
| WPR | Waypoint Position Reporting |

# APPENDIX B GLOSSARY

**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, etc.).

**ADS-C – Automatic Dependent Surveillance-Contract:**

ADS-C is the same as ADS-A. Automatic Dependent Surveillance-Addressed is 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).

**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.

**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.

**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.

**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.

**APPENDIX B**
**GLOSSARY**

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.

**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.

**LINK 2000+ – The EUROCONTROL LINK 2000+ Program:**

Packages a first set of en-route controller-pilot data-link-communication (CPDLC) services into a set for implementation in the European Airspace using the ATN and VDL Mode 2 (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.

**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.

APPENDIX B
GLOSSARY

**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.

**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 will be used within the US and Europe as an interim datalink solution for enroute ATC functions. VDLM2 provides a 31.5 kbps channel rate.