D2.2 ATMACA Functional Requirements Document (FRD)-Initial

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Abstract

This document outlines the initial functional requirements for the ATMACA solution. Its purpose is to define the functional requirements of ATMACA, serving as a guide for the development and implementation processes. The document categorises and explains all functional requirements in a structured manner.

Since functional requirements may need to be revised throughout the project, this document represents the initial functional requirements. The final set of functional requirements will be detailed in the final FRD document.

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ATMACA

AIR TRAFFIC MANAGEMENT AND COMMUNICATION OVER ATN/IPS

ATMACA

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Table of contents

List of tables

List of figures

1 Executive summary

The ATMACA (Air Traffic Management and Communication over ATN/IPS) project proposes an air traffic management and communication solution for the Aeronautical Telecommunication Network (ATN) based on the Internet Protocol Suite (IPS), supporting the transition from legacy ATN/OSI (ATN/Open Systems Interconnection) systems to a modern, flexible, and resilient digital infrastructure. The system is intended to be deployed across ATC sectors and aircraft domains to enable resilient, flexible, and efficient air-ground communication services. This Functional Requirements Document (FRD) of ATMACA defines the initial functional requirements serving as a guide for the development and implementation processes.

ATMACA integrates multiple technical components into a unified solution by distinguishing between foundational and operational applications. At its core, ATMACA delivers foundational context management application -Data Link Context Management (DLCM)- that enable robust and secure data link communication, including comprehensive mobility support (covering terminal, session, user, and service mobility), as well as connection, session, and context management services. Built upon this foundation, the system provides operational applications that directly support air traffic management activities, Controller-Pilot Data Link Communication (CPDLC) and Green Route Operations (GRO). These are complemented by enhanced Human-Machine Interfaces (HMIs) designed for both air traffic controllers (ATCos) and pilots.

The core functionalities include session management for efficient communication establishment and continuity; connection management to maintain secure, reliable, and redundant network access; mobility management to support seamless transitions between heterogeneous networks and ATC boundaries; context management to increase situational-awareness and data availability; and multilink capabilities to enable dynamic routing, load balancing, and performance optimization.

A key innovation in ATMACA is the concept of the “flight session,” a persistent and context-aware communication structure uniquely tied to each flight. This flight session aggregates all air-ground communication, service context, and operational data from DLCM across all flight phases, ensuring uninterrupted communication during sector transitions and enhancing situational awareness.

ATMACA aims to improve operational efficiency, continuity, and sustainability by:
- streamlining ATC and communication handovers;
- enabling flexible and customised flight session control;
- supporting real-time trajectory optimisation through GRO;
- and providing digital resilience and scalability to future Air Traffic Management (ATM) infrastructures.

The ATMACA solution is currently at TRL1 and is expected to advance to TRL2 during subsequent development phases.

Key assumptions are outlined for system interoperability, infrastructure readiness, and standardisation. The validation strategy includes simulations to assess operational feasibility, scalability, and technical maturity.

ATMACA is aligned with SESAR's long-term vision and is interoperable with existing and future infrastructure components, such as System Wide Information Management (SWIM) and Future Communication Infrastructure (FCI), e.g., Proxy Mobile IP version 6 (PMIPv6), GB-LISP. It complements these frameworks by offering a scalable and context-aware platform for future Air Traffic Management (ATM) applications.

2 Introduction

2.1 Purpose of the document

This document defines the functional requirements (FRD) for ATMACA at TRL2.

ATMACA's functional requirements are presented in five categories to enable better definition and understanding, namely: solution global requirements, datalink protocol requirements, application requirements, HMI requirements, and contingency requirements.

Solution global requirements outline the functional requirements that all components of the ATMACA solution must possess. Datalink protocol, application, and HMI requirements specify the functional requirements associated with each individual component. Finally, contingency functional requirements define the functional requirements that all components of ATMACA must meet under contingency operating conditions. Each subsection of this document provides a detailed explanation of its respective requirements. Furthermore, all requirements are associated with the use cases targeted by ATMACA.

All the requirements specified in this document are the initial set of requirements, and any new requirements that may emerge throughout the project lifecycle will be added to the document to form its final version.

2.2 Scope

The FRD includes and defines:

- Functional architecture of the ATMACA solution
- Solution global requirements
- Datalink protocol requirements
- Application requirements: General, CPDLC, DLCM and GRO
- HMI requirements
- Contingency requirements

2.3 Intended readership

This document has been prepared to provide guidance for the ATMACA project consortium in the design, implementation, and validation phases of the project. Therefore, its primary audience consists of the project consortium partners and SESAR project managers. In addition to these, the potential readers listed below may also benefit from this document.

- ATM Stakeholders
- Air Navigation Service Providers (ANSPs)
- ATM infrastructure and equipment suppliers
- Aircraft manufacturers and equipment suppliers
- Airspace Users (Aus)

- Airport Owners/Providers (AOs)
- Affected National Supervisory Authorities (NSAs)
- Affected staff organisations
- Communication Service Providers (CSPs)
- Common Information Service Providers (CISPs)
- Data Service Providers (DSPs)
- Entities involved in ATN research
- Regulatory and standardization organisations: European Union Aviation Safety Agency (EASA), International Civil Aviation Organization (ICAO), European ATM Standards Coordination Group (EASCG), European Organization for the Safety of Air Navigation (EUROCONTROL), European Organisation for Civil Aviation Equipment (EUROCAE)
- Other SESAR solutions partners

2.4 Background

Numerous academic and industrial research and innovation actions have been accomplished to improve the existing air-to-ground communication infrastructure within the ATM system.

Conventionally, aeronautical communication mainly relies on voice communications over Very High Frequency (VHF) radio links and data communications using CPDLC over VHF Datalink (VDL) Mode2. These systems, however, have serious drawbacks such as VHF bandwidth limitations, disruptions in transmissions because of losing line-of-sight, 220-character limitation per message, global coverage problems, etc.

Various SESAR exploratory research projects and industrial initiatives, such as PJ33-W3 FALCO (Flexible ATCo Endorsement and LDAX Complement) [28], SAPIENT (Satellite and terrestrial architectures improving performance, security and safety in ATM) [29] and MIAR (Making I-CNSS a Reality) [27], have set the foundation to address these drawbacks. PJ33-W3 FALCO project showed that L-Band Digital Aeronautical Communication System (LDACS) could provide a spectrum-efficient and broadband-capable datalink communication. SAPIENT and MIAR, on the other hand, focused on the improvement of integrated Communication, Navigation, Surveillance (CNS) services, seamless trajectory management and datalink performance. As a result, they provided important insights regarding the resolution of line-of-sight and bandwidth limitation issues. Besides these improvement efforts, various studies pointed out that the changeover to IP-based communication, such as ATN/IPS (Aeronautical Telecommunications Network using Internet Protocol Suite), was an imperative to ensure a seamless, efficient, scalable and secure communication infrastructure for future ATM.

The ATMACA project, built directly on these outcomes, proposes an innovative IP-based datalink communication solution to address the requirements of air-ground integration across all flight domains, including airport, TMA, en-route and oceanic airspace sectors under the gate-to-gate philosophy. This solution targets reducing dependency on VHF voice frequencies, relieving congestion and connectivity problems, and allowing high-availability, high-integrity, and high-continuity communication services.

Unlike conventional IP mobility solutions, which often require network or transport layer adaptations, ATMACA offers a mobility management system in the application layer. This innovative feature removes significant deployment barriers posed in network or transport layers and offers mobility

support without changing the existing commercial-off-the-shelf (COTS) IP technologies. This design enables seamless handovers between ground stations and network transitions with minimal delay and disruption, ensuring robust and continuous communication as aircraft transition between sectors or different service providers. In addition to providing terminal mobility, ATMACA also supports session, user, and service mobility as defined below (Table 1). Through terminal mobility, communication continuity over ATN/IPS is maintained independently of IP address changes. Furthermore, by incorporating session, user, and service mobility features, ATMACA aims to introduce significant flexibility and user benefits to ATM communications.

MOBILITY TIERS	
1. TERMINAL MOBILITY	Allows a mobile device to maintain continuous network connectivity regardless of changes in its physical location.
2. USER MOBILITY	Ensures that users retain a consistent identity and access personalized services across various devices or locations.
3. SESSION MOBILITY	Enables active communication sessions to continue uninterrupted as a user switches between devices or as a device moves across different networks.
4. SERVICE MOBILITY	Ensures that users can access the same application services across different networks and devices.

Table 1: Mobility Tiers of ATMACA

ATMACA's outcomes establish the theoretical basis for building a scalable, secure, and interoperable communication framework, aligning with the European ATM Master Plan 2020, the Digital European Sky vision, and the SESAR 3 Strategic Research and Innovation Agenda (SRIA) priorities.

ATMACA also leverages the results and technological developments from several relevant projects:

- The integration of LDACS capabilities for digital voice and data communication from PJ33-W3 FALCO;
- The resilience and efficiency enhancements for CNS systems are outlined in "Demonstration of a CNS data service provision" (CNS DSP);
- AI-based datalink performance monitoring approaches derived from "Software defined networking architecture augmented with Artificial Intelligence to improve aeronautical communications performance, security and efficiency" (SINAPSE);
- The exploration of satellite-based datalink feasibility studies from "Extended Communications in VHf Over Enhanced Satellite segment" (ECHOES) and "Reduced separations and improved efficiency based on VHF communications over LEO satEllites" (VOICE).
- PJ14-W2-77 PJ.14 W2 Integrated CNSS project under the H2020 Programme, which is also considered a highly relevant initiative.

By addressing the operational shortcomings of current datalink systems and proposing a new communication architecture supporting trajectory-based operations, dynamic sectorization, seamless handover and green route operations (considering environmental goals such as reducing fuel consumption and CO2 emissions), as well as a wide range of mobility capabilities, ATMACA is positioned to make a significant contribution toward realizing a fully digital, scalable, and sustainable European ATM ecosystem by 2030 and beyond.

In conclusion, the ATMACA project does not emerge in isolation, but is a direct evolution of and response to the challenges and research needs identified in previous SESAR solutions and broader aeronautical research. It synthesizes the lessons learned, addresses critical technological gaps, and proposes a transformative, operationally viable platform that will define the next generation of air-ground communications.

2.5 Structure of the document

In the subsequent sections of the document, the Functional Architecture View and the Functional Requirements of ATMACA will be presented. While defining the functional requirements, each requirement is grouped with its corresponding identifier code (Table 2) and colour.

Identifier	REQ-ATMACA-FRD-xx0s.000n
Title	Sample table for functional requirements
Requirement	Functional requirements tables should be organized in a user-friendly and easily understandable manner.
Status	<in progress>
Rationale	To present information in a clear, straightforward, and reader-friendly manner.
Category	<Functional> <Safety> <HMI> <Security> <Performance>

Table 2: Sample functional requirements table

The identifier code assigned to the functional requirements follows the format “REQ-ATMACA-FRD-xx0s.000n”. In this format, **xx** denotes the main group of the respective functional requirement, while **s** refers to the subgroup created within that main group.

The main groups and their abbreviations are as follows:

- Global Functional Requirements - GB
- Protocol Functional Requirements - PR
- Applications Functional Requirements - AP
    - General Functional Requirements - AP01
    - CPDLC Functional Requirements - AP02
    - DLIC Functional Requirements - AP03
    - GRO Functional Requirements – AP04
- HMI Functional Requirements – HM01
- Contingency Functional Requirements – CT01

The **n** in the identifier code “REQ-ATMACA-FRD-xx0s.000n” represents the requirement number. This number is restarted from 1 for each main group and subgroup, meaning that the numbering resets with every change in the xx0s group code. This approach is intended to help the reader easily comprehend the number of functional requirements defined for each main and sub-group.

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Additionally, apart from the identifier code, colour-coding is applied to the first row of each table to indicate grouping (Table 3). Based on the background colour in the first row, each functional requirement is associated with a use case scenario of the ATMACA solution. The colours used in the functional requirement tables and their corresponding use cases are listed below:

Colour Code	Use Cases and the Global Requirements
	Solution Global Requirements
	Streamlined advanced ATC and communication handover
	Fully flexible and customizable Flight Sessions Management
	Consistent and seamless datalink operations management featuring digitally enabled HMI for pilots and controllers
	Trajectory Prediction and Trajectory Improvement for GRO

Table 3: Colour code mapping to use cases and the global requirements

2.6 Glossary of terms

Term	Definition	Source of the definition
Air Traffic	All aircraft in flight or operating on the manoeuvring area of an aerodrome.	ICAO Annex 11 – ATS [40]
Air Traffic Control Service	A service provided for the purpose of: Preventing collisions: 1) between aircraft, and 2) in the manoeuvring area between aircraft and obstructions. Expediting and maintaining an orderly flow of air traffic.	EC Regulation (EU) No 2015/340 [43]
Air Traffic Controller	A person authorized to provide air traffic control services.	EUROCONTROL ATM Lexicon [42]
Air Traffic Management	The dynamic, integrated management of air traffic and airspace including air traffic services, airspace management, and air traffic flow management – safely, economically and sufficiently – through the provision of facilities and seamless services in collaboration with all parties and involving airborne and ground-based functions.	ICAO 4444 - ATM
Air Traffic Service	A generic term meaning variously, flight information service, alerting service, air traffic advisory service, air traffic control service (area	ICAO Annex 11 – ATS [40]

	control service, approach control service or aerodrome control service).	
Controller-pilot Data Link Communications	A means of communication between controller and pilot, using data link for ATC communications.	ICAO Global Operational Data Link Document (GOLD) [39]
Data Link Communication	A form of communication intended for the exchange of messages via a data link	ICAO Annex 11– ATS [40]
Data Link Initiation Capability	A data link application that provides the ability to exchange addresses, names and version numbers necessary to initiate data link applications.	ICAO Doc 9880 – Part I [41]

Table 4: Glossary of terms

2.7 List of acronyms

Term	Definition
ANSP	Air Navigation Service Providers
ASBU	Aviation System Block Upgrades
ATC	Air Traffic Control
ATCo	Air Traffic Controller
ATFCM	Air Traffic Flow and Capacity Management
ATM	Air Traffic Management
ATMACA	AIR TRAFFIC MANAGEMENT AND COMMUNICATION OVER ATN/IPS
ATM/ANS	Air Traffic Management/Air Navigation Services
ATN	Aeronautical Telecommunication Network
ATN/IPS	Aeronautical Telecommunications Network using Internet Protocol Suite
ATSU	Air Traffic Service Unit
CMA	Context Management Application
CNS	Communication, Navigation, and Surveillance
CNS DSP	Demonstration of a CNS data service provision
COTS	commercial-off-the-shelf
CPDLC	Controller Pilot Data Link Communications
CSP	Communication Service Provider
CWP	Controller Working Positions
DBL	Deep Blue
DLCM	Datalink Context Management
DLIC	Datalink Initiation Capability
DMU	De Montfort University
DSP	Datalink Service Provider
EASA	European Union Aviation Safety Agency

EASCG	European ATM Standards Coordination Group
ECHOES	Extended Communications in vHf Over Enhanced Satellite segment
EFB	Electronic Flight Bag
ENAC	Ecole Nationale De L' Aviation Civile
EOCs	Essential Operational Changes
ESTU	Eskişehir Teknik Üniversitesi
EUROCAE	European Organisation for Civil Aviation Equipment
Eurocontrol	European Organisation for the Safety of Air Navigation
FCI	Future Communication Infrastructure
FRD	Functional Requirements Document
GANP	ICAO Global Air Navigation Plan
GRO	Green Route Operations
HMI	Human-Machine Interface
ICAO	International Civil Aviation Organization
IPS	Internet Protocol Suite
LDACS	L-Band Digital Aeronautical Communications System
MIAR	Making I-CNSS a Reality
NSAs	National Supervisory Authorities
SAERCO	Servicios Aeronáuticos Control y Navegación
SAPIENT	Satellite and terrestrial architectures improving performance, security and safety in ATM
SDOs	Strategic Deployment Objectives
SESAR	Single European sky ATM research
SESAR 3 JU	SESAR 3 Joint Undertaking
SINAPSE	Software defined networking architecture augmented with Artificial Intelligence to improve aeronautical communications performance, security and efficiency
SRIA	SESAR 3 Strategic Research and Innovation Agenda
SWIM	system-wide information management
TBO	Trajectory Based Operations
THY	Turk Hava Yolları AO
TMA	Terminal Maneuvering Area
TRL	Technology readiness level
UPM	Universidad Politecnica de Madrid
VOICE	Reduced separations and improved efficiency based on Vhf cOmmunICations over LEO satEllites

Table 5: List of acronyms

3 Functional architecture view

3.1 SESAR solution overview

In response to the evolving landscape of aeronautical communications—marked by rising air traffic demand, frequency congestion, advancements in datalink technologies, the emergence of future aircraft data services, growing reliance on satellite communications, integration of aircraft network domains, and the transition to IP-based ATN architectures [26]—the ATMACA solution is designed to address current limitations in mobility management, session continuity, and datalink resilience. It aims to enhance the robustness, interoperability, and environmental efficiency of air–ground communications across European ATM systems.

ATMACA is an ATM solution designed for ATN/IPS, offering a scalable and flexible framework that integrates three core components: **(1) a specialised datalink communication protocol**; **(2) advanced operational applications**; and **(3) an enhanced HMI** tailored to improve controller–pilot interaction, situational awareness, and operational efficiency. By converging these components, ATMACA aims to ensure seamless communication, increased reliability, and support for GRO, while enabling future-proof integration with evolving ATM infrastructures. Figure 1 illustrates the main components of the ATMACA solution, highlighting their key functional elements and interrelationships.

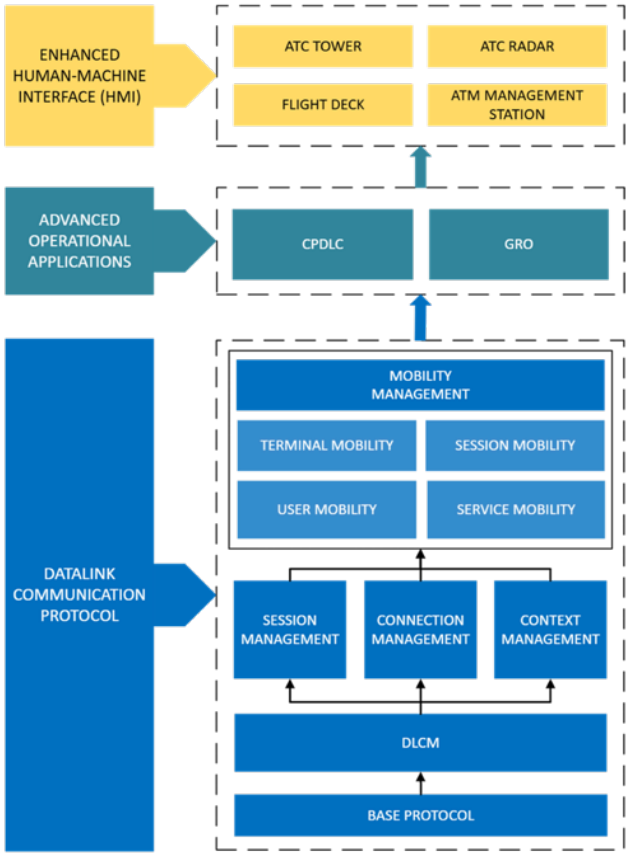

Figure 1: SESAR solution ATMACA overview

The **core enabler** of the ATMACA solution is the ATMACA datalink communication protocol, which is built upon a base protocol and the foundational Datalink Context Management (DLCM) application, and provides four main capabilities: session management, connection management, context management, and mobility management. DLCM functions as the Context Management Application (CMA) and also incorporates the DLIC (Data Link Initiation Capability) as an integrated service for initiating and supporting subsequent datalink communications.

Building upon its novel datalink communication protocol tailored for aeronautical communication, the ATMACA solution provides **advanced operational applications**, which are CPDLC and GRO. These are context-based operational applications specifically selected to demonstrate ATMACA's advantages in enhancing current air–ground communication capabilities.

In addition to improving air–ground communication over ATN/IPS, the ATMACA solution also provides **enhanced HMIs** to support improved controller–pilot interaction, situational awareness, and operational efficiency. Considering the end users of the ATMACA solution, the primary HMIs include those for ATC Tower, ATC Radar, ATM Management Station, and the Flight Deck.

The implementation of the ATMACA solution will have a direct impact on core operational and infrastructure systems, including ATC systems, Data and Communication Service Provider (DSP/CSP) systems, and the broader Future Communication Infrastructure (FCI) as envisioned in SESAR's ATM evolution roadmap.

The functional scope of the ATMACA solution includes the definition and implementation of a custom datalink protocol for ATN/IPS, support for flight session mobility, and integration with selected operational applications and HMIs. It does not include physical layer specifications, SWIM technical infrastructure development, or the development of new IP-based multilink communication infrastructure.

The ATMACA solution is a scalable and future-proof framework designed to meet the evolving needs of aeronautical communication networks. It enables the integration of existing and SWIM-enabled applications, while supporting the development of new datalink services. Through its framework-based approach, ATMACA ensures secure, reliable, and efficient communication, offering seamless application integration, interoperability, and enhanced situational awareness. Aligned with the SESAR framework, it supports the evolution of air traffic operations and delivers greater flexibility for all network users. The ATMACA solution will enable the use of digital data in air–ground communication over ATN/IPS, thereby contributing to the digitalisation of air traffic management and communication in Europe.

3.1.1 Supporting reasons for this SESAR solution

ATMACA solution introduces an IP-based air traffic management and communication framework including a datalink communication protocol, advanced operational applications, and HMIs. This framework is fully aligned with the multilink concept and FCI services [30], integrates with SWIM [31], and addresses the current gap in enabling integrated session, connection, context, and mobility management at the application layer of the ATN/IPS stack, while also providing a middleware layer to support protocol-level functionalities.

Considering the four-phased roll-out outlined in the European ATM Master Plan, 2025 Edition [24], the ATMACA solution is fully aligned with Phase D, contributing to the realisation of full air–ground system integration, distributed data services, and high levels of automation and connectivity. While the ATMACA solution is positioned within the early research phase (TRL1→TRL2), its core innovations in datalink protocol design, session, communication, and mobility management over ATN/IPS, as well as its integration with SWIM-enabled applications, directly contribute to the enabling next generation platforms envisioned for deployment by 2045 in the European ATM Master Plan [24].

In the context of the Strategic Deployment Objectives (SDOs)—also referred to as Essential Operational Changes (EOCs)—in the European ATM Master Plan [24], ATMACA solution directly contributes to SDO 7: "Transition towards high performance of air–ground connectivity (multilink)". In addition, considering the features of the ATMACA solution, it also contributes partially to SDO 8: "Service-oriented delivery model (Data-driven and cloud-based)", SDO 5: "Transformation to Trajectory-Based Operations (TBO)", and SDO 6: "Virtualisation of Operations".

In alignment with the ICAO Global Air Navigation Plan (GANP) [36], Aviation System Block Upgrades (ASBU) methodology [37], the ATMACA solution is fully aligned with the ASBU element COMI-B2/1: "Air–Ground ATN/IPS" and is partially aligned with COMI-B1/1: "Ground–Ground Aeronautical Telecommunication Network/Internet Protocol Suite (ATN/IPS)." Considering the current mapping between the European ATM Master Plan SDOs and ICAO GANP ASBU elements, the ATMACA solution directly addresses COMI-B2/1 element—a gap that is not yet explicitly covered in the current European ATM Master Plan [24]—and thus contributes significant added value by advancing the deployment of Air–Ground ATN/IPS capabilities in Europe.

3.1.2 ATM capabilities addressed by the SESAR solution

The ATMACA solution provides a scalable and flexible framework for air traffic management and communication over ATN/IPS, comprising three components: a specialised datalink communication protocol, advanced operational applications, and enhanced HMIs. Considering its architecture and functionalities, ATMACA extends the traditional notion of a communication session by introducing the concept of a "**flight session**"—a unified, unique, and univocal association between a flight and all its air–ground datalink communications, historical and real-time flight data (flight plans, radar tracks, trajectory information, etc.), and operational context. This consolidated approach allows the integration of all relevant elements into a single, coherent communication session entity.

Brief definitions of ATMACA's core functional capabilities are provided below:

Session Management: Maintains stable and continuous communication sessions across all flight phases, supporting seamless transitions and real-time application interactions.

Connection Management: Ensures persistent, secure, and optimized connectivity between aircraft, air traffic controllers, and supporting services across multilink aeronautical networks.

Context Management: Maintains, updates, and synchronizes operational context—including flight identity, session state, and system status—across all participating air and ground systems, ensuring coherent communication, service interoperability, and effective support for mobility and session continuity.

Mobility Management: Enables uninterrupted service continuity by dynamically managing session and routing transitions as aircraft traverse different network domains and operational sectors.

Based on the definitions of the core capabilities and the additional functionalities of the ATMACA solution, the corresponding solution capabilities are summarized below in Table 6.

SESAR solution capabilities	Comments on potential updates required at capability level
High-Performance Air–Ground Connectivity	- Multilink Monitoring and Selection Logic - Seamless Link Switching - Link Quality and Failover Management
Session and Context Management	- Persistent Flight Session Establishment - Session State Synchronisation Across ATSUs -Operational Context Binding (Flight Plans, Trajectory, Radar)
Application-Layer Mobility Management	- Session Mobility - Terminal Mobility - User Mobility - Service Mobility
Integration with SWIM	- SWIM Interoperability - Data Sharing Models for Advanced Operational Applications (CPDLC, GRO etc.)
Enhanced Human–Machine Interfaces (HMIs)	- Link Status and Session Monitoring - Link Status and Session Visualisation - User Alerting and Logging Tools
Support for Trajectory-Based Operations (TBO)	- Data Continuity for TBO Synchronisation -Trajectory enhancement based on real-time weather data
Support for Green Route Operations (GRO)	- Collaborative Trajectory Adjustment Tools - Environmental Data Integration via Datalink

Table 6: SESAR solution ATMACA capabilities

As a SESAR solution, ATMACA provides capabilities within the air–ground communication domain, as outlined in Table 6. Building on its core functional capabilities—connection management, session management, context management, and mobility management—these are respectively aligned with the SESAR architectural capabilities of High-Performance Air–Ground Connectivity, Session and Context Management, and Application-Layer Mobility Management.

Considering the functionalities provided by the ATMACA solution through its main components—advanced operational applications and enhanced HMIs—it delivers capabilities aligned with the SESAR architecture, including Integration with SWIM-Enabled Applications, Enhanced HMI, Support for TBO, and Support for GRO.

3.1.3 Stakeholders impacted by the SESAR solution

Stakeholder	Why it matters to the stakeholder
Air Navigation Service Provider (ANSP)	ATMACA enhances air–ground communication performance, session continuity, and controller handover procedures, enabling more resilient and flexible ATC service delivery aligned with virtualisation and distributed ATSU concepts.
Airspace User (AU)	The solution improves datalink reliability and mobility across networks, reducing pilot workload and supporting continuous service availability, particularly in complex or congested airspace environments.
Airport Operator (AO)	ATMACA enhances the robustness of air–ground communications by providing resilient session management, mobility support, and datalink continuity, which contribute to maintaining operational coordination between aircraft and ground systems. Although not directly targeting ground operations, the solution supports airport operations indirectly by ensuring communication continuity during contingency scenarios—such as system outages, network degradation, or congestion—through session persistence and dynamic mobility management, thereby improving the resilience and predictability of airport surface and approach operations.
Network Manager (NM)	The solution provides continuous, session-based access to aircraft trajectory and operational context, supporting improved network performance monitoring, flight planning, and trajectory management services.
Common Information Service Provider (CISP)	As ATMACA provides a scalable and interoperable air traffic management and communication framework over ATN/IPS, it offers a potential platform for implementing advanced operational applications within the U-space architecture, including those targeting U-space users. Its support for SWIM integration, context management, and application-layer mobility makes it a valuable enabler for Common Information Service Providers (CISPs) seeking to deliver real-time, high-

	integrity information services across diverse airspace users and operational domains.

Table 7: SESAR solution ATMACA stakeholders

3.2 SESAR solution functional view

3.2.1 Interaction(s) identification

This section identifies and explains the interactions between the capability configurations and technical systems involved in the ATMACA solution, in alignment with the European ATM system architecture. ATMACA introduces a layered architecture that enables resilient, session-centric air–ground communication and supports advanced operational applications over ATN/IPS. These interactions span from the foundational network layer to the upper layers of operational and user-facing systems, ultimately integrating with ATM and CNS systems to form a coherent and layered capability stack. Each layer builds upon the previous one to ensure continuity of service, enhanced situational awareness, and operational efficiency. The implementation of the ATMACA solution will directly impact key infrastructures—including ATM systems, CSP/DSP systems, and aircraft systems—while aligning with the broader vision of the FCI outlined in SESAR's ATM evolution roadmap. The capability configurations and technical systems of the ATMACA solution are illustrated in Figure 2.

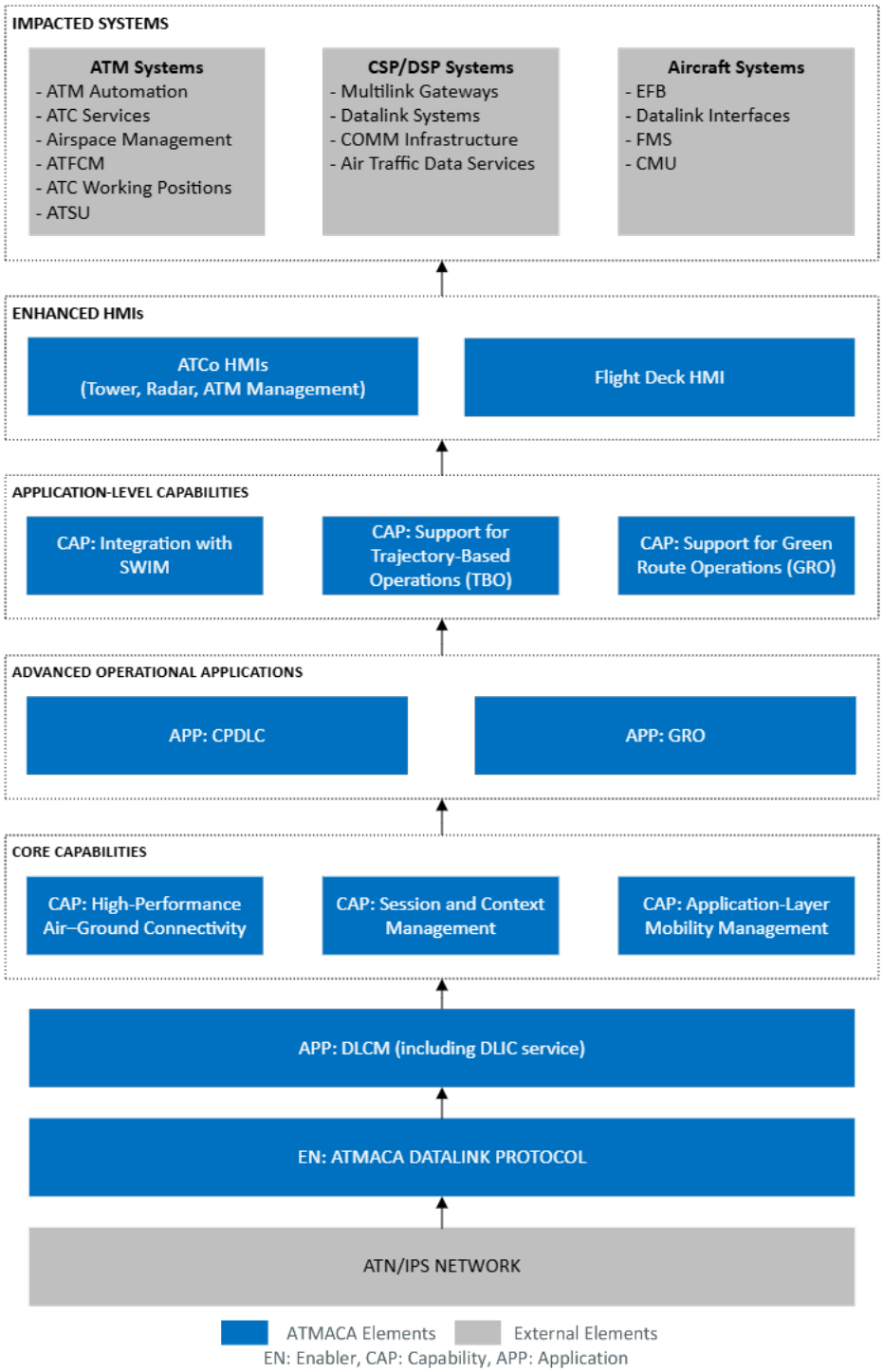

Figure 2: Capability Configurations and Technical Systems

ATMACA solution establishes its functions and capabilities over an existing ATN/IPS network layer, which provides IP-based connectivity between airborne and ground systems and is considered a foundational assumption for the solution. The ATMACA Datalink Communication Protocol serves as the core enabler, ensuring secure, reliable, and flexible datalink services over ATN/IPS, operating independently of the underlying transport protocols.

The **DLCM** is layered directly above the protocol and forms the **middleware** of the ATMACA solution. DLCM manages the operational context and enables persistent flight sessions that unify application-level data exchanges throughout the entire flight lifecycle. From the DLCM, **core capabilities** of the ATMACA solution are derived: *high-performance air–ground connectivity, session and context management, and application-layer mobility management*.

Benefiting from the core capabilities derived from the **ATMACA datalink protocol** and **DLCM**, the advanced operational applications enable operational context-specific air traffic management and communication within the relevant segments of the air traffic network. These core capabilities serve as the functional foundation for operational applications, namely CPDLC, and GRO.

Each of the foundational and advanced operational applications fulfils a distinct role within its operational context. For instance, within the DLCM application, **DLIC**—regulated for ANSPs under EC Regulation (EU) No 29/2009 [38]—facilitates the initial exchange of information required to establish data link communication between an ATSU and an aircraft. It is executed prior to the use of any other data link application. Enabled by the datalink, **CPDLC** provides a means for exchanging standardised and free text ATC messages between controllers and pilots via digital text-based communication, reducing voice channel congestion and enhancing clarity and efficiency in routine communications. Currently, both **DLIC** and **CPDLC** are predominantly operated over VDL Mode 2, the existing datalink infrastructure. However, in alignment with the SESAR vision for FCI, there is a growing need to transition these applications to operate over ATN/IPS. This migration is essential to ensure long-term scalability, improved performance, multilink flexibility, and secure integration with emerging digital ATM services. Lastly, **GRO** application is designed to enhance trajectory prediction and optimization by enabling the dynamic exchange of wind and temperature data between aircraft and ground systems via air–ground datalink communication. By leveraging real-time meteorological data gathered by aircraft flying ahead in the same airspace, GRO supports more accurate Estimated Time of Arrival (ETA) calculations and the generation of fuel-optimal trajectories. This reduces reliance on holding patterns, minimizes fuel burn, and contributes directly to environmentally efficient operations. As such, GRO plays a key role in supporting greener air traffic management and aligns with SESAR's sustainability objectives.

Through the advanced operational applications of the ATMACA solution, in addition to the core capabilities, **application-level capabilities** are also derived. These include support for trajectory-based operations, support for pilot-controller datalink message interchange, support for green route operations, and integration with SWIM-enabled applications, all of which contribute to broader SESAR-aligned capability configurations.

To enable the effective use of the ATMACA solution's datalink protocol and advanced operational applications in a user-friendly manner, and to deliver the solution capabilities, enhanced HMIs have been developed for the main end users of the solution, namely the primary ATCo working positions (ATC Tower, ATC Radar, ATM Management) and the flight deck.

Considering all components and capabilities of the ATMACA solution as a SESAR ATM solution, the main impacted systems within the ATM/ANS ecosystem are identified as ATM systems, CSP/DSP systems, and aircraft systems. Through the air traffic management and communication framework provided over ATN/IPS by the ATMACA solution, the following subsystems will be interacted with and impacted: within **ATM systems** — ATM automation, ATC services, airspace management, ATFCM, ATC working positions, and ATSUs; within **CSP/DSP systems** — multilink gateways, datalink systems,

communication infrastructure, and air traffic data services; and within **aircraft systems** — Electronic Flight Bags (EFBs), datalink interfaces, FMS, and CMUs. These systems interact with the ATMACA framework via existing and extended interfaces, supporting new service-based coordination, including mobility event awareness, flight session continuity, and operational context sharing across distributed actors.

3.2.2 Functional decomposition

This sub-section presents the functional decomposition of the capability configurations and technical systems required to support the ATMACA solution. It details how the solution's functional components are structured and traced across the framework, enabling capabilities, and impacted technical systems. To better illustrate the functional components of the ATMACA solution, the relationship between the ATMACA framework, its enabled capabilities, and the impacted systems is depicted in Figure 3.

The ATMACA solution is composed of three main components: a custom datalink communication protocol, advanced operational applications, and enhanced HMIs. In addition, the ATMACA framework incorporates DLCM that functions as middleware, enabling interoperability without requiring modifications to the underlying core protocol. The ATMACA solution delivers capabilities aligned with the SESAR architecture, addressing the needs of impacted systems—including ATM systems, CSP/DSP systems, and aircraft systems. These capabilities include:

- High-Performance Air–Ground Connectivity
- Session and Context Management
- Application-Layer Mobility Management
- Integration with SWIM
- Enhanced Human–Machine Interfaces (HMIs)
- Support for Trajectory-Based Operations (TBO)
- Support for Green Route Operations (GRO)

The ATMACA datalink protocol operates over the ATN/IPS network layer and provides resilient, secure, and efficient datalink communication. It abstracts transport layer variability and supports multilink communication across diverse infrastructures, enabling robustness and flexibility in communication services. Built on top of this protocol, the DLCM functions as a middleware layer, managing operational context, maintaining flight session integrity, and synchronizing communications. Through DLCM, a unified "flight session" abstraction is established, ensuring seamless service continuity across network domains and operational sectors. DLCM also includes DLIC, which facilitates the initial establishment of datalink communication between ATSUs and aircraft, providing the necessary foundation for subsequent datalink services.

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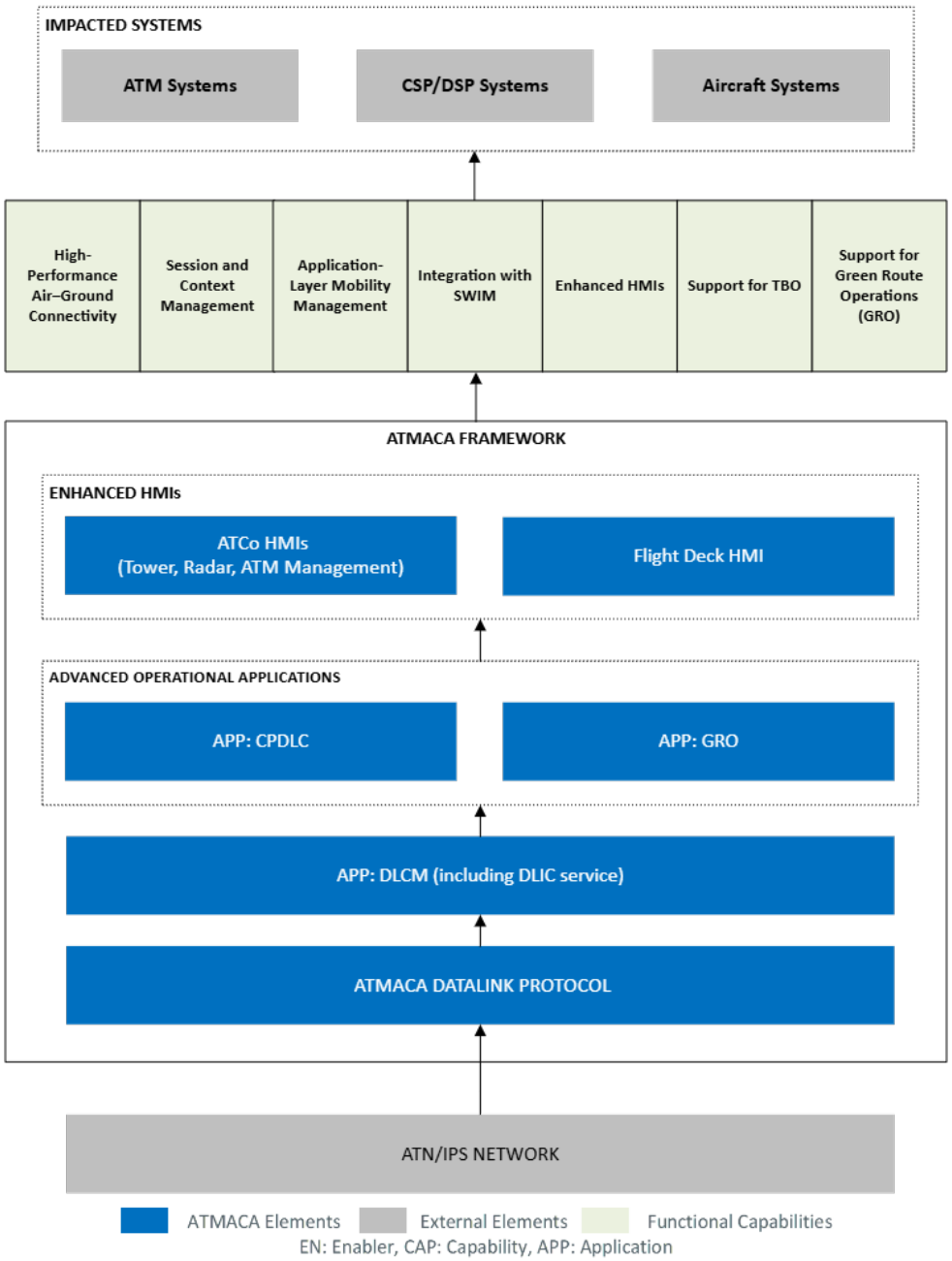

Figure 3: Functional Decomposition and Capability Mapping of the ATMACA Solution

The advanced operational applications within the ATMACA solution serve distinct roles in supporting air–ground communications. CPDLC enables text-based communication between controllers and pilots, reducing dependency on traditional voice communications and improving operational clarity and efficiency. GRO enhances trajectory prediction and optimisation by utilising real-time wind and temperature data sharing, supporting more fuel-efficient routing and contributing to environmentally sustainable air traffic management operations.

The enhanced HMIs for ATCos and pilots provide end-users with visualisations and interaction capabilities for datalink session management, message exchange, and trajectory coordination, ensuring operational situational awareness.

The main components of the ATMACA framework -namely the datalink protocol, advanced operational applications, and enhanced HMIs- form the foundation of the solution's functional breakdown. Each component plays a critical role in delivering the operational capabilities required by the ATMACA solution. In addition, the ATMACA solution introduces a unique functional structure derived from its specific architectural innovations and operational advantages. The classification of functional requirements, which also reflects this functional breakdown, is illustrated in

Figure 4.

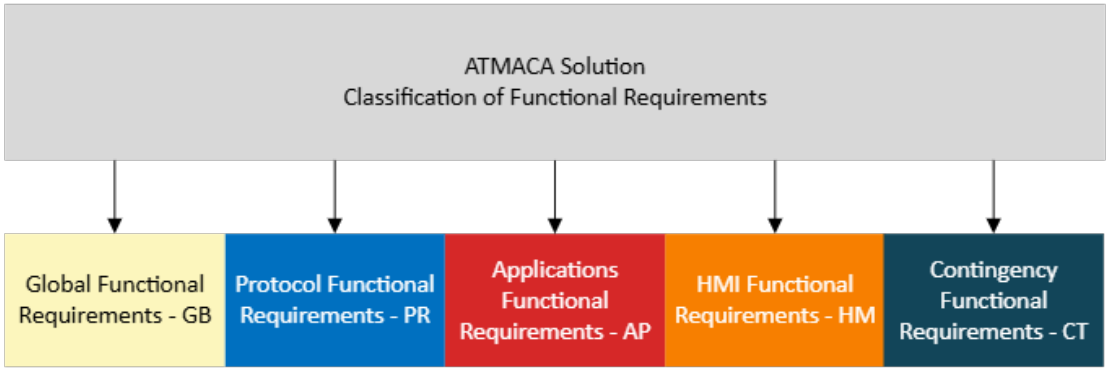

Figure 4: Classification of Functional Requirements

Solution Global Requirements

These requirements define the overarching system-level functionalities and performance characteristics necessary for the ATMACA solution. They address global functions such as status display, user logon management, IP trackability, and operational data sharing, ensuring consistent service behaviour across the framework.

Datalink Protocol Requirements

These requirements specify the essential functionalities of the ATMACA datalink protocol. They address key aspects such as message exchange reliability, protocol robustness, session establishment and maintenance, handover management, and mobility support at the protocol layer.

Application Requirements

These requirements focus on the operational applications developed within the ATMACA solution—namely CPDLC and GRO. They define the context-specific service-level behaviours, functional expectations, and interaction patterns necessary to ensure seamless and reliable operation within the ATM environment.

HMI Requirements

These requirements describe the functional expectations for the HMIs supporting ATMACA solution. They encompass ATCo HMIs and flight deck HMIs, addressing standardized communication workflows, visualisation needs, user interaction design, status monitoring of datalink sessions, and the integration of outputs from operational applications.

Contingency Requirements

These requirements ensure service continuity, controlled degradation, and operational resilience in case of failures such as communication loss, network congestion, or mobility events. They cover fallback behaviours, session persistence strategies, and rerouting mechanisms to maintain safety and operational effectiveness.

3.3 High-level impact of the SESAR solution on the baseline SESAR architecture

This sub-section provides a high-level overview of the expected changes and impacts on the SESAR architecture baseline resulting from the implementation of the ATMACA solution. It identifies the technical systems, operational functions, and roles that will be impacted or enhanced to achieve the solution's capabilities. Given that the ATMACA solution aims to reach TRL2 maturity, this section focuses on a textual description of the architectural impacts without formal modelling. The detailed mapping is presented in Table 8 below.

Technical systems impacted by the SESAR solution	Functions / roles impacted by the SESAR solution	Comments on required updates
ATM Systems – ATC Automation Systems	Flight session management, trajectory services integration, datalink coordination	Existing ATC automation logic may require adaptation to handle dynamic flight sessions, mobility-triggered updates, and integrated ATN/IPS messaging.
ATM Systems – ATSU Systems	Air–ground communication establishment, session management handovers	ATSUs may require session-aware service modules to support persistent datalink communication and handle mobility across control sectors.
ATM Systems – Controller Working Positions (CWPs)	Datalink session visualization, pilot–controller interaction management	CWPs need minor interface updates to visualize flight session states, link conditions, and to integrate ATMACA-enabled messaging flows.
CSP/DSP Infrastructure – A/G Datalink Systems	Resilient message transport, session continuity support	A/G datalink nodes may require protocol enhancements to manage session persistence

		across multiple links and ensure dynamic routing based on ATMACA session states.
CSP/DSP Infrastructure – Multilink Gateways	Mobility management, seamless handover across communication media	Multilink gateways must support seamless session handovers, QoS monitoring, and mobility event signalling compatible with ATMACA's middleware-driven handover triggers.
Aircraft Systems – Communications Management Unit (CMU)	Datalink session management, mobility event handling	CMUs may need software updates to manage flight session identifiers, mobility event triggers, and protocol handling for ATMACA communication sessions.
Aircraft Systems – Flight Management System (FMS)	Wind and temperature data provision for GRO trajectory optimization	FMS units may require minor updates to provide available onboard wind and temperature data to ATMACA systems in real time, supporting trajectory-based optimization for GRO applications.
Aircraft Systems – Avionics Interfaces	Air–ground datalink integration, display of session-related information	The ATMACA solution requires only minimal adjustments to avionics, such as the optional integration of ATMACA applications into EFBs or similar onboard systems, without impacting core avionics systems or certified flight-critical functions.

Table 8: Systems impacted by SESAR solution ATMACA

As shown in the table above, the ATMACA solution introduces targeted and incremental updates to existing ATM, CSP/DSP, and aircraft systems. These updates primarily focus on enhancing datalink session continuity, enabling mobility management, improving operational resilience, and supporting trajectory-based operations without requiring disruptive changes to core avionics or network infrastructures. The impacts are carefully aligned with the SESAR architecture principles, ensuring a scalable and future-proof integration pathway.

In line with the European ATM Master Plan and SESAR's SDOs, which aim to improve air–ground datalink performance, accelerate technology adoption, and foster economies of scale—the future air–ground communication infrastructure is expected to evolve towards full support of ATN/IPS multilink capabilities. To support this transformation across the ATM/ANS ecosystem, several SESAR solutions

are currently under development and deployment. These include PJ.14-W2-77, focusing on “FCI Services” [30]; PJ.14-W2-107, addressing “Future Satellite Communications Datalink” [32]; PJ.14-W2-60, dedicated to “FCI Terrestrial Datalink (LDACS)” [33]; PJ.14-02-06, which integrates “AeroMACS with ATN, Digital Voice, and Multilink” [34]; and Solution #102, targeting the “Aeronautical Mobile Airport Communication System (AeroMACS)” [35].

Together with the FCI concept—which aims to enable integrated CNS services over multiple IP-based broadband air–ground datalinks (multilink)—these efforts represent a fundamental structural shift in the modernization of ATN/IPS-based communication systems. In parallel with the development of FCI infrastructure and the broader evolution of the ATM environment, communication and SWIM standards are also being defined and consolidated by international regulatory bodies to ensure global interoperability and harmonized deployment.

As infrastructure and standardization efforts continue to advance in the ATM environment, the next critical step will be the development of COTS-based solutions capable of supporting air–ground aeronautical services and flight-critical communications over ATN/IPS. The ATMACA solution directly addresses this need by offering a scalable, modular and interoperable communication framework that supports the deployment of communication and operational applications over ATN/IPS. In doing so, it reinforces both the European ATM Master Plan and SESAR strategies, offering an evolutionary step forward that complements and extends previous SESAR solutions focused on air–ground communication over ATN/IPS.

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4 Functional requirements

All requirements presented in this section are, as previously explained, indicated using colour codes. Colour-coding is applied to the first row of each table to signify grouping (Table 9). Based on the background colour in the first row, each functional requirement is linked to a specific use case scenario of the ATMACA solution. The colours used in the functional requirement tables and their corresponding use cases are listed below.

Colour Code	Use Cases and the Global Requirements
	Solution Global Requirements
	Streamlined advanced ATC and communication handover
	Fully flexible and customizable Flight Sessions Management
	Consistent and seamless datalink operations management featuring digitally enabled HMI for pilots and controllers
	Trajectory Prediction and Trajectory Improvement for GRO

Table 9: Colour code mapping to use cases and the global requirements (repeated for readability)

4.1 Solution Global Requirements

Identifier	REQ-ATMACA-FRD-GB01.0001
Title	Displaying actively connected flight
Requirement	HMI shall be able to display the list of connected aircraft on ATCo screen
Status	<in progress>
Rationale	To provide air traffic controllers with real-time situational awareness and facilitate efficient monitoring and management of aircraft communication links
Category	<Functional>

Identifier	REQ-ATMACA-FRD-GB01.0002
Title	Displaying user login status
Requirement	HMI shall be able to indicate the user about the login status for all users
Status	<in progress>
Rationale	To provide clear feedback on authentication state and improve user interaction with the system
Category	<Functional>

Identifier	REQ-ATMACA-FRD-GB01.0003
Title	User login/logout
Requirement	The system shall support secure and encrypted user login and logout functionality
Status	<in progress>
Rationale	To protect user credentials and prevent unauthorized access to the system
Category	<Functional> <Security>

Identifier	REQ-ATMACA-FRD-GB01.0004
Title	User login/logout status
Requirement	The system shall be able to inform the user about its presence, whether logged in or logged out
Status	<in progress>
Rationale	To enhance user awareness and system transparency during session transitions
Category	<Functional> <Security>

Identifier	REQ-ATMACA-FRD-GB01.0005
Title	Network Mobility
Requirement	The protocol shall support intra-domain and inter-domain mobility across different networks
Status	<in progress>
Rationale	To enable seamless connectivity and service continuity across various networks
Category	<Functional>

Identifier	REQ-ATMACA-FRD-GB01.0006
Title	IP Tracking
Requirement	The protocol shall track the IP address of each endpoint
Status	<in progress>
Rationale	To ensure accurate routing and maintain reliable communication paths
Category	<Functional>

Identifier	REQ-ATMACA-FRD-GB01.0007
Title	Data transmission verification
Requirement	The protocol shall ensure successful data transmission
Status	<in progress>

Rationale	To guarantee data transformation and reliable end-to-end communication
Category	<Functional>

Identifier	REQ-ATMACA-FRD-GB01.0008
Title	Connection management
Requirement	Protocol shall be able to initiate and maintain the connection between applications
Status	<in progress>
Rationale	To ensure continuous data exchange and application interoperability
Category	<Functional>

Identifier	REQ-ATMACA-FRD-GB01.0009
Title	Standardized File Structure Usage in Applications
Requirement	All applications shall be able to properly use predefined file structure for network communication
Status	<in progress>
Rationale	To ensure data consistency and compatibility across all system components
Category	<Functional>

Identifier	REQ-ATMACA-FRD-GB01.0010
Title	Data back-up for safety and security
Requirement	All applications shall be able to store all data as backup and recovery for security and safety purposes
Status	<in progress>
Rationale	To prevent data loss and support system restoration in case of failures
Category	<Functional> <Safety> <Security>

Identifier	REQ-ATMACA-FRD-GB01.0011
Title	Accessibility of the applications
Requirement	Applications shall be easily reachable with single request on the ATCo screen
Status	<in progress>
Rationale	To improve usability and enable quick access during operational tasks
Category	<Functional>

Identifier	REQ-ATMACA-FRD-GB01.0012
Title	Secure connection establishment
Requirement	Robust security measures shall be adopted
Status	<in progress>
Rationale	To authenticate and encrypt all connections, ensuring protection against unauthorised access, data breaches, and other cybersecurity threats
Category	<Functional> <Security>

Identifier	REQ-ATMACA-FRD-GB01.0013
Title	Real-Time Connection Health Monitoring
Requirement	Continuous monitoring shall be performed to assess the status and performance of connections in real time
Status	<in progress>
Rationale	To enable prompt detection and resolution of issues to maintain high reliability and quality of service (QoS)
Category	<Functional> <Performance>

Identifier	REQ-ATMACA-FRD-GB01.0014
Title	Multilink Support with Automatic Failover
Requirement	Multiple simultaneous connections shall be supported across diverse communication links (e.g., VDL Mode 2, SATCOM, LDACS), with automatic failover mechanisms
Status	<in progress>
Rationale	To enhance resilience and ensure uninterrupted connectivity
Category	<Functional>

Identifier	REQ-ATMACA-FRD-GB01.0015
Title	Display ATCos in the related sectors along the flight route
Requirement	HMI shall be able to display ATCos in the related sectors along the flight route and allow the pilot to easily select and contact them
Status	<in progress>
Rationale	To facilitate efficient communication and reduce pilot workload during sector transitions
Category	<Functional> <HMI>

Identifier	REQ-ATMACA-FRD-GB01.0016
Title	Suggest ATCos in the next sectors along the flight route
Requirement	HMI shall be able to suggest to the pilot the next ATCo along the flight route to contact
Status	<in progress>
Rationale	To optimize communication handovers by proactively identifying the appropriate ATCo, thereby streamlining pilot decision-making during transitions
Category	<Functional> <HMI>

Identifier	REQ-ATMACA-FRD-GB01.0017
Title	Displaying active ATCo list
Requirement	HMI shall be able to list all active ATCo positions
Status	<in progress>
Rationale	To provide pilots and systems with real-time visibility of available ATCo resources for coordination and communication
Category	<Functional> <HMI>

Identifier	REQ-ATMACA-FRD-GB01.0018
Title	Communication modalities
Requirement	HMI shall enable the pilot and ATCos to communicate through diverse modalities such as voice calls, messages, etc.
Status	<in progress>
Rationale	To increase communication flexibility and ensure operational continuity under various conditions
Category	<Functional> <HMI>

Identifier	REQ-ATMACA-FRD-GB01.0019
Title	Sharing information/files
Requirement	The HMI shall enable the pilot and ATCos to share information or files, such as datasets, text documents, or images, through a structured and secure file-sharing mechanism that adheres to predefined formats and complies with relevant security and access control protocols
Status	<in progress>
Rationale	To increase communication flexibility and ensure operational continuity
Category	<Functional> <HMI>

4.2 Protocol

Identifier	REQ-ATMACA-FRD-PR01.0001
Title	User login/logout
Requirement	The system shall support secure and encrypted user login and logout functionality
Status	<in progress>
Rationale	To protect user credentials and prevent unauthorized access to the system
Category	<Functional> <Security>

Identifier	REQ-ATMACA-FRD-PR01.0002
Title	User login/logout status
Requirement	The system shall be able to inform the user about its presence, whether logged in or logged out
Status	<in progress>
Rationale	To enhance user awareness and system transparency during session transitions
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0003
Title	Network Mobility
Requirement	The protocol shall support intra-domain and inter-domain mobility across different networks
Status	<in progress>
Rationale	To enable seamless connectivity and service continuity across various networks
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0004
Title	IP Tracking
Requirement	The protocol shall track the IP address of each endpoint
Status	<in progress>
Rationale	To ensure accurate routing and maintain reliable communication paths
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0005
Title	Data transmission verification
Requirement	The protocol shall ensure successful data transmission
Status	<in progress>
Rationale	To guarantee data integrity and reliable end-to-end communication
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0006
Title	Connection management
Requirement	Protocol shall be able to initiate, maintain and recover the connection between applications
Status	<in progress>
Rationale	To ensure continuous data exchange and application interoperability
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0007
Title	Secure Connection Establishment
Requirement	Robust security measures shall be adopted
Status	<in progress>
Rationale	To authenticate and encrypt all connections, ensuring protection against unauthorised access, data breaches, and other cybersecurity threats
Category	<Functional> <Security>

Identifier	REQ-ATMACA-FRD-PR01.0008
Title	Real-Time Connection Health Monitoring
Requirement	Continuous monitoring shall be performed to assess the status and performance of connections in real time
Status	<in progress>
Rationale	To enable prompt detection and resolution of issues to maintain high reliability and quality of service (QoS)
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0009
Title	Multilink Support with Automatic Failover
Requirement	Multiple simultaneous connections shall be supported across diverse communication links (e.g., VDL Mode 2, SATCOM, LDACS), with automatic failover mechanisms
Status	<in progress>
Rationale	To enhance resilience and ensure uninterrupted connectivity
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0010
Title	Accessibility of the endpoints
Requirement	Protocol shall be able to access and list all ATC units and aircraft to be hand over to the related ATC units
Status	<in progress>
Rationale	To ensure accurate coordination and timely handover between ATC units during flight operations
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0011
Title	IP Mapping
Requirement	Protocol shall be able to perform IP mapping
Status	<in progress>
Rationale	To enable correct identification and routing of network endpoints
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0012
Title	IP Mapping
Requirement	Protocol shall be able to store all IPs relevant aircraft & ATC unit
Status	<in progress>
Rationale	To maintain up-to-date addressing information for secure and efficient communication
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0013
Title	Handover management
Requirement	The system shall be able to confirm and match the authorization of the user role to prevent wrong communication transfer
Status	<in progress>
Rationale	To ensure secure role-based access control and prevent unauthorized or erroneous communication actions
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0014
Title	Handover management
Requirement	The system shall be able to allow the user to return the previous communication channel upon user request
Status	<in progress>
Rationale	To enhance flexibility and ensure recovery in case of miscommunication or unintended handover
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0015
Title	Automatic handover of traffic between ATCos in different locations
Requirement	The system shall allow for automatic handover of flights as the aircraft transfers airspace
Status	<in progress>
Rationale	To ensure seamless control transfer and reduce manual workload during sector transitions
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0016
Title	Flexible handover of traffic between ATCos in different locations
Requirement	The system shall be able to transfer flights to any ACC connected to ATMACA based on ATCos request
Status	<in progress>
Rationale	To enable flexible coordination and seamless flight handover between integrated control centres
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0017
Title	Access to the applications
Requirement	The system should be able to select the session of the responsible ATC currently providing service to the aircraft
Status	<in progress>
Rationale	To ensure efficient operational coordination and minimize communication delays
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0018
Title	Traffic transfer in emergencies
Requirement	The system shall allow to transfer traffic to other ACCs in emergency situations
Status	<in progress>
Rationale	To ensure service continuity and maintain safety during contingency operations
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0019
Title	Managing flights via portable devices
Requirement	The system should allow the use of portable devices to manage flights in emergency scenarios
Status	<in progress>
Rationale	To ensure operational flexibility and maintain control capabilities in case of system disruptions
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0020
Title	Accessing the flight information
Requirement	The system shall allow ATCos to access its associated flight information
Status	<in progress>
Rationale	To increase the ATCos situational awareness with detailed information about the flight
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0021
Title	Transferring the associated flight session information
Requirement	The system shall transfer all applications' data associated to the flight during handovers between ATC units.
Status	<in progress>
Rationale	To ensure information consistency and maintain operational continuity during controller transitions.
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0022
Title	Backup and restore of flight session information
Requirement	The system shall ensure continuous access to flight information, storing it when connection problems are encountered
Status	<in progress>
Rationale	To maintain operational continuity and prevent data loss during network disruptions
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0023
Title	Content of the flight session
Requirement	The flight session shall include all flight information such as departure airport, arrival airport, type of aircraft, planned departure and arrival times, planned route points, ATC units etc
Status	<in progress>
Rationale	To ensure complete situational awareness of ATCo and support consistent information sharing across systems
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0024
Title	Transfer of the flight session
Requirement	The system shall allow to transfer one or more flight session from one ATC unit to another
Status	<in progress>
Rationale	To enable flexible delegation of flight control and ensure seamless coordination between ATC units
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0025
Title	Transfer of the flight session from physical to virtual ATC unit
Requirement	The solution shall allow to transfer one or more flight session from physical ATC unit to virtual ATC unit
Status	<in progress>
Rationale	To support dynamic reallocation of control responsibilities and enable remote or contingency operations
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0026
Title	Flight session management capabilities for different ATC unit
Requirement	The system shall be allowed to group, merge and separate flight sessions for a dedicated ATC unit or units
Status	<in progress>
Rationale	To provide operational flexibility in managing workload distribution across control sectors
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0027
Title	Initiating the session
Requirement	The system shall initialise the flight session once the aircraft registers and logs in
Status	<in progress>
Rationale	To ensure timely session setup and enable seamless integration into the air traffic management system
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0028
Title	Authentication of the session
Requirement	The system should authenticate the session by checking with Eurocontrol flights database
Status	<in progress>
Rationale	To validate flight data accuracy and ensure alignment with authoritative traffic information
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0029
Title	Connection of applications
Requirement	The applications shall connect to the session through ATMACA
Status	<in progress>
Rationale	To standardize session access and ensure consistent integration across applications
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0030
Title	Seamless connectivity
Requirement	The system shall initiate and maintain connectivity against network interruptions
Status	<in progress>
Rationale	To preserve operational continuity and prevent data or context loss during network interruptions.
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0031
Title	Storing flight session data
Requirement	The system shall store in the flight session information
Status	<in progress>
Rationale	To centralize operational data and enable consistent access throughout the session lifecycle
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0032
Title	Standby Message Retrieval on Disconnect
Requirement	The system shall ensure access to the flight session and standby messages when connection is lost
Status	<in progress>
Rationale	To maintain session continuity and prevent message loss during communication outages
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0033
Title	Managing datalink connections
Requirement	The system shall automatically manage all datalink connections
Status	<in progress>
Rationale	To ensure uninterrupted communication and reduce manual workload during operations
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0034
Title	IP Management
Requirement	The system shall provide IP management for all devices
Status	<in progress>
Rationale	To ensure reliable identification, routing, and communication across the network
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0035
Title	Contextual App Communication Management
Requirement	The system shall get the data from the aircraft with the applications needed for each phase of the flight after the first login
Status	<in progress>
Rationale	To ensure that aircraft have timely access to phase-specific functionalities and support mission-critical operations
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0036
Title	Connectivity Check and User Notification
Requirement	The system shall automatically check the connection status and communicate it to other users
Status	<in progress>
Rationale	To support situational awareness and enable timely action in case of connectivity issues
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0037
Title	Connection recovery
Requirement	The system shall automatically reconnect when connection is lost.
Status	<in progress>
Rationale	To minimize communication downtime and maintain operational continuity.
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0038
Title	Flight session management
Requirement	Each session shall maintain a structured set of attributes and shall be dynamically updated throughout its lifecycle to reflect changes in network status and operational parameters.
Status	<in progress>
Rationale	To ensure proper tracking, continuity, and security.
Category	<Functional> <Security>

Identifier	REQ-ATMACA-FRD-PR01.0039
Title	Seamless Session Continuity
Requirement	Session continuity shall be preserved during aircraft transitions across ATSUs or underlying network infrastructures
Status	<in progress>
Rationale	To ensure uninterrupted communication and seamless data exchange during network or service unit handovers
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0040
Title	Resilient and Secure Session Management
Requirement	Session replication and monitoring shall be implemented
Status	<in progress>
Rationale	To enhance availability, redundancy, and security
Category	<Functional> <Security>

Identifier	REQ-ATMACA-FRD-PR01.0041
Title	Cross-Domain Session Management
Requirement	The system shall manage sessions securely, continuously, and interoperability across different airspaces, network security domains, and operational jurisdictions, in full compliance with applicable regulatory and technical constraints
Status	<in progress>
Rationale	To ensure seamless, compliant, and secure session handling across complex operational and regulatory environments
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0042
Title	Terminal Mobility
Requirement	Continuous network connectivity shall be maintained for aircraft regardless of changes in their physical location
Status	<in progress>
Rationale	To ensure seamless communication as the aircraft changes position
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0043
Title	User Mobility
Requirement	Access shall be seamless and persistent for authorised users (e.g., pilots, ATCos and supervisors), irrespective of transitions between terminals or devices
Status	<in progress>
Rationale	To ensure continuous availability of network services
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0044
Title	Session Mobility
Requirement	Ongoing communication sessions shall be maintained seamlessly during transitions between different aeronautical communication datalink technologies
Status	<in progress>
Rationale	To ensure continuity of service
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0045
Title	Service Mobility
Requirement	Service shall be preserved without degradation or interruption, regardless of changes in the underlying network connectivity
Status	<in progress>
Rationale	To ensure continuous system operation and maintain user trust under varying network conditions
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0046
Title	Context Preservation for Service Continuity
Requirement	Essential session information, including authentication states and QoS parameters, shall be preserved during mobility events
Status	<in progress>
Rationale	To support uninterrupted and consistent service delivery
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0047
Title	Air-ground data transmission
Requirement	Protocol shall be able to transmit wind and temperature data provided by pilot from A/C to GRO server continuously
Status	<in progress>
Rationale	To provide the GRO system with up-to-date meteorological inputs for dynamic route optimization and eco-efficient flight planning.
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0048
Title	Ground-ground data transfer
Requirement	Protocol shall be able to transmit route advisories from GRO server to planner ATC & A/C periodically or on request
Status	<in progress>
Rationale	To enable flexible and timely delivery of optimized route information, supporting dynamic planning and coordination
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0049
Title	Communicate and receive real-time wind and weather data, along with ETA and other trajectory information
Requirement	The system should allow for real-time data communication through ATMACA instant messaging
Status	<in progress>
Rationale	To ensure immediate, seamless communication between systems and support time-sensitive operations
Category	<Functional>

Identifier	REQ-ATMACA-FRD-PR01.0050
Title	Communicate and receive real-time wind and weather data, along with ETA and other trajectory information
Requirement	GRO shall connect to all necessary applications and share related wind, weather and trajectory data
Status	<in progress>
Rationale	To ensure seamless integration and optimal data flow between systems, supporting accurate and timely decision-making
Category	<Functional>

4.3 APPLICATIONS

4.3.1 General

Identifier	REQ-ATMACA-FRD-AP01.0001
Title	Standardized File Structure Usage in Applications
Requirement	All applications shall be able to properly use predefined file structure for network communication
Status	<in progress>
Rationale	To ensure data consistency and compatibility across all system components
Category	<Functional>

Identifier	REQ-ATMACA-FRD-AP01.0002
Title	Data back-up for safety and security
Requirement	All applications shall be able to store all data as backup and recovery for security and safety purposes
Status	<in progress>
Rationale	To prevent data loss and support system restoration in case of failures
Category	<Functional>

Identifier	REQ-ATMACA-FRD-AP01.0003
Title	Handover initiation
Requirement	Application shall be able to perform automatic handover upon the ATC instructions or manual handover upon pilot's inputs
Status	<in progress>
Rationale	To ensure that control transitions are executed accurately and in compliance with ATC commands
Category	<Functional>

Identifier	REQ-ATMACA-FRD-AP01.0004
Title	Access to the applications
Requirement	The system should be able to select the session of the responsible ATC currently providing service to the aircraft
Status	<in progress>
Rationale	To ensure efficient operational coordination and minimize communication delays
Category	<Functional>

Identifier	REQ-ATMACA-FRD-AP01.0005
Title	Connection of applications
Requirement	The applications shall access to the sessions through ATMACA
Status	<in progress>
Rationale	To standardize session access and ensure consistent integration across applications
Category	<Functional>

Identifier	REQ-ATMACA-FRD-AP01.0006
Title	Storing flight session data
Requirement	The applications shall send all associated flight data and messages to be stored on the flight session
Status	<in progress>
Rationale	To ensure centralized storage of operational data and support consistent session tracking
Category	<Functional>

Identifier	REQ-ATMACA-FRD-AP01.0007
Title	Managing datalink connections
Requirement	The system shall automatically manage all datalink connections
Status	<in progress>
Rationale	To ensure uninterrupted communication and reduce manual workload during operations
Category	<Functional>

Identifier	REQ-ATMACA-FRD-AP01.0008
Title	Contextual App Communication Management
Requirement	The system shall get the data from the aircraft with the applications needed for each phase of the flight after the first login
Status	<in progress>
Rationale	To ensure that aircraft have timely access to phase-specific functionalities and support mission-critical operations
Category	<Functional>

4.3.2 CPDLC

Identifier	REQ-ATMACA-FRD-AP02.0001
Title	Maintaining CPDLC Connection
Requirement	The CPDLC connection shall preserve the active flight session and maintain connectivity resilient against network interruptions
Status	<in progress>
Rationale	To preserve operational continuity and prevent data or context loss during network interruptions
Category	<Functional><Safety>

Identifier	REQ-ATMACA-FRD-AP02.0002
Title	CPDLC messaging structure
Requirement	CPDLC shall allow to write and send through ATMACA standard and free text CPDLC message
Status	<in progress>
Rationale	To ensure standard and customized messaging for air-to-ground communication
Category	<Functional>

Identifier	REQ-ATMACA-FRD-AP02.0003
Title	Transferring the associated flight session information
Requirement	The system shall transfer all applications' data associated to the flight during handovers between ATC units
Status	<in progress>
Rationale	To ensure information consistency and maintain operational continuity during controller transitions
Category	<Functional>

Identifier	REQ-ATMACA-FRD-AP02.0004
Title	Communicate and receive real-time wind and weather data, along with ETA and other trajectory information
Requirement	The system should allow for real-time data communication through ATMACA instant messaging
Status	<in progress>
Rationale	To ensure immediate, seamless communication between systems and support time-sensitive operations
Category	<Functional>

4.3.3 DLCM

Identifier	REQ-ATMACA-FRD-AP03.0001
Title	CPDLC Session Establishment and Context Management
Requirement	DLCM shall establish CPDLC datalink connections and manage flight session context
Status	<in progress>
Rationale	To ensure seamless and reliable communication throughout the flight by maintaining CPDLC session establishment and context management
Category	<Functional>

Identifier	REQ-ATMACA-FRD-AP03.0002
Title	Seamless connectivity
Requirement	The system shall initiate and maintain connectivity against network interruptions
Status	<in progress>
Rationale	To preserve operational continuity and prevent data or context loss during network interruptions
Category	<Functional>

4.3.4 GRO

Identifier	REQ-ATMACA-FRD-AP04.0001
Title	Data Access
Requirement	GRO: shall be able to access accurate position, wind and temperature data from A/C
Status	<in progress>
Rationale	To enable optimal route planning based on real-time atmospheric conditions and support fuel-efficient, eco-friendly operations
Category	<Functional>

Identifier	REQ-ATMACA-FRD-AP04.0002
Title	Air-ground data transmission
Requirement	The protocol shall be capable of continuously transmitting instantaneous wind and temperature data from the A/C's FMS to the GRO server
Status	<in progress>
Rationale	To provide the GRO system with up-to-date meteorological inputs for dynamic route optimization and eco-efficient flight planning
Category	<Functional>

Identifier	REQ-ATMACA-FRD-AP04.0003
Title	Data storage and progress capacity
Requirement	GRO should be capable of storing and processing the necessary and enough data
Status	<in progress>
Rationale	To support real-time analysis, optimize route recommendations, and handle continuous input from multiple aircraft
Category	<Functional>

Identifier	REQ-ATMACA-FRD-AP04.0004
Title	Communicate and receive real-time wind and weather data, along with ETA and other trajectory information
Requirement	The system should allow for real-time data communication through ATMACA instant messaging
Status	<in progress>
Rationale	To ensure immediate, seamless communication between systems and support time-sensitive operations
Category	<Functional>

Identifier	REQ-ATMACA-FRD-AP04.0005
Title	Communicate and receive real-time wind and weather data, along with ETA and other trajectory information
Requirement	GRO shall connect to all necessary applications and share related wind, weather and trajectory data
Status	<in progress>
Rationale	To ensure seamless integration and optimal data flow between systems, supporting accurate and timely decision-making
Category	<Functional>

4.4 HMIs

Identifier	REQ-ATMACA-FRD-HM01.0001
Title	Displaying actively connected flight
Requirement	HMI shall be able to display the list of connected aircraft on ATCo screen
Status	<in progress>
Rationale	To provide air traffic controllers with real-time situational awareness and facilitate efficient monitoring and management of aircraft communication links
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0002
Title	Displaying user login status
Requirement	HMI shall be able to indicate the user about the login status
Status	<in progress>
Rationale	To provide clear feedback on authentication state and improve user interaction with the system
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0003
Title	User login/logout authentication
Requirement	The system shall be able to inform the user about its presence, whether logged in or logged out
Status	<in progress>
Rationale	To enhance user awareness and system transparency during session transitions
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0004
Title	Accessibility of the applications
Requirement	Applications shall be easily reachable with single request on the ATCo screen
Status	<in progress>
Rationale	To improve usability and enable quick access during operational tasks
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0005
Title	Display ATCos in the related sectors along the flight route
Requirement	HMI shall be able to display ATCos in the related sectors along the flight route and allow the pilot to select and contact them easily
Status	<in progress>
Rationale	To facilitate efficient communication and reduce pilot workload during sector transitions
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0006
Title	Display ATCos in the related sectors along the flight route
Requirement	HMI shall be able to display ATCos in the related sectors along the flight route and allow the pilot to easily select and contact them
Status	<in progress>
Rationale	To facilitate efficient communication and reduce pilot workload during sector transitions
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0007
Title	Displaying active ATCo list
Requirement	HMI shall be able to list all active ATCo positions
Status	<in progress>
Rationale	To provide pilots and systems with real-time visibility of available ATCo resources for coordination and communication
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0008
Title	Communication modalities
Requirement	HMI shall enable the pilot and ATCos to communicate through diverse modalities such as voice calls, messages, etc.
Status	<in progress>
Rationale	To increase communication flexibility and ensure operational continuity under various conditions
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0009
Title	Sharing information/files
Requirement	The HMI shall enable the pilot and ATCos to share information or files, such as datasets, text documents, or images, through a structured and secure file-sharing mechanism that adheres to predefined formats and complies with relevant security and access control protocols
Status	<in progress>
Rationale	To increase communication flexibility and ensure operational continuity
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0010
Title	Knowledge of active communication channels
Requirement	HMI shall be able to list of past/present/future ATC unit endpoints
Status	<in progress>
Rationale	To provide traceability of communication history and assist in planning upcoming sector transitions
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0011
Title	Handover management
Requirement	The HMI shall be able to allow the user to return the previous communication channel upon user request
Status	<in progress>
Rationale	To enhance flexibility and ensure recovery in case of miscommunication or unintended handover
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0012
Title	Handover management
Requirement	The HMI system should guide the pilot with giving the next control unit
Status	<in progress>
Rationale	To support timely and accurate handovers between control units during flight operations
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0013
Title	Handover of traffic between ATCos in different locations
Requirement	The HMI should display the handover process to both ATCos, allowing for easy visualization and control
Status	<in progress>
Rationale	To improve situational awareness and coordination between controllers during handover operations
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0014
Title	Transferring the associated flight session information
Requirement	The HMI shall optimally display all context information received
Status	<in progress>
Rationale	To enhance user awareness and support accurate interpretation of operational context
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0015
Title	Handover management
Requirement	The HMI shall integrate visual and audio alerts to notify controllers of pending or completed handoffs
Status	<in progress>
Rationale	To improve controller awareness and reduce the risk of missed or delayed coordination during handover processes
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0016
Title	Flight session management capabilities for different ATC unit
Requirement	The HMI shall be allowed to group, merge and separate flight sessions for a dedicated ATC unit or units
Status	<in progress>
Rationale	To provide operational flexibility in managing workload distribution across control sectors
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0017
Title	Initiating the session
Requirement	The HMI shall visually display the login process
Status	<in progress>
Rationale	To provide user feedback and enhance transparency during authentication
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0018
Title	Storing flight session data
Requirement	The HMI shall allow to easily visualize flight data stored in the flight session
Status	<in progress>
Rationale	To enhance situational awareness and facilitate quick access to relevant flight data
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0019
Title	Dynamic session management
Requirement	The HMI shall display real-time session status to ensure controllers have clear situational awareness
Status	<in progress>
Rationale	To support timely decision-making and reduce the risk of miscommunication during flight operations
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0020
Title	Dynamic session management
Requirement	The HMI shall enable multi-user access, allowing supervisors to monitor and intervene if necessary
Status	<in progress>
Rationale	To ensure operational oversight and support collaborative control in critical situations
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0021
Title	All in one HMI
Requirement	The HMI for the pilots shall be all in one structure. All related application can be accessible on the same hardware with application dedicated windows
Status	<in progress>
Rationale	To simplify pilot interaction, reduce workload, and ensure quick access to all necessary tools in a unified interface
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0022
Title	Operational environment for the HMI
Requirement	The HMI shall be executable for tablet computers
Status	<in progress>
Rationale	To support mobility and ensure access to HMI functionalities in portable environments
Category	<HMI> <Functional>

Identifier	REQ-ATMACA-FRD-HM01.0023
Title	Information and warning display
Requirement	The HMI shall present all information and warnings to the pilot clearly and comprehensibly
Status	<in progress>
Rationale	To ensure effective pilot response and reduce the risk of misinterpretation during operations
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0024
Title	Information and warning display
Requirement	The HMI shall prioritize the warnings to be communicated to the pilot according to their importance and present these warnings to the pilot by indicating and observing their priority
Status	<in progress>
Rationale	To help pilots focus on the most critical issues and support timely decision-making in high-workload environments
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0025
Title	Managing datalink connections
Requirement	The HMI shall display communication status and datalink information and messages
Status	<in progress>
Rationale	To provide users with real-time insight into communication health and message flow for operational awareness
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0026
Title	Standardized communication
Requirement	The HMI shall support concise and standardized communication, reducing unnecessary dialogue
Status	<in progress>
Rationale	To improve communication efficiency and minimize controller and pilot workload
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0027
Title	Phraseology suggestions
Requirement	The HMI shall provide automated phraseology suggestions of CPDLC to assist with standard ATC communication
Status	<in progress>
Rationale	To ensure consistency in controller-pilot communication and reduce the risk of misinterpretation
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0028
Title	Standardized communication
Requirement	The HMI shall integrate visual indicators to show if a pilot is transmitting, preventing overlapping transmissions
Status	<in progress>
Rationale	To reduce communication conflicts and improve clarity during simultaneous transmission scenarios
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0029
Title	Information to be presented to the user
Requirement	HMI shall be able to display route advisory information from GRO server to ATC & A/C screen
Status	<in progress>
Rationale	To ensure that both controllers and pilots receive synchronized route optimization guidance for enhanced decision-making
Category	<HMI>

Identifier	REQ-ATMACA-FRD-HM01.0030
Title	Information to be presented to the user
Requirement	The HMI should display GRO data, including real-time wind and weather information, ETA, and other trajectory details communicated and received during the operation
Status	<in progress>
Rationale	To ensure that relevant route optimization data is visible and accessible for decision-making during operations
Category	<HMI>

4.5 Contingency

Identifier	REQ-ATMACA-FRD-CT01.0001
Title	Data back-up for safety and security
Requirement	All applications shall be able to store all data as backup and recovery for security and safety purposes
Status	<in progress>
Rationale	To prevent data loss and support system restoration in case of failures
Category	<Safety> <Security>

Identifier	REQ-ATMACA-FRD-CT01.0002
Title	Handover of traffic between ATCos in different locations
Requirement	The system shall allow to transfer traffic to other ACCs in emergency situations
Status	<in progress>
Rationale	To ensure service continuity and maintain safety during contingency operations
Category	<Functional>

Identifier	REQ-ATMACA-FRD-CT01.0003
Title	Managing flights via portable devices
Requirement	The system should allow the use of portable devices to manage flights in emergency scenarios
Status	<in progress>
Rationale	To ensure operational flexibility and maintain control capabilities in case of system disruptions
Category	<Functional>

Identifier	REQ-ATMACA-FRD-CT01.0004
Title	Backup and restore of flight session information
Requirement	The system shall ensure continuous access to flight information, storing it when connection problems are encountered
Status	<in progress>
Rationale	To maintain operational continuity and prevent data loss during network disruptions
Category	<Functional>

Identifier	REQ-ATMACA-FRD-CT01.0005
Title	Seamless connectivity
Requirement	The system shall initiate and maintain connectivity against network interruptions
Status	<in progress>
Rationale	To preserve operational continuity and prevent data or context loss during network interruptions
Category	<Functional>

Identifier	REQ-ATMACA-FRD-CT01.0006
Title	Standby Message Retrieval on Disconnect
Requirement	The system shall ensure access to the flight session and standby messages when connection is lost
Status	<in progress>
Rationale	To maintain session continuity and prevent message loss during communication outages
Category	<Functional>

Identifier	REQ-ATMACA-FRD-CT01.0007
Title	Connectivity Check and User Notification
Requirement	The system shall automatically check the connection status and communicate it to other users
Status	<in progress>
Rationale	To support situational awareness and enable timely action in case of connectivity issues
Category	<Functional>

Identifier	REQ-ATMACA-FRD-CT01.0008
Title	Connection recovery
Requirement	The system shall automatically reconnect when connection is lost
Status	<in progress>
Rationale	To minimize communication downtime and maintain operational continuity
Category	<Functional>

5 Assumptions

This chapter lists the assumptions applicable to the ATMACA SESAR solution, focusing on those that may influence the functional requirements defined in Chapter 4. These assumptions cover network infrastructure, system capabilities, operational environment, and service dependencies, ensuring that the functional design remains coherent and traceable across different stages of SESAR solution maturity.

5.1 Common assumptions for SESAR solution ATMACA

Existing ATN/IPS Network Availability

It is assumed that an operational, IP-based ATN/IPS network infrastructure is available between airborne and ground systems. The ATN/IPS network provides baseline connectivity, security, and Quality of Service (QoS) guarantees required by ATMACA.

Multilink Communication Infrastructure:

The multilink environment (e.g., LDACS, SATCOM, AeroMACS) is assumed to be available and interoperable with ATN/IPS transport layers, enabling seamless mobility and handover management.

Aircraft Systems Support ATN/IPS Standards

Aircraft avionics (specifically CMU, FMS, and datalink units) are assumed to be capable of operating over ATN/IPS, supporting basic network layer functionality necessary for ATMACA-enabled applications.

Compliance with SWIM and FCI

ATMACA solutions build upon System-Wide Information Management (SWIM) and Future Communication Infrastructure (FCI), and it is fully compatible with them.

No Changes to Physical Layer Protocols

ATMACA operates at the datalink, session, and application layers. Changes or developments to the physical transmission media (e.g., new radios, modems) are outside the scope of this solution and are assumed to be available and interoperable.

Compliance with SESAR Operational Concepts

The deployment of ATMACA assumes alignment with SESAR operational concepts for Trajectory-Based Operations (TBO), Green Route Operations (GRO), and Digital Air–Ground Communications.

Interoperability with Existing ATC Systems

It is assumed that ATC automation systems, ATSUs, and Controller Working Positions (CWPs) will evolve to accommodate flight session awareness, enhanced datalink messaging, and mobility event reporting as required by ATMACA.

Use of Commercial-Off-The-Shelf (COTS) Products

Integration with COTS networking and computing platforms is assumed to be feasible, leveraging standardised interfaces and protocols without the need for proprietary hardware.

Safety and Performance Framework Consistency

It is assumed that safety and performance requirements for datalink communications (e.g., latency, availability, continuity) as outlined in existing SESAR performance frameworks are applicable and will guide future validation activities.

5.2 Specific assumptions for ATMACA Datalink Protocol

The ATMACA protocol layer will rely on existing IP-based transport services without modifying lower layers.

Security services (e.g., encryption, authentication) will be provided externally or by existing ATN/IPS network layers.

5.3 Context Management Application (CMA)

CMA assumes consistent availability of session-related metadata (e.g., aircraft ID, flight plan ID, network identifiers) from ATSUs and aircraft.

CMA requires interoperability with SWIM information exchange models to share context data with ground-based ATM systems.

5.4 Advanced Operational Applications (CPDLC, GRO)

CPDLC assume that standard ATS B1 services are implemented and operational under ATN/IPS.

GRO applications assume the availability of real-time atmospheric data shared between aircraft and ground systems via datalink.

Operational use of GRO requires coordinated trajectory prediction services at ground-based systems (e.g., NM services).

5.5 Human–Machine Interfaces (HMIs)

HMIs assume that controller and flight deck interfaces will be upgraded or adapted to visualise datalink session states, link quality, and service continuity indicators.

It is assumed that HMIs will integrate new operational alerts (e.g., session handover, mobility events) in a non-intrusive manner, respecting human factors guidelines. Also integrate the context information and operational applications (CPDLC) without increasing workload.

6 References

6.1 Applicable documents

This FRD complies with the requirements set out in the following documents:

Content integration

[1] Common Taxonomy, ed. 01.00

[2] Content Integration – Executive Overview, ed. 00.01

Content development

[3] DES HE SESAR solution ATMACA OSED, ed. 01.05

System and service development

[4] ICAO 10039 - Manual on the System-wide Information Management (SWIM) Concept - First Edition

[5] ICAO 10203 - Manual on the System-wide Information Management (SWIM) Implementation - First Edition

[6] ICAO 9896 - Manual on the Aeronautical Telecommunication Network (ATN) using Internet Protocol Suite (IPS) Standards and Protocol - Second Edition

[7] EUROCAE ED-315 - Minimum Aviation System Performance Standard on ATN/IPS End-to-end Interoperability and Certification

Performance management

[8] DES Performance Framework, ed. 00.01.04

[9] DES Common Assumptions, ed. 00.02.01

Validation

[10] DES HE Requirements and Validation/Demonstration Guidelines, ed. 03.00

[11]EUROCONTROL European Operational Concept Validation Methodology (E-OCVM), Ver. 3

System engineering

[12] SESAR Operational Concept Document OCD 2023, ed. 02.00.00

[13] DES Maturity Gate Guidance, ed. 02.00.00

[14] SESAR 2020 Architecture Description Document PJ.19 W2 CI: ADD (2023), ed. 01.01.00

Safety

[15] DES Expanded Safety Reference Material (E-SRM), ed. 1.2

[16] EUROCONTROL Guidance to Applying the Expanded Safety Reference Material (E-SRM), ed. 1.1

Human performance

[17] SESAR Human Performance Assessment Process TRL0-TRL8, ed. 00.04.02

Environment assessment

[18] SESAR Environment Assessment process, ed. 05.00

[19] ICAO 10031 - Guidance on Environmental Assessment of Proposed Air Traffic Management Operational Changes - First Edition

Security

[20] DES security risk assessment methodology (SecRAM 2.0), ed. 03.00.01

Project and programme management

[21] ATMACA Grant Agreement n. 101167070, 25/06/2024

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