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Copyright Statement

PJ.14-W2 I-CNSS

INTEGRATED COMMUNICATION, NAVIGATION AND SURVEILLANCE SYSTEM

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Abstract

The objective of PJ14-W2-77 solution Task 03 is to define the specification of the Future Communication Infrastructure (FCI) solution, which is an enabling technology for Air Traffic Control as well as Airlines Operational Communications services. The FCI is a new IPv6-based, worldwide Air-Ground and Ground-Ground communications infrastructure; for the Air-Ground segment it is based on new broadband A/G data links, i.e. Long-term standards like Long Term IP SATCOM (Class A), LDACS, AeroMACS and IP VDLM2. However, it is extensible to integrate other data link technologies and to interoperate with other existing networks as ATN-OSI, Military networks, ACARS/FANS and Public Open Networks (see PJ.14-W2-61 "Hyper Connected ATM").

The target is to reach TRL6 maturity within the end of Wave 2.

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1 Executive summary

This deliverable defines the TRL6 Final TS/IRS and TRL6 Architecture of the Future Communication Infrastructure (FCI), developed in the PJ.14-W2-77 solution and it aims at achieving and validating the TRL6 maturity level to support ATS B2 services, future ATS B3 services, AOC services, AIS/AIM, MET and safety SWIM services, as well as interoperability with ATN/OSI, ACARS/FANS, MIL and Public Open Networks systems and infrastructure (see Figure 2 "Logical view of the FCI" in [2]).The "future ATS B3 services will not be validated but the QoS required by these services are provided by FCI."

This document updates the Initial TS/IRS delivered in July 2021 ([23]) with the feedbacks collected in the validation exercises ,whose results are reported in the TVALR deliverable ([25]), and from the ICAO WG-I standardization activities of 2021 and 2022. The Final TS/IRS includes also the updates to the requirements based on the review and the feedbacks received by PJ19 over the Solution 77 MEGA model and NSVs in EATMA.

The FCI and the data links should also be able to support new future digital voice functionality (e.g. sector-less voice communication) as well as civil-military coordination through the ground/ground communication segment.
This deliverable has been written and reviewed by SESAR PJ14-W2-77 solution "FCI Services" as part of Task 3 of Solution 77. Task03 is aimed at specifying the Technical Requirements and Interfaces definition of the FCI that will support the "Overall Concept of Operation"[2].

This deliverable defines the flexible use of the four Data Links through the definition and specification of the Multilink function, as well as of the global IP Mobility solution and the support for specific security features.
The major updates are related to these areas and topics of TRL6 TS/IRS:

- New FCI ConOps [2] requirements that have impact on the FCI architecture and FCI requirements;
- Update of FCI Ground ATN according to Network to GB-LISP profile requirements [39];
- A-R and AGMI Proxy requirements for the assessment of IF9 (AGMI) protocol specification;
- Harmonization of Safety and Security requirements Specification.
- IP VDLM2 integration in the Multilink management and FCI architecture;
- FCI digital voice requirements (not addressed in this Initial TS/IRS);
- New A/G security requirements to include DTLS protocol for the user applications;
- New scenarios have been specified and defined in the EATMA/MEGA NSV-4 technical view, according to the new FCI ConOps inputs[2].
- Assessment and update of NSV-1, NSV-2 and NSV-4 technical view described in the MEGA tools.

2 Introduction

This is the Technical Specification and Interface Requirements Specification (TS/IRS) for the Future Communication Infrastructure (FCI), implemented as future ATM communication infrastructure to offer the communication services needed to convey data (and voice) flows over the Ground-Ground and Air-Ground segments and to support the required Concept of Operations [2].

This document provides the requirements specification and covers functional, non-functional as well as interface requirements related to SESAR Technological Solution PJ.14-W2-77.
For each Functional Block, the solution has specified the elements that are essential to achieve the TRL6 maturity level:

- Functional Requirements;
- Interface Requirements;
- Security Assumptions, Requirements and design constraints;
- MEGA architecture and Data Model definitions;
- Performance requirements;
- Physical characteristics;
- Environmental and facility conditions

For each EATMA/MEGA Functional Block element we have identified what already existed from the previous Wave 1 project PJ14.02.04 and the new elements and specifications in the TRL6 description.
The term “Functional Block” will be used in this document with the meaning of “ATM subsystems”, according to the architecture description reported in the DS21 draft EATMA/MEGA tool.

The TS/IRS document captures the impacted EATMA/MEGA views that help the validation scenarios execution and the reporting of the validation results.

2.1 Purpose of the document

The TS/IRS provides information so as to allow the Functional Block to be designed and implemented either as separate functional block or as part of an integrated system.

This document provides the architectural viewpoints description and the requirements specification covering functional, non-functional and interface requirements concerning the FCI technical system.

The architecture is a set of “Technical Systems” that are broken in a set of Functional Blocks (ATM subsystem).

These Functional Blocks (FB) in the scope of the PJ14-W2-77 solution have been specified in the document:

- FCI Airborne Router (A-R), which is part of the Airborne IPS System[1];
- FCI Access Router (AC-R)
- FCI A/G Router (A/G-R)
- FCI AGMI Proxy
- FCI Mobility Service Endpoint (MSE) that include the MS/MR GB-LISP function;
- FCI Ground-Ground Router (G/G)
- FCI IPS Gateways (IPS GW)
- FCI CIV-MIL Gateways (CIV-MIL GW)
- FCI Ground Support Systems
- FCI Security Service Systems
- FCI AGMI endpoint (airborne)
- FCI Simple name lookup server
- FCI Ground DNS server
- FCI Hyper connected ATM GW (HCATM-GW)
- FCI Airborne Safety-critical Systems

In the table below we show the mapping among technical systems and the Functional Blocks, which are impacted by the TS/IRS requirements and are building elements of the FCI Architecture:

[1] According to the design specified in ARINC PP858 [21])

Configuration Capability (CC)	Technical System (TS)	Functional Block (FB)
Civil Aircraft	Aircraft	Airborne Router
Civil Aircraft	Aircraft	AGMI endpoint (airborne)
Civil Aircraft	Aircraft	Simple name lookup server
Civil Aircraft	Aircraft	Airborne Safety-critical Systems
Communication Infrastructure	Routing Networking Equipment for A/G Datalink	A/G-R, AC-R
Communication Infrastructure	Ground ATM Networks	G/G-R, MSE(MS/MR),
Communication Infrastructure	OSI-IPS Gateway	IPS-GW
Communication Infrastructure	IPS-OSI Gateway	IPS-GW
Communication Infrastructure	Civil Military Gateway	CIV-MIL GW[2]
Management Infrastructure	Ground Support Systems	NMS

Table 1- FIC Service - MEGA Configuration Capability

[2] The ground-ground CIL-MIL GW is developed by Pj14-W2-101 GREEN SWIM Profile and the integration is EATMA/MEGA is done by this solution.

2.2 Scope

This document contains the FCI TS/IRS requirements to achieve the TRL6 maturity level of FCI solutions for the solution Capabilities and functional specification.

This is the Technical Specification / Interface Requirements Specification TS/IRS) for the Future Communication Infrastructure, that shall be implemented by Communication Service Providers (CSP) and shall offer the communication services needed to convey data (and voice) flows over the Ground-Ground and Air-Ground segments.
This document includes the FCI architecture definition and the requirements that should support the validation activities and support the service migration activities that will be described in the Task02 deliverable (D5.1.800 – PJ14-W2-77 TRL6 Deployment and Transition Strategy FCI Services).

See also section 2 Introduction.

2.3 Intended readership

The SESAR intended audience for this document is other PJ.14-W2 I-CNSS team members and related Solutions, namely Sol 60, Sol61, Sol107, Sol100, as well as PJ19.02 and PJ19.04 Transversal Activities projects.

External to the SESAR Programme, other stakeholders are to be found among:

- Standardization Bodies (EUROCAE WG 108, RTCA SC 223, ICAO WG-I/Mobility and WG-I/Security);
- Air Navigation Service Providers (ANSP);
- AOC service providers;
- Airport owners/providers;
- Airspace Users (AU);
- Industry.

2.4 Background

This document reports the TS and architecture solution update required for achieving the TRL6 maturity at the end of W2 phase. The document is an update and improvement of the previous TS/IRS document delivered for the W1 TRL4 phase (PJ14.02.04 D5.4.010), having the FCI Solution previously achieved the TRL4 maturity status as PJ14.02.04 W1 solution.

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2.5 Structure of the document

The delivery is composed by these parts:

- This delivery (Part I) covers the main body of the Technical Specification/Interface Requirement Specification.
- For a Technological Solution, Part II covers the Technological Safety Assessment Report (SAR) that describes the safety assessment work done for the SESAR Solution.
- For a Technological Solution, Part III covers the Security Assessment Report (SecAR) that describes the security risk assessment work done for the SESAR Solution.

Note: The Safety (0) and Security (4.2.7) requirements are updated with the new Wave 2 Safety and Security Risk Assessment results, which are documented in the D5.1.120 – Final TS/IRS Part II SAR and Part III SecAR.

2.6 Glossary of terms

Term	Definition	Source
4DwxCube	A virtual repository of MET information, produced by multiple contributors (MET service providers), from diverse locations, that will provide end users with a common weather picture. The 4DwxCube can be viewed as the interface between SWIM and providers of MET information, being a single point of contact for all ATM MET information. It will 'hide' the complexity of the MET system infrastructure from the ATM domain. This net centric approach allows each request over SWIM for MET information, to be directed in the most optimal way, to return the required result(s), irrespective of data origin. Standards and specifications developed and used by the 4DwxCube will be layered on top of core services provided by the SWIM infrastructure	SESAR Integrated Dictionary
4D trajectory	The 4D trajectory is: - the lateral path consisting of route waypoints, and - the vertical path consisting of the predicted altitude and vertical constraints, if any, at each of the waypoints forming the lateral path, and - the predicted speed and speed constraints, if any, at each of the waypoints forming the lateral path, and - the predicted time and time constraints, if any, at each of the waypoints forming the lateral path.	PJ.14.02.04 TRL4 Initial Concept Description
ADS-C	A means by which the terms of an ADS-C agreement will be exchanged between the ground system and the aircraft, via a data link, specifying under what conditions ADS-C reports would be initiated, and what data would be contained in the reports.	SESAR Integrated Dictionary

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Term	Definition	Source
A/G Data Link system (AG DL)	A future ground-based communication system that is providing A/G datalink communications with aircraft to allow data bidirectional exchanging between ground and aircraft for operational purposes.	SOL 77
Aircraft Derived Data	A generic term that refers to avionics data transmitted from the aircraft to the ground and possibly to other aircraft for surveillance application. These data may be displayed to the Air Traffic Controller (ATCO) or used in ground processing functions. These data can include both data from the FMS and from on-board sensors (e.g. altitude, air-velocity, humidity, pressure) and can be transmitted by several technical means such as SSR, ADS-B, ADS-C.	PJ.14.02.04 TRL4 Initial Concept Description
ATC Clearance	Authorization for an aircraft to proceed under conditions specified by an air traffic control unit. Note 2.— The abbreviated term “clearance” may be prefixed by the words “taxi”, “take-off”, “departure”, “En Route”, “approach” or “landing” to indicate the particular portion of flight to which the air traffic control clearance relates.	ICAO Doc 4444
ATC Instruction	Directives issued by air traffic control for the purpose of requiring a Flight Crew to take a specific action.	ICAO Doc 4444]
AGMI	The Air Ground Mobility Interface being standardized by the ICAO WG-I Mobility Subgroup	ICAO WG-I Mobility Subgroup
Airborne IPS system	The collection of airborne components and functions that provide ATN/IPS services	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
Application	The ultimate use of an information system, as distinguished from the system itself.	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
APT (Airport)	Consists of the airport surface and immediate vicinity around the airport, typically an area of 10 miles in diameter and up to ~5000 feet above ground level.	ED228A

Term	Definition	Source
ATC – Air Traffic Control	A service operated by an appropriate authority to promote the safe, orderly, and expeditious flow of air traffic.	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
ATM system	A system that provides ATM through the collaborative integration of humans, information, technology, facilities, and services, supported by air and ground- and/or space-based communications, navigation, and surveillance	ICAO Doc 4444]
ATN – Aeronautical Telecommunication Network	A global internetwork architecture that allows ground, air-ground and avionic data subnetworks to exchange digital data for the safety of air navigation and for the regular, efficient, and economic operation of air traffic services.	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
ATN/IPS – Aeronautical Telecommunication Network/Internet Protocol Suite	The set of technical provisions and standards that define the architecture and operation of Internet Protocol-based networking services.	ATN/IPS – Aeronautical Telecommunication Network/Internet Protocol Suite
ATS – Air Traffic Service	A generic term meaning variously, flight information service, alerting service, air traffic advisory service, or air traffic control service (area control service, approach control service or aerodrome control service).	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
ATSU – Air Traffic Services Unit	A generic term meaning variously, ATC unit, flight information centre, or ATC service area control services reporting office.	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
Autonomous system	A connected group of one or more IP prefixes, run by one or more network operators, which has a single, clearly defined routing policy	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
Availability	Availability is a system requirement, associated with the data communication service. Availability is a unit-less probability and is defined as the ratio between the time the system is actually available for service (MTBF) and the time the system is planned for service (MTTR + MTBF).	
Collaborative Decision Making	Collaborative decision making (CDM) is defined as a process focused on how to decide on a course of action articulated between two or more community members. Through this process, ATM community members share information related to	ICAO Doc 9971

Term	Definition	Source
	that decision and agree on and apply the decision-making approach and principles. The overall objective of the process is to improve the performance of the ATM system as a whole while balancing the needs of individual ATM community members. From a military perspective CDM is a process from which all participating parties can gain benefits through the negotiation of proposed options. The negotiation stops either at the moment when all participating parties agree with the result or when they reach a limit in their capability to accept further compromise due to defined priorities.	
Controlled Time Over (CTO)	Used by ground to describe time constraints originating from ATC. A CTO may be specified as At, At/Before, or At/After, and can include a specification of the allowable tolerance in meeting the constraint.	ED228A
Control Plane	Data exchanged to manage communication sessions between users. The control plane includes protocols providing information needed to move traffic from one device to another through the network. Routing protocols and DNS belong to the control plane.	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
DS – Dialog Service	Interface between the ATN applications and the ATN/OSI or ATN/IPS upper layer protocols via the control function.	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
ENR-1 (En-route)	Is a volume of controlled airspace that encloses the flight paths above and between airports where air traffic service in TMA is provided. Jet routes and airways are typically used to traverse the EN route airspace structure. The typical separation minima in this airspace are 3NM, 5NM, appropriate vertical and/or visual separation as required.	ED228A
ENR-2 (En-route)	Is a volume of controlled airspace that is characterized by the use of procedural control and the lack of ATS surveillance service provision. The airspace is typically characterized by the use of flex tracks and customized trajectories but may also use of fixed jet routes and airways. The typical separation minima in this airspace are 60NM to 100NM lateral, 80NM to 100NM longitudinal, 1000ft (RVSM) as required.	ED228A
EPP data	Specifies the aircraft predicted trajectory up to 128 waypoints including for each waypoint, Latitude, Longitude and when available, Fix, Level, ETA, Airspeed, Vertical type(s), Lateral type(s), Level constraint, Time constraint, Speed constraint. When available, provides the relevant data for the trajectory as	SESAR Integrated Dictionary

Term	Definition	Source
	Current gross mass and EPP trajectory intent status. It indicates the date and time these values were computed.	
Future A/G Data Links	A future ground-based communication system (identified as LDACS), a future satellite-based communication system (identified as Class A SATCOM), and a future system for surface communications at airports with high density traffic and complexity (identified as AeroMACS).	PJ.14.02.04 TRL4 Initial Concept Description
Global (Unicast) Address	A unicast address that is globally unique within the context of a single internet.	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
Ground ATN/IPS Router	A ground device that is used to support ATN/IPS packet forwarding in both air/ground and ground/ground environments.	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
Ground IPS System	The collection of ground components and functions that provide ATN/IPS services	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
Handover (HO)	Handover (HO)' is defined as a process where an aircraft is moving across heterogeneous A/G sub-networks, including the ANSP ground networks and is able to switch between the different A/G DLs and access the A/G networks with minimum impact for transactions in transit (e.g. delayed or even loss of transaction).	PJ.14.02.04 TRL4 Initial Concept Description
Handoff	A micro-mobility procedure used when a Mobile Node moves between access points on the same Mobile Network. Handoff may be "break before make" or "make before break". In the former case, there may be discontinuity of communication during the handoff. In the latter case, the handoff procedure guarantees full continuity of communication	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
Human Performance	1. Human Performance is used to denote the human capability to successfully accomplish tasks and meet job requirements. In this way, "Human Performance" can be considered as focusing on the observable result of human activity in a work context. Human Performance is a function of Human Factors. It also depends on aspects related to Recruitment, Training, Competence, and Staffing as well as Social Factors and Change Management.	SESAR Integrated Dictionary

Term	Definition	Source
	2. Human capabilities and limitations which have an impact on the safety, security, and efficiency of aeronautical operations. 3. The expression 'human performance' refers not to a decomposition of the human as a vulnerable and unreliable system component, but in the specific context that the way that a human works within a human system is significantly influenced by under-specification of the structural and procedural system design and the performance variability that the human system is confronted with. The human adapts to these stressors upon the system and provides the means to sustain system operation	
Infrastructure	This is a general term corresponding to the communication systems that support the application sets. It consists of the Network and Sub-networks functions.	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
IPS Air/Ground Router	Ground IPS router that interfaces directly with an adjacent airborne host/router over RF media. In other words, the air/ground router is the first-hop ground router for the airborne host/router. Note: IPS Gateway could be consider as an IPS Node.	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
IPS Boundary Router	Ground IPS router that routes IP packets across two interconnecting administrative domains.	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
IPS Host	Originator or terminator of IP packets in the IPS System. The IPS Host ignores IP packets that are not addressed to it. IPS Host is a node that is not an IPS router.	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
IPS Router	A node that forwards Internet protocol (IP) packets not explicitly addressed to itself. A router manages the relaying and routing of data while in transit from an originating end system IPS Host to a destination end system IPS Host.	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
IPS System	The all-encompassing Aviation Internet that provides data transport, networking, routing, addressing, naming, mobility, multilink and information security functions to the aviation services. The IPS System includes the Layer 3 and Layer 4 functions of the ISO/IEC 7498-1 OSI 7-layer Reference Model. The IPS System does not include the underlying access network functions that provide connectivity or the Applications.	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services

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Term	Definition	Source
Legacy A/G Data Links (Legacy AG DL)	Analog VHF (Plain Old ACARS – POA), VHF Digital Link (VDL), HF Digital Link, and Satellite Data Link (Inmarsat Class B, Inmarsat classic aero and Iridium as defined within ICAO Doc 9925 part II and part III	PJ.14.02.04 TRL4 Initial Concept Description
IPS Node	A device that implements IPv6. There are two types of IPS nodes: an IPS Host and an IPS Router.	IPS Node
Link-layer address	Link-Local addresses are for use on a single link. Link-Local addresses are designed to be used for addressing on a single link for purposes such as automatic address configuration, neighbour discovery, or when no routers are present. (RFC 4291)	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
ML System	An interacting combination of elements to accomplish the Multi Link Operational Concept	PJ.14.02.04 TRL4 Initial Concept Description
Mobile subnetwork	A subnetwork connecting a mobile system with another system not resident in the same mobile platform. These subnetworks tend to use free-radiating media (e.g. VHF/UHF radio, satellite, or secondary surveillance radar) rather than contained media (e.g. wire or coaxial cable); thus, they exhibit broadcast capabilities in the truest sense.	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
Mobility	The ability of a Mobile Node to move between or make concurrent use of two or more Mobile Networks without changing its global IP Address(es) (Macro-mobility) or local IP Address(es) (Micro-mobility).	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
Mobility Service Provider (MSP)	A service provider that provides mobile IPv6 service within the ATN/IPS. An MSP is an instance of an administrative domain (AD) which may be an air communications service provider (ACSP), air navigation service provider (ANSP), airline, airport authority, government organization, etc.	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
Multilink	Ability to use all available A/G sub-networks in order to provide the specified performance.	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
Network Operations Plan	The Network Operations Plan is a set of information and actions derived and reached collaboratively both relevant to, and serving as a reference for, the management of the Pan-European network in different timeframes for all ATM stakeholders, which includes, but is not limited to, targets, objectives, how to achieve them, anticipated impact. The NOP has a dynamic and rolling lifecycle starting in the planning phases and is progressively	SESAR NOP Project Team

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Term	Definition	Source
	updated up to and including the execution and post-operations phases.	
Primary A/G Data Link	A future DL being used in a given airspace for the transfer of operational service messages, used by an application. There may be several primary DLs in a given airspace.	PJ.14.02.04 TRL4 Initial Concept Description
Reference Business or Mission Trajectory	The Reference Business or Mission Trajectory (RBT/RMT) is created from the last version of the SBT/SMT. It is the trajectory that the Airspace User agrees to fly and that the ANSP and Airport agree to facilitate. It is associated to the filed flight plan and includes both air and ground segments. It consists of 2D routes (based on published way points and/or pseudo waypoints computed by air or ground tools to build the lateral transitions and vertical profiles); altitude and time constraints where and when required; altitude, time and speed estimates at waypoints, etc.	SESAR Integrated Dictionary
Secondary A/G Data Link	A future DL, which is activated and used for the transfer of operational service messages, used by an application, only upon the primary link has become unavailable or degraded	PJ.14.02.04 TRL4 Initial Concept Description
SN – Subnetwork	An actual implementation of a data network that employs a homogeneous protocol and addressing plan and is under control of a single authority.	PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services
TMA (Terminal Manoeuvring Area)	Is a volume of controlled airspace set up at the confluence of airways in the vicinity of one or more major airports to protect traffic climbing out from and descending to airports. It is shaped like an upside-down triangle, in that the layers gradually get larger with increasing altitude. The typical separation minima in this airspace are 3NM, appropriate vertical and/or visual separation as required.	ED228A
Trajectory	The description of movement of an aircraft both in the air and on the ground including position, time, and at least via calculation, speed, and acceleration.	SESAR Integrated Dictionary
Trajectory Management (4D)	Trajectory management is the process by which the Business or Mission Trajectory of the aircraft is planned, agreed, updated, and revised. It is achieved through Collaborative Decision Making (CDM) processes between Airspace users (Airspace Users) and ATM Service Providers (ANSP, Airports, Network Manager) or directly between Flight Crew and Controller during the execution phase when time does not permit CDM.	PJ.14.02.04 TRL4 Initial Concept Description

Table 2: Glossary

2.7 Acronyms and Terminology

Term	Definition
4D	Four Dimensional
ADD	Architecture Description Document
AAA	Authentication, Authorisation and Accounting
AIAP	ATN/IPS Aircraft Protocol
A/G-R	Air Ground Router
AC	Aircraft
ACARS	Aircraft Communications Addressing and Reporting System
ACAS	Aircraft Collision Avoidance System
AC-R	Access Router
ADS-B	Automatic Dependent Surveillance – Broadcast
ADS-C	Automatic Dependent Surveillance – Contract
AeroMACS	Aeronautical Mobile Airport Communication System
A/G-R	Air-Ground Router
AGBR	A/G Boundary Router
AGCP	Air-Ground Control Protocol
AGMI	Air Ground Mobility Interface
AIDC	Air Traffic Services Interfacility Data Communications
AIS	Aeronautical Information Services
AMHS	Aeronautical Message Handling System
AMQP	Advanced Messaging Queuing Protocol
AMSRS	Aeronautical Mobile Satellite (Route) Service
ANSP	Air Navigation Service Provider
AO	Aircraft Operator
AOA	ACARS over AVLC
AOC	Airlines Operational Communications
APT	Airport
AR	Airborne Radio
A-R	Airborne Router
ASBR	Autonomous System Border Router

ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
ATN	Aeronautical Telecommunication Network
ATNPKT	Aeronautical Telecommunication Network Packet
ATN/IPS	Aeronautical Telecommunication Network (based on) Internet Protocol Suite
ATS	Air Traffic Service
ATSC	Air Traffic Services Communication
ATSU	Air Traffic Service Unit
AU	Airspace Users
AVLC	Aviation VHF Link Control
BER	Bit Error Rate
BGP	Border Gateway Protocol
C2	Command and Control
CC	Capability Configuration
CDM	Collaborative Decision Making
CFMU	Central Flow Management Unit
CM	Context Management
ConOps	Concept of Operations
CoS	Class of Service
CPDLC	Controller – Pilot Data Link Communications
CSP	Communications Service Provider
CTO	Controlled Time Over
DDOS	Distributed Denial of Service
DDT	Delegated Database Tree
DMM	Distributed Multilink Mobility
DNS	Domain Name Service
DSCP	Differentiated Service Code Point
DL	Data Link
eATM	European ATM Portal
EATMA	European ATM Architecture
E-ATMS	European Air Traffic Management System

EF	Expedited Forwarding
EID	End system ID
ETR	Egress Tunnel Router (ETR)
ENR	En-Route
EPP	Extended Projected Profile
ES	End System
ETA	Estimated Time of Arrival
ETO	Estimated Time over significant point
ETR	Egress Tunnel Router
EXE	Exercise
FANS	Future Air Navigation System
FCI	Future Communications Infrastructure
FCU	Flight Control Unit
FER	Frame Error Rate
FIB	Forwarding Information Base
FIS	Flight Information Service
FMS	Flight Management System
FOC	Flight Operations Centre
FRD	Functional Requirements document
FRDS	Flight Relevant Data Set
G-AERO	Ground Based AERO
GDOI	Group Domain of Interpretation
G/G-R	Ground-Ground Router
GGBR	G/G Boundary Router
GTW	Gateway
HF	High Frequency
HMI	Human Machine Interface
HO	Handover
HTTPS	HyperText Transfer Protocol Secure
ICAO	International Civil Aviation Organization
ICD	Interface Control Document
IER	Information Exchange Requirement

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IF	Interface
ITR	Ingress Tunnel Router (ITR)
INTEROP	Interoperability Requirements
INIT	Initiator
IOP	Interoperability
IP	Internet Protocol
IPS	Internet Protocol Suite
IPSEC	Internet Protocol Security
IRS	Interface Requirements Specification
IS-IS	Intermediate System to Intermediate System Protocol
ISRM	Information Services Reference Model
ITR	Ingress Tunnel Router
LAN	Local Area Network
LDACS	L-Band Digital Aeronautical Communication System
LISP	Locator ID Separation Protocol
LMA	Local Mobility Anchor
LQ	Link Quality
MAC	Medium Access Control
MAG	Media Access Gateway
MANSP	Mobility Access Network Service Provider
MED	Multi Exit Disc
MET	Meteorological
MMF	Multilink Management Function
MSE	Mobility Service Endpoint
METAR	Meteorological Aerodrome Report
MHS	Message Handling System
MIL	Military
MIPv6	Mobile IPv6
MITM	Man-in-the-middle
MLD	Multilink
MNP	Mobile Network Prefix
MS/MR	Map Server / Map Resolver

MSE	Mobility Service Endpoints
MTSAT	Multifunction Transport Satellite
NEMO	Network Mobility
NOC	Network Operation Center
NOP	Network Operations Plan
OSED	Operational Service and Environment Definition
OSI	Open Systems Interconnection
OTK	One Time Key
PBR	Policy Based Routing
PDP	Policy Decision Point
PDU	Protocol Data Unit
PEP	Policy Enforcement Policy
PHB	Per-Hop Behaviour
PKI	Public Key Infrastructure
PMIPv6	Proxy Mobile IPv6
POA	Plain Old ACARS
PPP	Point to Point Protocol
QoS	Quality of Service
RAT	Radio Access Technology
RBT	Reference Business Trajectory
RCP	Required Communication Performance
RCTP	Required Communications Technical Performance
RESP	Responder
RF	Radio Frequency
RIB	Routing Information Bases
RLOC	Routing Locator
RMT	Reference Mission Trajectory
RPAS	Remotely Piloted Aircraft Systems
RTT	Round Trip Time
RVSM	Reduced Vertical Separation Minimum
SATCOM	Satellite Communications
SBT	Shared Business Trajectory

SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SMT	Shared Mission Trajectory
SN	Sub-Network
SNMP	Simple Network Management Protocol
SPR	Safety and Performance Requirements
SSH	Secure Shell
SSM	Source Specific Multicast
SSP	Satellite Service Provider
SSR	Secondary Surveillance Radar
SWIM	System Wide Information Management
TCP	Transmission Control Protocol
TCAM	Ternary Content Addressable Memory
TMA	Terminal Manoeuvring Area
TRL	Technology Readiness Level
TS	Technical Specification
TRN	Transaction
TS-IRS	Technical Specification
TTL	Time To Live
UML	Unified Modelling Language
UDP	User Datagram Protocol
UA-MNP	Unique Aggregated IPv6 Mobility Network address Prefix
VDL(M)2	VHF Data Link Mode 2
VHF AM	Very High Frequency – Amplitude Modulation
VoIP	Voice over IP
XTR	Egress Tunnel Router (ETR) or Ingress Tunnel Router (ITR)
WAN	Wireless Area Network

Table 3: Acronyms and terminology

3 SESAR Solution Impacts on Architecture

3.1 Target Solution Architecture

The eATM Portal provides an overview of the European ATM system architecture context, and it displays the external connectivity of the European ATM system and the internal connectivity between the Capability Configurations used as reference in the European ATM Architecture.

The European ATM System Architecture Overview provides a set of reference Capability Configurations required to support the full set of ATM capabilities and activities defined in the SESAR Concept of Operation.

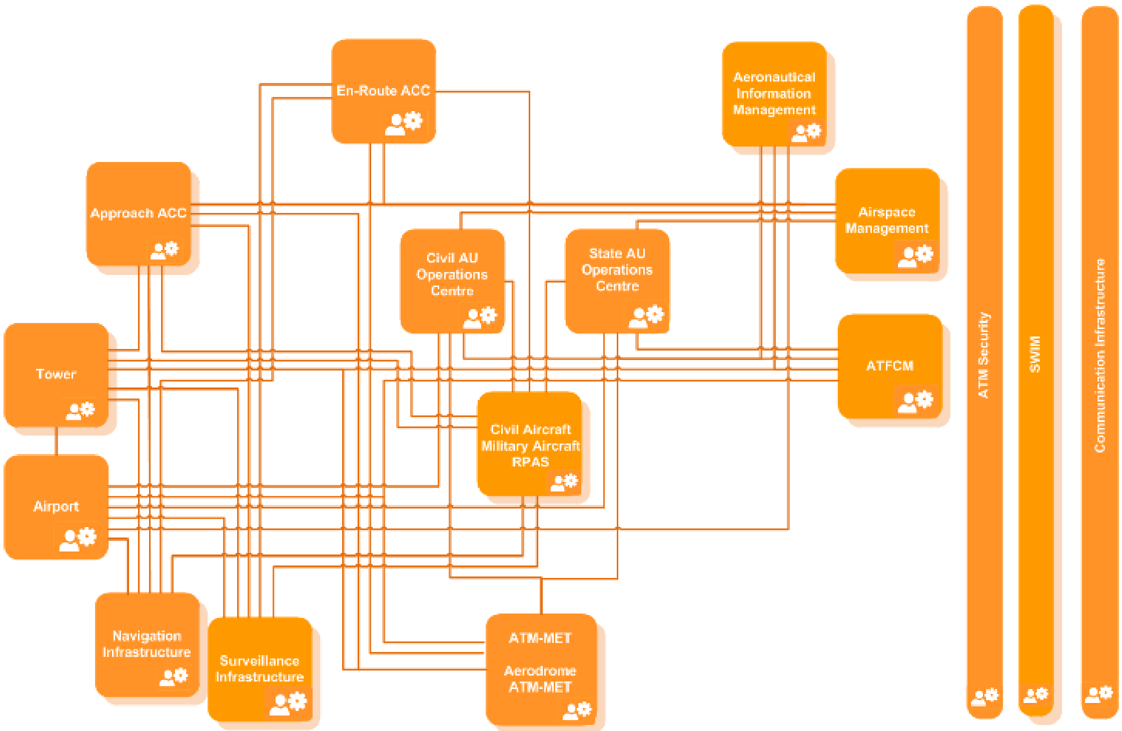

Figure 1: EATM System Architecture Overview Capability Configuration

The Communication Infrastructures, implemented by COM Service providers, provide the communication services needed to convey voice and data flows over the Ground-Ground and Air-Ground segments that are part of the technical systems. In the following picture, all technical systems which are used as reference in the European ATM Architecture are shown. Red squares evidence technical system impacted by the FCI.

Note that "Voice Radio Stations" are shown integrated within the FCI, as future support for digital voice.

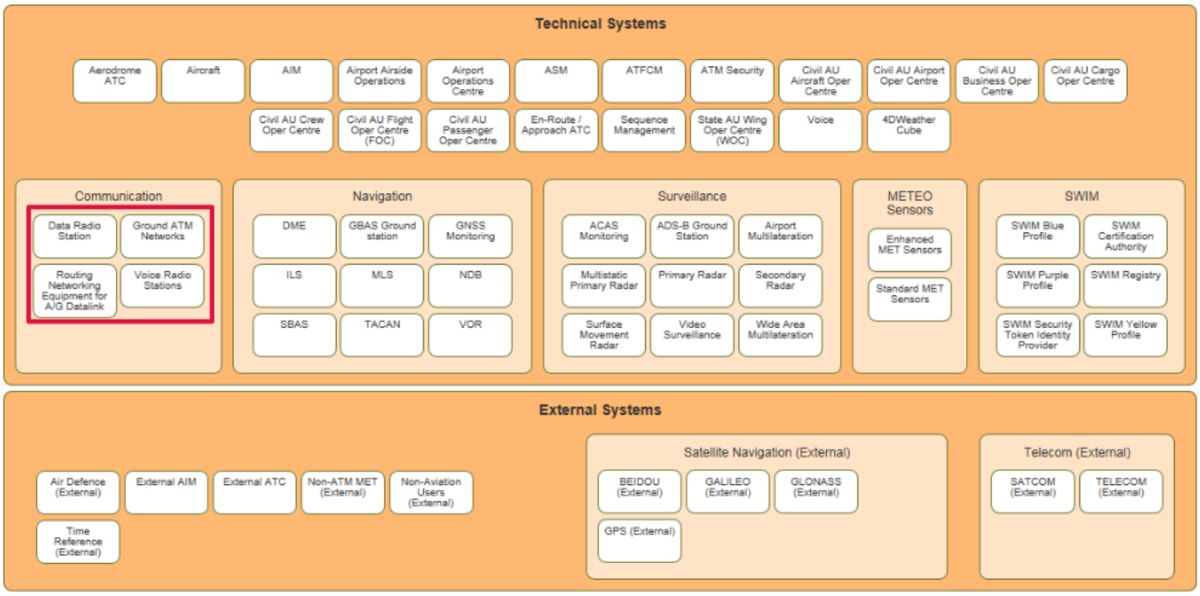

Figure 2: EATMA Technical Systems Overview

The Solution PJ.14-W2-77 relationship with EATMA functional blocks and the enablers is listed in the table below:

SESAR Solution ID and Title	Functional Blocks/Role impacted by the SESAR Solution (from EATMA)	Enabler ID (from EATMA)	POI/OI	Enabler Title (from EATMA)	Enabler coverage/
Technological Solution PJ.14-W2-77 - Future Communications Infrastructure	Communication Infrastructure - Routing Networking Equipment for Data Link	CTE-C04	POI-0015-ATM Future Communication Infrastructure Network	Future Communication Infrastructure - ATN/IPS and Multilink	Required and Developed
Technological Solution PJ.14-W2-77 - Future Communications Infrastructure	Communication Infrastructure - Data radio station	CTE-C02d	POI-0029-COM-ATM High Performance Airport Datalink	New Airport Data Link Technology (AeroMACS)	Optional and Used
Technological Solution PJ.14-W2-77 - Future Communications Infrastructure	Communication Infrastructure - Data radio station	CTE-C02e	POI-0022-COM — ATM High Performance Terrestrial Data Link	New A/G datalink using ATN/IPS over L-band (to augment the VDL2 datalink services)	Optional and Used
Technological Solution PJ.14-W2-77 - Future Communications Infrastructure	Communication Infrastructure - Data radio station	CTE-C02f	POI-0018-COM — SATCOM Class B for ATM	SATCOM Data Link (Class B) in Multilink	Optional and Used
Technological Solution PJ.14-W2-77 - Future Communications Infrastructure	Communication Infrastructure - Data radio station	CTE-C02h	POI-0019-COM — SATCOM Class A for ATM	Future Satcom for ATM - Long term Satcom/IRIS (class A Satcom)	Optional and Used
Technological Solution PJ.14-W2-77 - Future Communications Infrastructure	Communication Infrastructure - Routing Networking Equipment for Data Link	CTE-C06b	CNS-0001-B — Rationalisation of COM systems/infrastructure for SESAR2020 Wave 1	PENS - Phase 2	Required and Used

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SESAR Solution ID and Title	Functional Blocks/Role impacted by the SESAR Solution (from EATMA)	Enabler ID (from EATMA)	POI/OI	Enabler Title (from EATMA)	Enabler coverage/
Technological Solution PJ.14-W2-77 – Future Communications Infrastructure	ATN-OSI VDLm2, single and multi-frequency	CTE-C02b and CTE-C02c	POI-0015-COM-Future Communication Infrastructure Network	ATN-OSI VDLm2, single and multi-frequency	Optional and Used
Technological Solution PJ.14-W2-77 – Future Communications Infrastructure	Communication Infrastructure - Data radio station	CTE-C02j	POI-0015-COM-Future Communication Infrastructure Network	Ground part of A/G datalink terrestrial Infrastructure via ATN/IPS over VDLM2	Optional and Used
Technological Solution PJ.14-W2-77 – Future Communications Infrastructure	Communication Infrastructure - Data radio station	CTE-C02k	POI-0015-COM-Future Communication Infrastructure Network	A/G datalink exchange via ATN/IPS over VDLM2	Optional and Used
Technological Solution PJ.14-W2-77 – Future Communications Infrastructure	Civil Aircraft (CC)/ Aircraft – Airborne Router	A/C-95	POI-0015-COM-Future Communication Infrastructure Network	FCI - Airborne part of ATN/IPS and Multilink	Required and Developed
Technological Solution PJ.14-W2-77 – Future Communications Infrastructure	Civil Aircraft (CC)/ Aircraft – Data radio	A/C-93	POI-0015-COM-Future Communication Infrastructure Network	Avionic Technology for the new Airport Data Link (AEROMACS) integrated with ATN/OSI and ATN/IPS	Optional and Used
Technological Solution PJ.14-W2-77 – Future Communications Infrastructure	Civil Aircraft (CC)/ Aircraft – Data radio	A/C-98	POI-0015-COM-Future Communication Infrastructure Network	Avionic Technology for New A/G datalink using ATN/IPS over L-band	Optional and Used
Technological Solution PJ.14-W2-77 – Future	Civil Aircraft (CC)/ Aircraft – Data radio	A/C-31e	POI-0015-COM-Future Communication	Airborne part of A/G datalink exchange via	Optional and Used

SESAR Solution ID and Title	Functional Blocks/Role impacted by the SESAR Solution (from EATMA)	Enabler ID (from EATMA)	POI/OI	Enabler Title (from EATMA)	Enabler coverage/
Communications Infrastructure			Infrastructure Network	ATN/IPS over VDLM2	
Technological Solution PJ.14-W2-77 – Future Communications Infrastructure	Civil Aircraft (CC)/ Aircraft – Data radio	A/C-33a	POI-0015-COM-Future Communication Infrastructure Network	Class B SATCOM	Optional and Used
Technological Solution PJ.14-W2-77 – Future Communications Infrastructure	Civil Aircraft (CC)/ Aircraft – Data radio	A/C-33b	POI-0015-COM-Future Communication Infrastructure Network	A/C SATCOM Long Term	Optional and Used

Table 4: SESAR Solution PJ14-W2-77 Functional Blocks/roles & Enablers

These Standards for FCI Architecture are referenced in MEGA:

- STD-039 — EUROCAE Standards for D-TAXI A/G datalink using Multilink
- STD-040 — ICAO Standards for A/G datalink using Multilink
- AGDLS-TECH-2 — New ICAO Standard for ATN / IPS (ICAO Doc 9896)
- LISP Protocol – Locator/Identifier Separation Protocol

3.1.1 SESAR Solution(s) Overview

The FCI solution is a “system of systems” supported by **IP network infrastructures**, which integrates existing and new technological components. The ground core networks can be operated by ANSPs or Airspace Users and is interconnected via New PENS. Air/ground datalink networks provide connectivity to the aircraft and implement radio technology standards (AeroMACS, LDACS, IP SATCOM and IP VDLM2). The FCI should also secure seamless continuation of operations supporting the current and future requirements, to safeguard investments in infrastructure and equipage, and to facilitate the required transitions.

The FCI TS-IRS document provides functional requirements of **network functions** common to all services and required for the supported **communication profiles** in the SESAR Airspace Architecture.

ATM applications over the FCI are required to support one of the following **communication profiles or protocol stacks:**

- ATN Application Service Elements (ASE) and Dialogue Service (DS);
- SWIM PP for Advisory Information Sharing and SWIM PP for Safety Critical Information Sharing.; (as defined by ICAO 9896, AEEC PP858, and EUROCAE WG-108 IPS Profiles).
- Upper layer protocol stack over IPS, defined at ICAO or EUROCAE level, which includes provisions for end-to-end service performance requirements for IPS native applications.

The TS-IRS specifies the security, safety and performance requirements for the network functions and required by the ATM Application and services (for safety of life and regularity of flight), which are provisioned by the FCI.

However, the long term FCI is expected to **interoperate with other co-existing networks** under certain conditions. Provisions are supported for the following interfaces:

- An OSI-IPS Gateway function allows ground accommodation for ATN-OSI-only Aircraft and for ATN-OSI-only ATCOs

Civil-military communications interoperability will be based on interfacing between military systems and ATM-related IP structures and exchange of aeronautical information. These **technical systems** are part of the FCI solution and are involved in the FCI technical system specification:

1. Aircraft Technical Systems
2. A/G Technical systems for access to communications;
3. G/G Technical System for Ground communication.

In order to integrate FCI components, EATMA models have been adapted as follows:

- Aircraft Technical System Airborne Router (A-R) and four Data Links (DLs) have been added as follows:
    - Airborne Router ATN-IPS;
    - Airborne Router ATN-OSI
    - LDACS radio system;
    - SATCOM A and B radio system;
    - AeroMACS radio system;

    - IP enabled VDLM2 radio system;
- Communications Infrastructure - this Capability Configuration has been changed, in order to insert new Technical Systems for A/G and G/G communications;
- Technical System for A/G communication: (Access System):
    - LDACS A/G datalink communication, this system ensures terrestrial Air-Ground connectivity in the L-band;
    - SATCOM A and SATCOM B A/G DL Communication System, this system ensures “global” -Air-Ground connectivity especially for oceanic areas;
    - AeroMACS A/G DL Communication System that ensures -Air-Ground connectivity in the C-band on Airport surface;
    - IP VDLM2 new IP A/G DL communication system that ensures terrestrial -Air-Ground connectivity in the FCI;
- **G/G communication systems,** which include those sub-systems that guarantee all Layer 3 network functionality for ensuring upper layer End to End Data Link connectivity between Airborne and Ground. The system includes these sub-systems:
    - A/G ATN IPS Boundary Router for Interfacing Air-Ground Radio Networks and implementing Ground Based LISP Mobility functionalities in cooperation with the LISP Mapping Server / Mapping Resolver (MS/MR);
    - Mobility Service Endpoint (MSE), in FCI the LISP MS/MR, for implementing the Multilink and Mobility functionalities in cooperation with the G/G ATN IPS Boundary Router and Airborne Router ATN IPS (A-R);
    - G/G ATN IPS Boundary Router, interfacing Ground End Systems and implementing Ground Based LISP Mobility and Multilink functionalities in cooperation with the MS/MR;
    - OSI-IPS Gateway, this gateway allowing the following:
        a. CPDLC & ADS-C data exchanging between an OSI Airborne End System with an IPS Ground End System;
        b. CPDLC & ADS-C data exchanging between an IPS Airborne End System with an OSI Ground End System;

        When referring to “OSI-IPS Gateways” in this document we refer to ATN-OSI to ATN-IPS Gateways, and not to any other legacy OSI network in existence (e.g. X.25, or similar).
    - DATA RADIO STATIONS - the modelling is identical; to the scope of FCI requirements definition, it is sufficient to define a network access (Access Router), a security function (AAA server) and a "Ground Radio system" (it includes one or more Base Stations plus control functions)

3.1.1.1 FCI Reference Architecture

The generic Mobility Access Network Service Provider (MANSP) reference architecture is show in the next Figure.

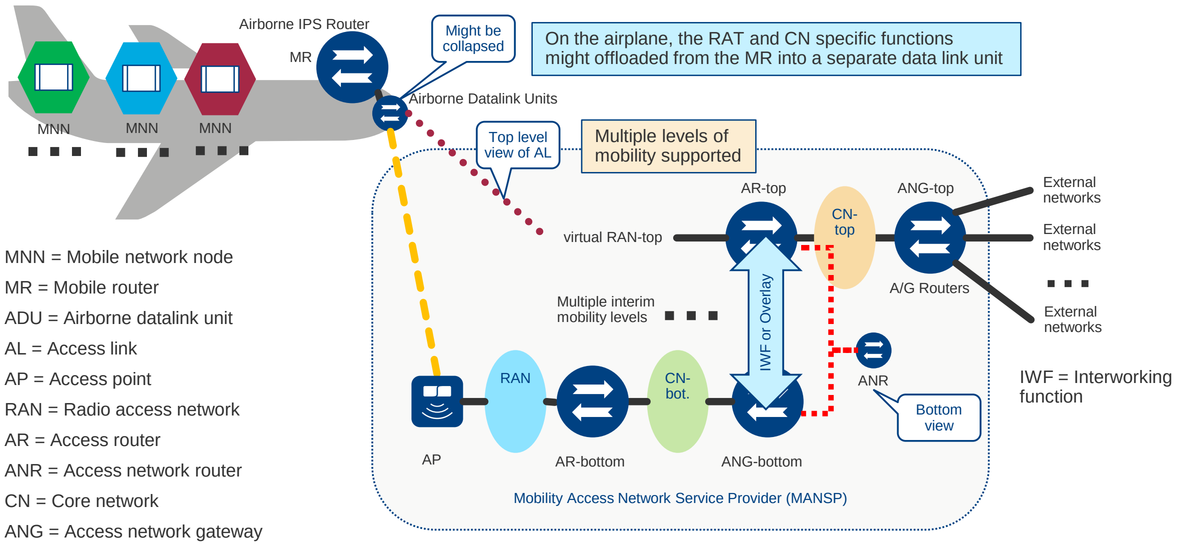

Figure 3: Generic MANSP reference architecture for FCI

There could be multiple layers of local mobility solutions for a RAT Data Link. The FCI Data Link is at the top of this hierarchical mobility and tunnelling stack. The top level is also called the user plane since this is the only visible layer for the end systems. The lower mobility layers cannot be reached by the end systems.

The IETF mobility terminology is defined for a single layer only. In a real-life environment this would become a context sensitive usage depending on the perspective.

Older FCI documents refer to an A/G Router (AGR) in FCI context. However, this is in contradiction with the current ATN/IPS profile from RTCA/EUROCAE where this term is used for an Access Router in the IETF terminology. Until this terminology issue is fixed in those standards, a distinction can be emphasized by adding the word “Boundary” everywhere. The new correct naming is “A/G Boundary Router” (AGBR). The AGBR has the following characteristics:

- Border router between mobility access network provider administrative domain and the global mobility service provider administrative domain
- Top mobility level ANG function – Top AR and ANG might be also collapsed
- Single node or dual node (see later)
  - Single node version used for simplicity here
  - Dual node implements a full user plane/control plane separation – Might be necessary if the FCI control plane functions cannot be added directly unto a COTS IP router

Similarly, the G/G Router (GGR) in older FCI documents will be renamed to G/G Boundary Router (GGBR) for emphasizing that it is at the edge of the global mobility domain and has interfaces both in the RLOC and EID spaces. The GGBR has the following characteristics:

- Border router between the global mobility domain and the mobile service customer networks (ATS, AOC, etc.)
- Might be operated by
  - Directly by the customer
  - Outsourced to a network service provider

In FCI architecture IPv6 packet forwarding is done mainly by normal destination address based routing. The mobility service used for each aircraft a so-called “Mobile Network Prefix” (MNP). The UA-MNP is defined as the aircraft unique aggregated IPv6 mobility network address prefix covering all IPv6 subnetworks on the airplane. For clarifications of context the MNP might qualified as UA-MNP for better clarity. However, when the context is already set, it can be simply referred as MNP. The UA-MNP has the following characteristics:

- Not interface specific
- Might be divided into domain subnetworks
- Different interface identifiers (IID) might be assigned to various applications on the same host

The UA-MNP is assigned by ICAO and might be computable from previous ICAO identifiers. The details are still under discussion in ICAO Mobility SG.

The UA-MNP might have subnetworks for various aircraft domains. Each subnetwork is an MNP itself from a generic perspective. The following abbreviations are used for the subnetworks of UA-MNP:

- If the context need clarification, then use SubMNP.
- If a reference to a specific SubMNP is needed, then use
  - SubMNP<id>, where <id> could be a number or some letters
  - For example:
  - SubMNP0, SubMNP1, SubMNP2, … when the usage is not relevant in this viewpoint
  - SubMNP-ATS: traffic intended for ATS
  - SubMNP-AOC: traffic intended for AOC
  - SubMNP-NMS: traffic intended for network management system or control plane functions

The next Figure demonstrates the usage of SubMNP for different aircraft domains.

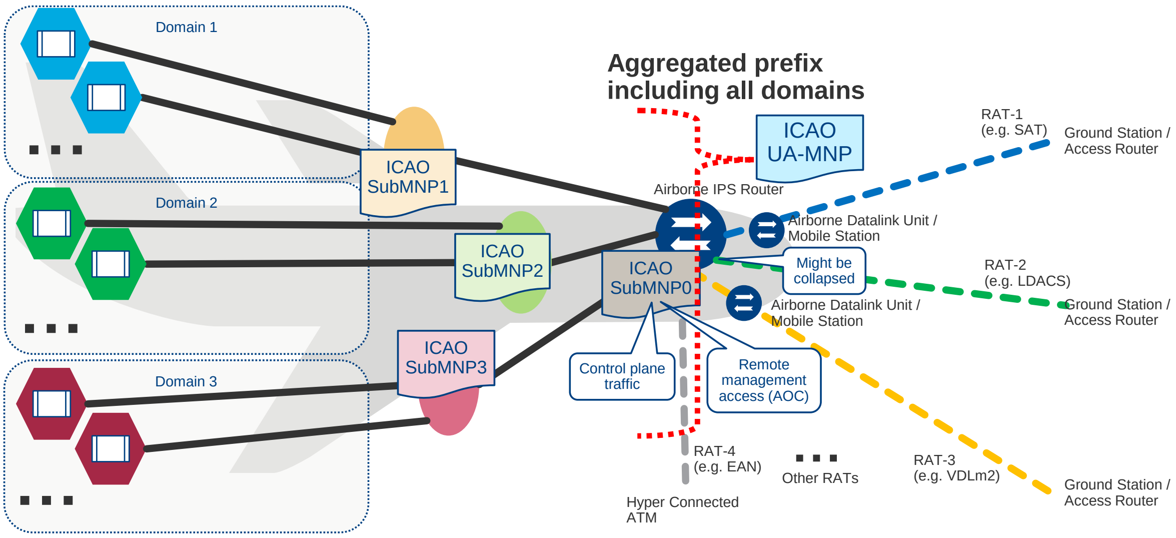

Figure 4: Generic aircraft network reference architecture for FCI

The SubMNP can be used to express link preferences. The details will be explained later.

All the air-ground interface address in the user plane are not visible for the end-systems. It is not necessary to allocate these addresses from the MNP range. These interface addresses might be local the link owner or can be allocated even dynamically from the prefix ranges of the local link owner. The air side address of an FCI datalink follows the usual local mobility scheme of assigning the MN interface address from the ground based on the AAA session. The MN itself has no authority usually to assign air-ground interface addresses.

Control plane access or remote management of ADUs or mobile radio stations

- {A} it is only a local matter of the link owner, so the IP address is assigned from its own address ranges. Similar scenario: if it is accessed by one of the underlays and not through an embedded connection inside the top-level user plane.
- {B} multiple players need an access, so it is allocated from the MNP range

If the Airborne Router itself is seen as a control plane or management plane end point, then it might need to be accessed by multiple players, so they need a non-local address from the MNP range. The SubMNP0 is proposed for such addresses in the previous Figure.

The various RAT data links might use different local mobility solutions and architectures. The following Figure shows an example where provider A and B are following different approaches.

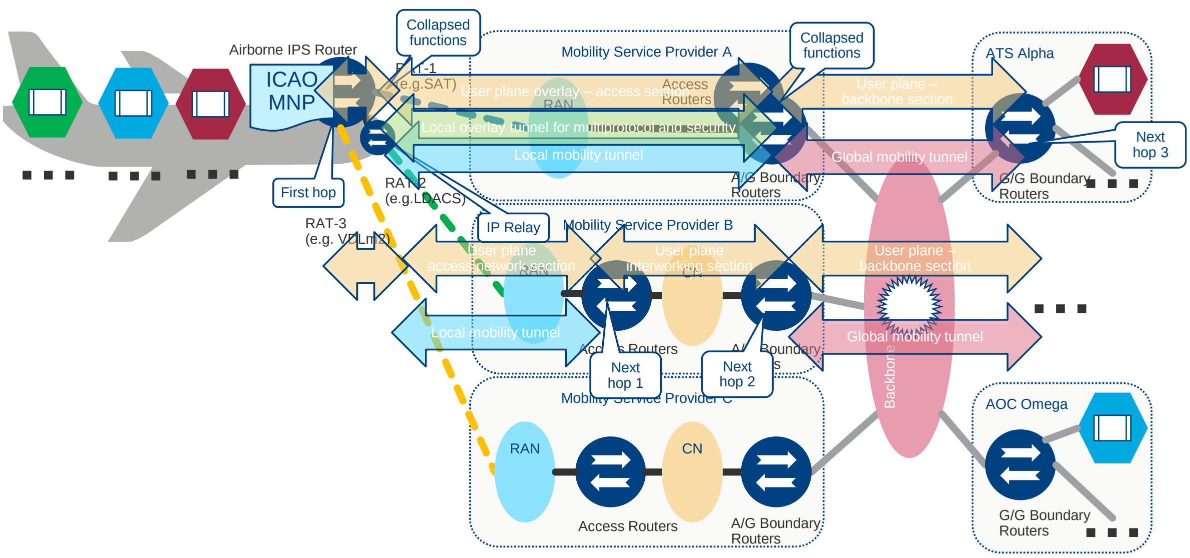

Figure 5: Interworking model in access network integration

The previous Figure demonstrates the interworking model for the aircraft. The RAT links are terminated in separate device from the Airborne IPS Router. There is an interworking function (Airborne Modem) between the Airborne IPS Router and the RAT link.

Going from the airborne end system, the first hop is the Airborne Router, the next hop if the IP relay. In the service provider B example network, there are 3 more hops in the user plane until the customer network is reached. However, each mobility access network might have a different architecture. In the service provider A example network, the user plane tunnels are going up to the A/G Boundary Router, so practically the Access Router and AGBR function are collapsed into a single node. Such collapse is feasible only if there is no need for horizontal scalability. Otherwise, it is beneficial to have a separation of the Access Router and AGBR functions since this would provide and independent horizontal scalability possibility.

The next Figure shows this architecture from the protocol stack perspective.

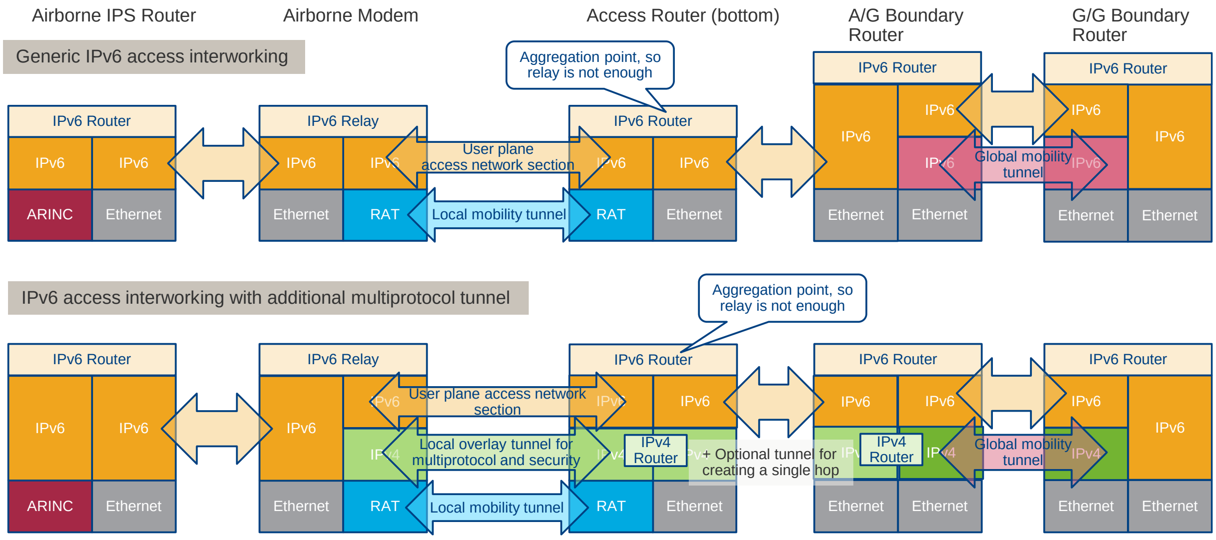

Figure 6: Interworking model in access network integration – data plane protocol stacks

Please, note that the previous Figure is just an illustration, it is not a complete description of all possible scenarios.

The Airborne Modem terminates the L3 connections, but it is not a full router, just an IPv6 relay with simple static routes. On the ground there is a separation of the Access Router functions. The Access Router and the AGBR has an interworking relationship.

The next Figure demonstrates another approach where the RAT link termination is integrated into the Airborne IPS router. In this case, the user plane A/G tunnel termination is not in a separate Airborne Modem, but directly inside the Airborne IPS router.

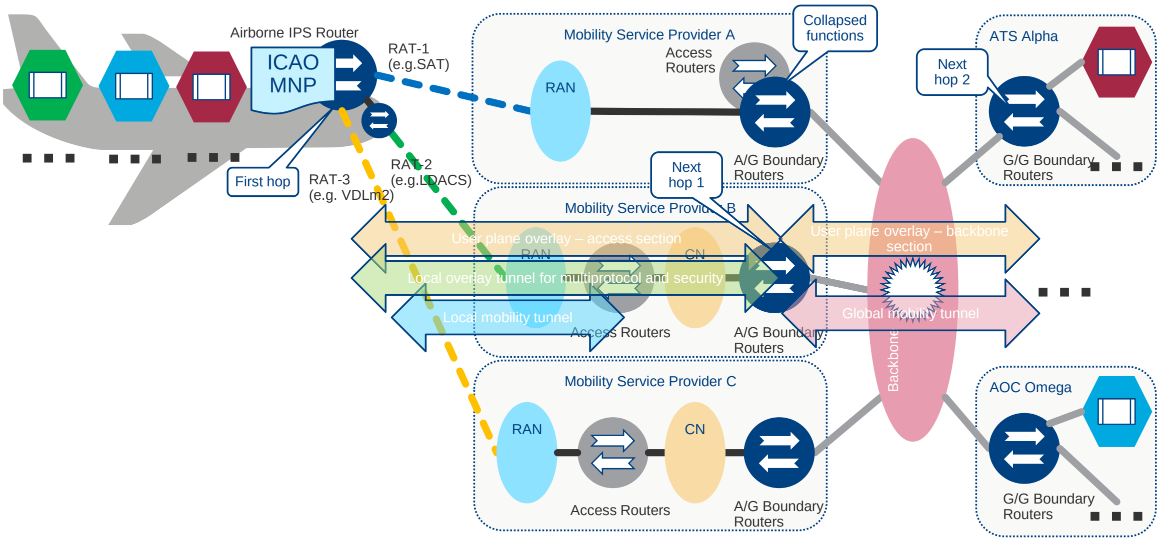

Figure 7: Overlay model in access network integration

Please, note that there could be multiple layers of mobility tunnels. In the service provider B example network, there is a native IPv4 local mobility solution using a RAT specific transport with host mobility only. Above this there an IPv6 tunnel that also provide network mobility. At the top we see the user plan IPv6 connectivity.

The overlay model is also explained in the Figure from the protocol stack perspective.

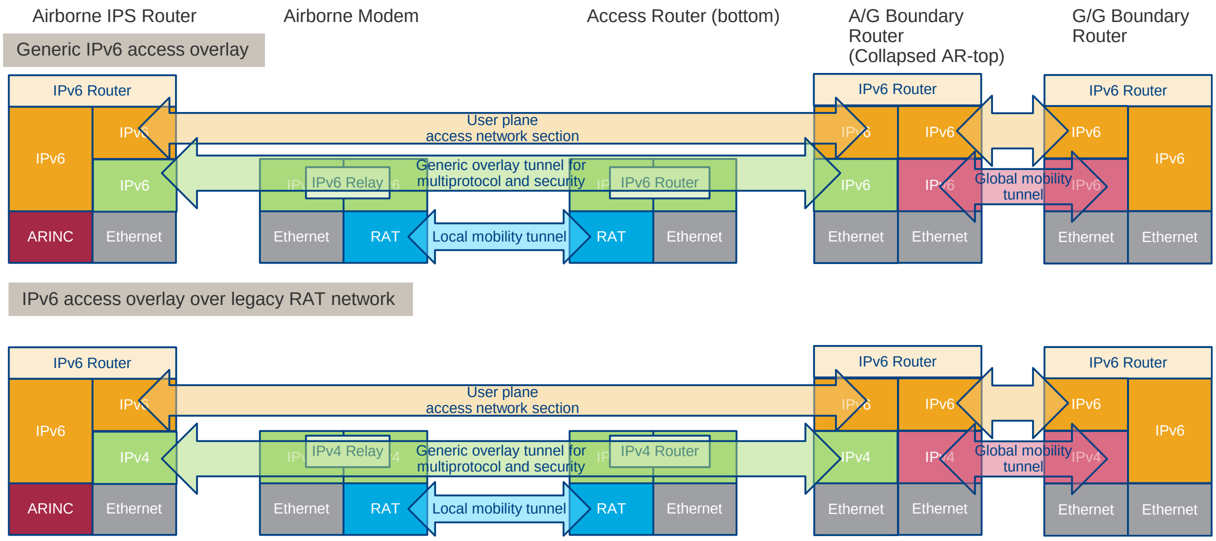

Figure 8: Overlay model in access network – data plane protocol stacks

Please, note that the previous Figure is just an illustration, it is not a complete description of all possible scenarios.

The overlay model lacks intermediate IPv6 nodes such as the Airborne Modem or the Access Router in the user plane. In the underlays of course there are still multiple IP hops.

In real-life scenarios a combination of the interworking and overlay architectural approaches might happen. This is shown in the next Figure from the protocol stack perspective.

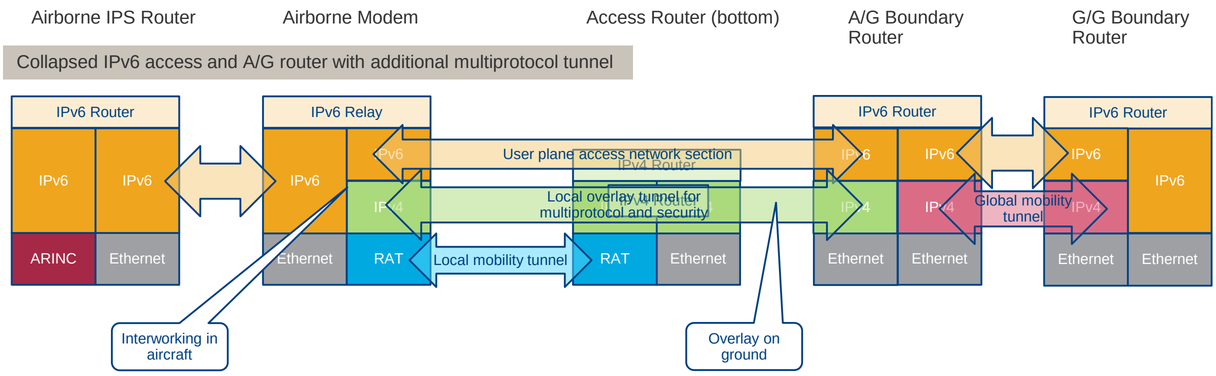

Figure 9: Hybrid interworking and overlay models in access network

Other variants are also possible, this is just an example for illustrating the possible scenarios.

The global mobility integration might also have fundamentally different architectural approaches:

- Demarcation between two routers
    - Both routers are fully contained in their own domains (e.g. BGP peering)
- Demarcation inside a router
    - Requires special virtualization inside the router (e.g. consumer home routers)

The FCI preferred architecture is based on the demarcation through the MS/MR federation for the top-level mobility in the control plane. The GB-LISP Mapping System uses

- EID-to-RLOC mappings

- Pub/sub with proxy-reply mode -- no direct control plane messages needed between A/G and G/G

The demarcation between two routers for the mobility access network domain and the customer network domain is defined for the top-level mobility data plane (EID space) by the LISP tunnel between A/G BR and G/G BR.

The demarcation between two routers in the RLOC space is based on the classical BGP peering relationship between A/G Boundary Router as an RLOC BGP router and the transport network provider border AS border gateway router as an RLOC BGP router (no LISP control plane). This will divide logically the global mobility backbone into a GB-LISP solution provider and a backbone transport provider. These abstract functions might be fulfilled by different companies or a single company. The technological architecture is the same in all cases.

The FCI Reference Architecture supports sending various traffic unto different datalinks by using the SubMNP scoping for link preferences. That requires certain routing capabilities in some of the functional nodes. The next Figure shows an example for such SubMNP specific routing on different links.

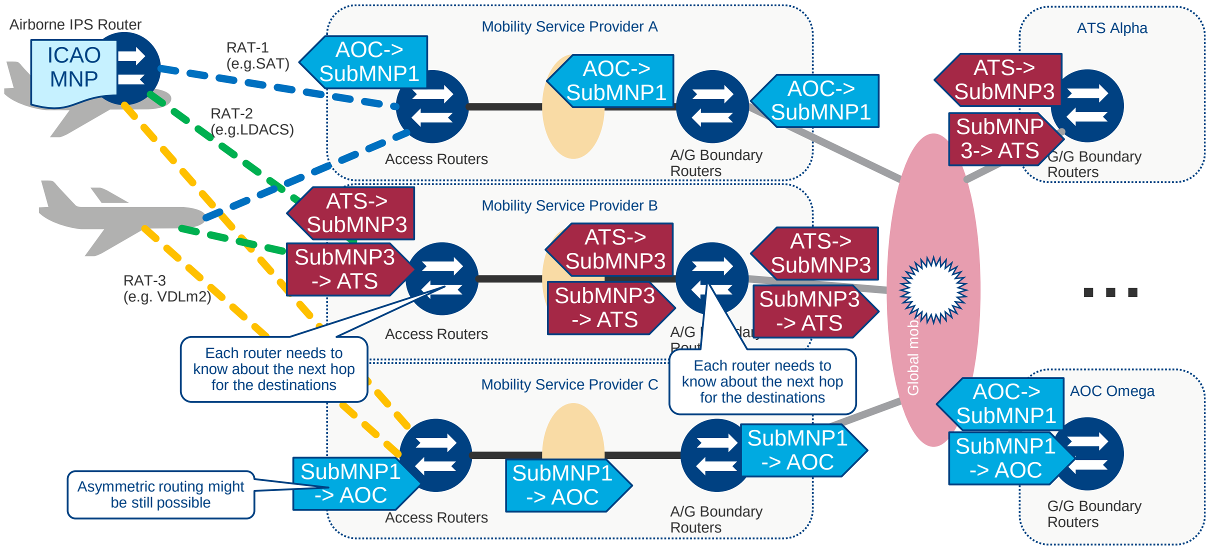

Figure 10: Simplified ground logic architecture of a multi-link mobility solution

The various interworking or overlay models will influence in which network nodes it is necessary to maintain dynamic routing information. The GGBR needs to learn to which AGBR to send packets for a certain SubMNP. The AGBR should have the capability to send packets to the proper airplane. If a single RAT link is served logically by a single logical AGBR, then it is enough to have the MNP routing information in the AGBR. The next Figure show the perspective of the Airborne IPS Router.

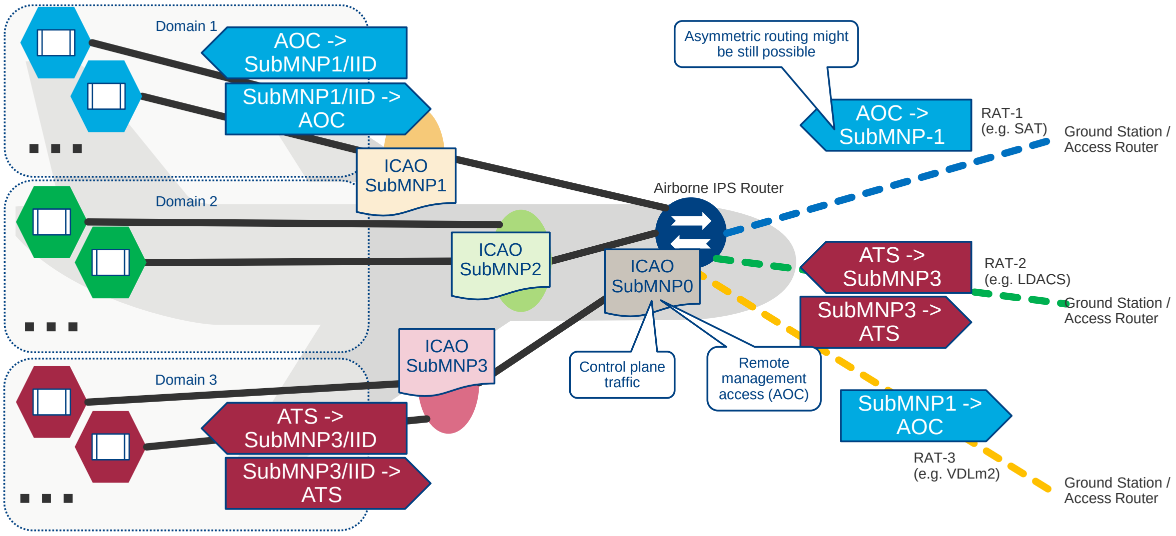

Figure 11: Simplified airborne logical architecture of a multi-link mobility solution

The Airborne IPS router also need a dynamic routing information for each SubMNP. This information is available locally on the aircraft, there is no need to communicate with anyone else. In the FCI Reference Architecture the Airborne IPS Router will decide on which RAT link to use towards the ground based on its local administrative policy, status awareness and the resulting link preferences.

3.1.1.2 Deviations with respect to the SESAR Solution(s) definition

No deviations have been introduced with respect to the solution definition.

3.1.1.3 Relevant Use Cases

Refer to the Concept of Operation document ([2]) and to the following section 3.1.1.4.

3.1.1.4 CONOPS Operational scenarios

This section describes the main representative scenarios of FCI included in the Concept of Operation document [2], which illustrates the new operating method that shall be supported by the FCI capabilities.

The ConOps provides a set of target scenarios that illustrate operational uses of the FCI. Each scenario represents a typical sequence of utilisation of FCI services by actors in the provision of ATM applications. The scenarios described reflect the ConOps assumption that they are not mutually exclusive, i.e., more than one may be happening simultaneously involving the same aircraft and ground infrastructure systems.
In the TS-IRS these scenarios have been used as drivers to review and formulate the new functional requirements needed in each Technical Systems and EATMA Functional Block to implement the required operational use case of FCI services.

NOTE: the document "FCI IF6 - ATN IPS AG-R to GB-LISP Interface Control Document" ([22]), which is an external appendix to this TS/IRS, specifies in detail the design of the Mobility & Multilink protocol exchanges (Message Sequence Charts, state Machines, etc.), covering the PJ14-W2-77 Validation Scope [see Appendix C - IF6 Description and details] .

3.1.1.4.1 Provider RAT Datalink status (ATS/CSP) definitions

Each available A/G Radio Access Technology (RAT) datalink in the scope of this document is identified as having an “Up” or “connected” status, when the RAT airborne equipment has successfully established the connection with its own Mobility Access Network domain managed by the Mobility Access Network Service Provider (MANSP).

The RAT DL communication in **“Up”** status will be available in the FCI Multilink Service only when the Airborne Router has completed its registration process with the FCI Mobility Access Network and its Service Provider. The RAT Datalink communication set-up procedure is defined by each datalink Standard and Access Network and therefore these procedures are not included in this TS-IRS document.

3.1.1.4.2 FCI Datalink Status definitions

The underlay radio link status is expressed usually “Up” or “Down” or “Degraded”. However, the edge-to-edge FCI User Plane status might be different since it should cover the IPS network from the IPS airborne router to the GGBR including both the mobility access network and the global mobility backbone. The FCI Use plane is in the “opened” state if it is fully operation edge-to-edge. If it is not operational, then it shall be in the “closed” state. A “closed” state is possible even if the underlay radio link status is “Up”. A “closed” state might happen if the global mobility backbone or the integration of the mobility access network with the global mobility backbone has critical operational problems.

The FCI User Plane will be in the **“opened”** status only after the FCI Airborne Router (A-R) has successfully completed the registration of the Aircraft in the FCI Mobility Access Network. **[**See Figure 38**-NSV-4-** **Airborne Registration to FCI Access Network Service]**.

Each Airborne RAT shall notify to the Airborne Router the Status “Up” or ”Down” of each datalink (Up/Down). In the following requirements, also a DEGRADED state is considered

3.1.1.4.3 FCI Service Policy selection

Both on the aircraft and in the ground, administrative policies might be selected by human actors (pilot or network operator) from a predefined list of tested and approved policies. This includes changing to a backup contingency system, disabling some links temporarily, or enforcing certain link preferences. This policy selection solution is intentionally not standardized by Solution 77.

3.1.1.5 Air-Ground Control Protocol Concepts

The main rational behind designing a new Air-Ground Control Protocol (AGCP) is the limited bandwidth available. The SESAR Wave 1 FCI validation used OSPF for simulating the AGCP. However, this would not fulfil the special requirements of bandwidth effectiveness as a final solution. The Air-Ground Mobility Interface (AGMI) protocol [20] was designed for the Solution 77 validation prototype in Wave 2 as a replacement of the old Wave 1 Interface IF7.

Some Radio Access Technologies (RAT) might provide only a few dozens or hundreds of Kbps per aircraft. Running classical routing protocols would add too much overhead. It is recommended to send only status updates when situation changes. It is required to Send only the minimally required information, do not add too much overhead.

Each aviation RAT has significant differences in their architecture. Multi-link mobility requires a unified view in network layer. The multilink mobility scheme should be a network layer solution. Cross-layer signalling is only for optimizations, but it should work even without that. Using the AGMI as an AGCP implementation provides independence from RAT specific details.

Current LISP mobility specifications are designed only for end host mobility. In theory a unified LISP backbone could be assumed. In this case, the LISP domain is extended to the first ground access router (AR) from the air perspective. This solution has the advantage of having no need for route redistribution from other protocols and would result in a simple mobility configuration. Current LISP mobility specifications are not designed for multi-link mobility for non-LISP mobile routers representing moving networks, so it is necessary to have such an AGCP implementation that can handle the special situation in a multilink mobility environment.

In reality, aviation networks shall support long-term co-existence with legacy technologies. End-to-end, unified LISP backbone is not possible for decades, only some network sections can be moved to LISP. It is necessary to have such an AGCP implementation that might work with multiple mobility access network technologies and multiple global mobility backbone solutions, not just GB-LISP.

AGCP as minimum shall provide information on each aircraft RAT link status of up or down. Sometimes it is even difficult to decide on this. A clear definition is needed for each RAT link type.

AGCP shall include information for supporting a fully distributed mobility scheme (DMM) covering

- Different Mobility Access Network Service Provider (MANSP) for different RAT
- Same MANSP for multiple RATs
- Multiple MANSPs for the same RATs
- Aggregation networks between MANSP and ground customer (ATS, AOC)

Details will be defined in later sections.

AGCP might be extended in the future to

- Share aircraft preferences for traffic type dependent path selection policies
- Send ground information on RAT link status for avoiding the aircraft to send into black holes
  - Might be implemented by a forced link layer down action as an interim solution
- Distribute QoS information on each RAT link
  - E.g., radio signal strength, bit error rate, packet loss, packet delay, packet delay variation, generic quality index, estimate QoE per traffic type, quality stability etc.
  - Might be utilized by path selection policies
- Support for geographical 4D trajectory-based predictions and optimization

3.1.1.6 Aircraft Policies and Preferences

3.1.1.6.1 Routing policy concepts

[REQ.14.77-TS-MLNK-0018]

Routing policy execution has to be done per packet, and it can be based only on information inside a packet. If the destination address is used, a good performance can be achieved. If the forwarding decision should be based on DSCP, then it requires the policy-based routing (PBR) feature in the router. PBR is simple in the Airborne IPS router since it is all software based and not using an ASIC. PBR might cause difficulties at aggregation points in the ground. ASIC chips might have limited TCAM memory for PBR. Running out of TCAM space might lead to a significant performance degradation and the un-deterministic behaviour.

Policy and preference scopes might be specified using a traffic flow bundle defined by source address, protocol, ports. It would also require PBR with all its limitations.

Policy definitions for link usage might be needed both for the air and ground (separate, can be different). These policies might require complex conditions with many inputs on creating actual link preferences. The policy life cycle might be static for the whole duration of a single flight.

Policy decisions on link preferences are needed at all times. The system would continuously evaluate environment for situational awareness using observation from various sensors, such as position, geographic region, regulatory domain, weather, 4D trajectory, etc.

The policy decision subsystem shall generate an actual link preference regularly or by event:

- {A} for all links, even if inactive
- {B} for only those links that are active

It would be possible to provide a configuration item to choose in the final solution. The link preferences might change multiple times during a flight.

Link preferences are mandatory to send by the aircraft and anticipate by the ground. Ground might have some override, if justified. The preferences are defined as a list of links with a preference ranking, such as first, second, third, etc. The links must have a unique identification. The current aircraft link preferences should be displayed (original and merged)

- In cockpit, on HMI
- In ground NOC, on-demand on HMI

A manual override by the aircraft pilot shall be supported in the final solution. All preference change events shall be logged on aircraft.

Sending preferences from the ground to the air is currently optional, not included in the validation scope of PJ14-W2 Solution 77 but mentioned only as possible enhancement beyond Wave 2, in case additional new policy needs arise in the future[3]. The aircraft could override, if justified. It would be in a form of list of links with a preference ranking, such as first, second, third, etc. The links must have a unique identification. The current ground link preferences should be displayed (original and merged)

- In cockpit, on HMI
- In ground NOC, on-demand on HMI

Manual override by the network operator shall be supported by the final solution. All preference change events shall be logged on ground.

3.1.1.6.2 Preference communication methods

Preference communication may be based on automatic repeat request (ARQ). However, this has the disadvantage of additional overhead and jitter. In some cases, it is better not using ARQ in the control plane but let the error handling happened in the application layer or mitigate the errors by simulcasting the preference information on all available links. There is another dimension for alternatives: if the

[3] This is only an option and its absence from the validation scope does not impact the completeness of the solution and its maturity level.

preferences are sent on all available links without taking into account the current data link preferences, or if the preferences are sent only on single link using the best link available.

Taking into account the identified alternatives, the preference information communication methods on data links might be selected from the following cases:

- {a} send on all available links, without ARQ (automatic repeat request)
  - No need for taking into account current preferences
- {b} send on all available links, with ARQ (automatic repeat request)
  - No need for taking into account current preferences
- {c} send on one link with ARQ on same link and then move to another link
  - Use actual link preferences
- {d} send on one link with ARQ repetition on another link
  - Use actual link preferences

Selection could be controlled by a configuration item in the final solution.

It is possible to reuse preference communication for link status checking. Preference communication success might reset link status expiration timers. If the aircraft experiences a preference communication failure with ARQ, then it should initiate an FCI link status closed change.

Decouple preference and link status communications on air-ground links. Send only when absolutely needed. Triggers could be

- Preference – change in situational awareness
- Link status – change in link usability

A local link status report for the link owner is generated if the link is in the FCI opened state. The MANSP can add its own identifier to an advertisement to the MSE.

A foreign link status report is generated about a link that is down. However, this must be then sent through a foreign link since the owner link cannot transfer messages anymore. This foreign report requires a MANSP identifier to know where to send the report for the link owner.

A link status change will be implemented as a change in the MNP related routing table entries on all user plane routers, such as AR, ANR, ANG/AGBR, GGBR.

A preference change will be implemented as a change in the SubMNP or traffic flow bundle related routing table entries. It is not necessary where there are no more choices to implement preferences, such as the local mobility top level AR or the AGBR. It is necessary where choice has to be executed, such as the MSE, the GGBR. The special situation for a shared AGBR is explained in a later section.

3.1.1.6.3 Aircraft policy architecture

The **policy decision point (PDP)** is a logical function with different deployment possibilities. It might be hosted on airborne router. The PDP takes the following inputs:

- Static policy
- Situational awareness signals
- [O] Received preferences from ground

The PDP generates the following output:

- Policy decision sent to the aircraft PEP
- Current updated link preferences sent to the ground

The **policy Enforcement point (PEP)** is a logical function deployed on user plane IPv6 router, the Airborne IPS router. It might not be needed on datalink units that are simple static IPv6 relays.

The PEP inputs are:

- Current link preference (merged)
- Link status (local and from ground)

The PEP fills out the routing table by masking the link preferences with the link status.

The PEP generates the following output:

- Per packet decision on which air-ground interface to forward

The PDP and the PEP may have various deployment schemes. Their operations are mostly independent from the specific deployment scenario.

The possible air to ground forwarding with policy enforcement is shown in the next Figure.

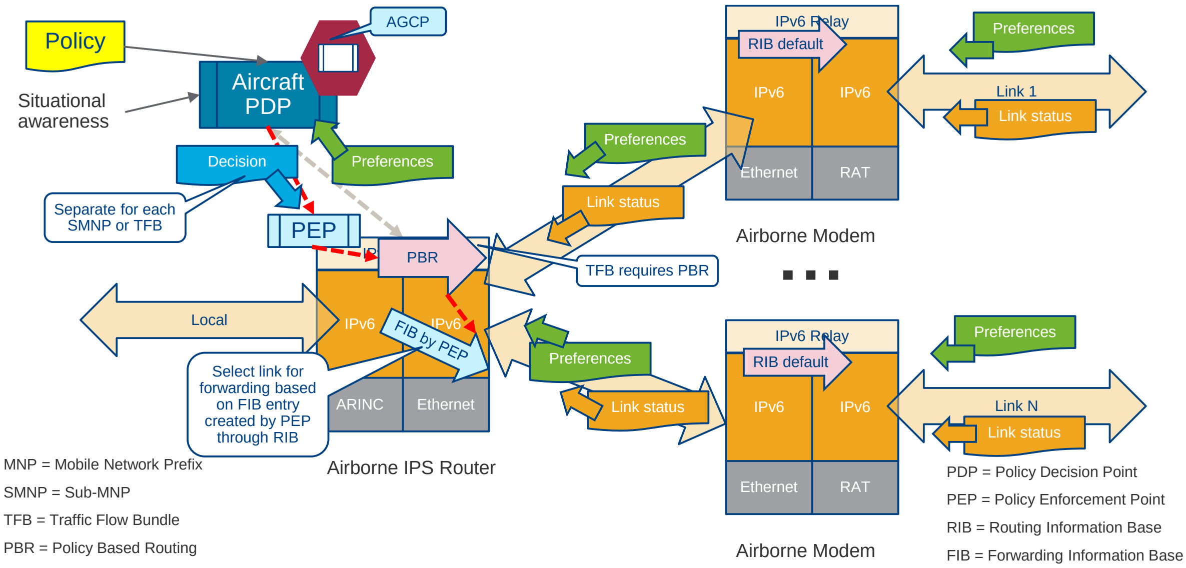

Figure 12: Aircraft policy architecture – air to ground forwarding

The forwarding to the ground is based on the injected default routes. In the Solution the link status and the preferences will not be communicated from the ground to the air. This scheme is presented only for completeness for a potential future solution.

The ground to air forwarding with policy enforcements is demonstrated in the next Figure.

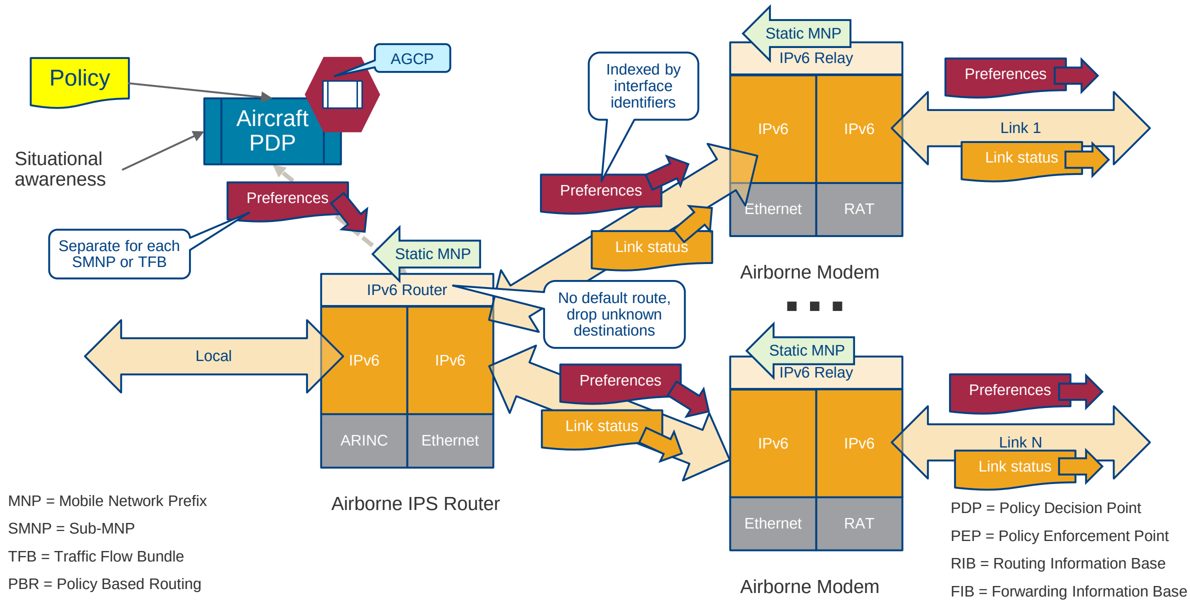

Figure 13: Aircraft policy architecture – ground to air forwarding

The forwarding from the Airborne Modems to the Airborne IPS router would use static MNP routing entries. This, combined with a default route for the other direction, would make the Airborne Modem into an IPv6 relay. The Airborne IPS router would have no default route, so a specific routing entry shall be used for all ground destination groups determined from the Preferences received from the PDP.

3.1.1.6.4 Ground policy architecture

The **policy decision point (PDP)** is a logical function with different deployment possibilities. It might be hosted on the MSE or on the AGR/GGR, or both. It should be fully distributed, with no central point. It could be part of a federation of multiple administrative domains.

The PDP has the following inputs:

- Static policy
- Situational awareness signals

The PDP has the following outputs:

- Policy decision sent to all ground PEPs
- Current updated link preferences sent to the aircraft (only optional, not included in the validation scope of PJ14-W2 Solution 77[4])

The **Policy Enforcement Point (PEP)** is a logical function deployed on the user plane IPv6 routers in the global mobility backbone. It is implemented on the FCI AGBR and GGBR. The PEP function is fully distributed, with no anchors.

The PEP inputs include:

[4] This is only an option and its absence from the validation scope does not impact the completeness of the solution and its maturity level.

- Current link preference (merged)
- Link status (local and from air)

The PEP internal status is maintained in the routing table by masking the link preferences with the link status.

The PEP generates the following output:

- Per packet decision on which local mobility link to forward

There are multiple variations how the PDP and PEP functions could be deployed.

The ground policy architecture for the ground to air forwarding direction is demonstrated in the next Figure.

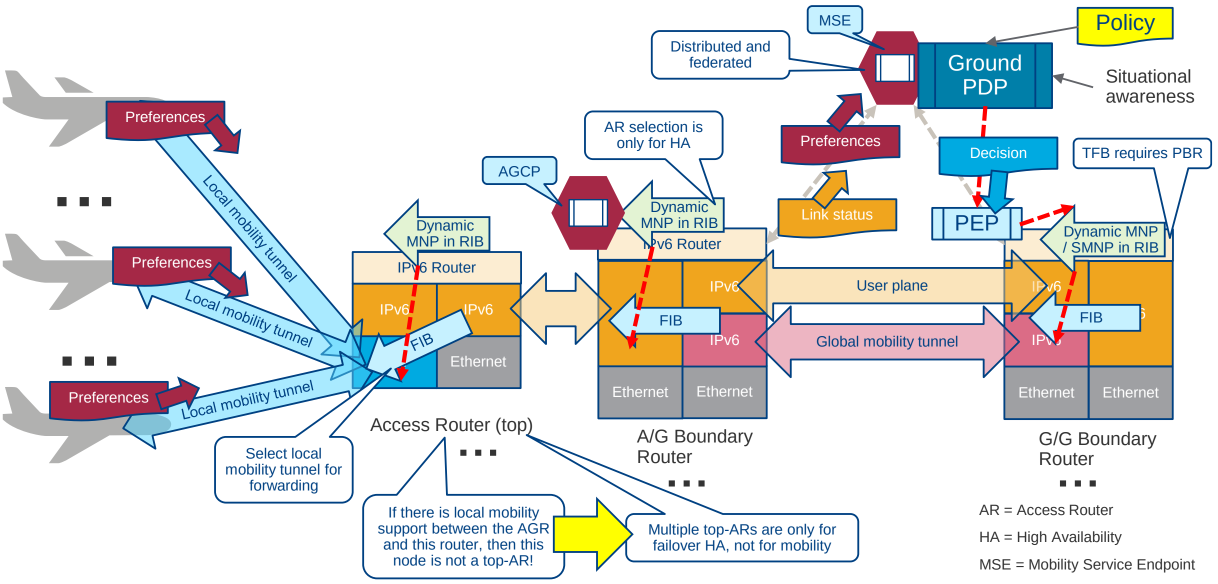

Figure 14: Ground policy architecture – ground to air forwarding

The default ground policy architecture scenario assumes a one-to-one mapping between a RAT link access network instance and the ABGR. For the Solution 77 validations, since the AGBR has nothing to choose on the multilink level, it can be enough to maintain the MNP route in the AGBR. It is not necessary to have the SubMNP specific routes in the AGBR. Only the GGBR must have the SubMNP related route entries.

There could be a situation when a MANSP would like to use a single AGBR for serving multiple different RAT link types for a single aircraft. It is also possible that the ground wants to send the SubMNP-ATS and SubMNP-AOC information into two separate PDP context. In this case, the single physical AGBR role cannot do forwarding on MNP accessibility alone. The following solution alternatives were identified:

- {1} Dedicate an AGBR for each link type on aircraft
  - Inside such a dedicated AGBR, only the MNP needs to be learned, since there are no choices towards the aircraft
- {2} Use a VRF on a single physical AGBR for each link type on aircraft
  - Same as {1}, just for VRF
- {3} Maintain all SubMNP or traffic class policy-based routing (PBR) information in the AGBR as well

A high availability scheme for AGBRs can be implemented based on these assumptions. The control plane should advertise the same MNP/SubMNP for all redundant AGBRs. In the GB-LISP context this would be supported by:

- Use same priority for each AGBR
- Use the LISP "weight" attribute to control load balancing between the AGBRs
  - Expressed in percentage of overall traffic

The next Figure shows the ground policy architecture in other direction, for the air to ground forwarding.

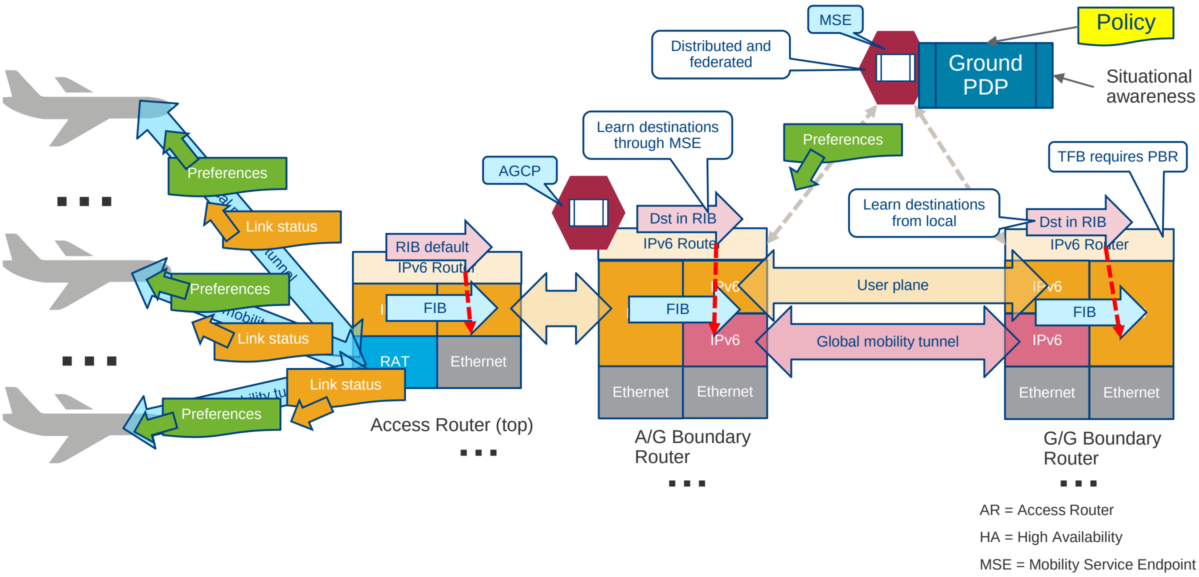

Figure 15: Ground policy architecture – air to ground forwarding

The AGBR and the GGBR would learn all possible destination through GB-LISP. The GGBR should advertise all of their local routes to be accessed by the airplanes into the LISP Mapping System. This does not require any special methods. Standard LISP features could be utilized.

Mapping preference changes into routing table entries could use some generic principles. It is recommended to decouple link status and preference changes. This is based on the longest matching (more specific) route principle. The optional SubMNPs shall be treated as more specific than pure MNP routes. The MNP routes are changed only by link status change events, not impacted by preferences. If there are no preferences, forwarding can be still done by MNP.

SubMNP routes (or PBRs) are changed by preference change events. SubMNP routes (or PBRs) are more specific, so take precedence over the MNP routes.

MNP route withdrawal for a specific link shall trigger the withdrawal of all related SubMNP routes (or PBRs) (!) on the same link. This feature might be not implemented yet in COTS routers – so it might need to be implemented in the AGMI Ground Proxy.

MNP routes behave like a kind of safety net in case the preferences receiving or processing is failing. The SubMNP routes might have a shorter expiration timer than MNP routes.

In the GB-LISP context, the preferences are mapped into the "priority" attribute in LISP. The MNP routes might be maintained in the MS/MR according to the ground preferences. By default, SubMNP routes are maintained in the MS/MR according to the aircraft preferences. Optionally, the air and ground preferences might be combined for SubMNP routes. However, this is used only in one basic scenario in Solution 77 validation prototype. A simple test of such a local override was executed using the CLI control. It was checked, during the development of the SATCOM ATN/IPS Gateway in the ESA Iris IOC project, that a machine-to-machine API is available using YANG over NETCONF or YANG over gRPC for some of the COTS implementations. That enables to have a distributed PDP function, where for some flows the default COTS mechanism is used automatically, while for some other interesting flows a ground-based policy enforced initiated by a PDP part residing outside of the GGBR.

Various trust models could be used on the ground between multiple MANSPs depending on the preferences communication method

- {a}, {b} send on all links [see Section 3.1.1.6.2]
  - Only the link owner will register the SubMNP route with MS/MR
  - Does not require the MANSP identifiers in the preferences message
- {c}, {d} send only on preferences report [see Section 3.1.1.6.2]
  - {F} full delegated trust: register directly all SubMNP routes – require knowledge of related RLOCs and getting the MANSP identifiers in the preferences message
  - {H} hints only: forward the preferences to the link owners as a hint – only the link owner can register the SubMNP routes

These trust model alternatives are elaborated in the IF6 ICD [22].

For what concerns the ”foreign report”, the FCI Solution 77 validation prototype will implement only the {F} full delegated trust model. This does not apply instead to the Link Preferences, where a trust model is not absolutely necessary.

If new policy needs arise, to have less trust between the Service Providers for what concerns the “foreign report”, then the option {H} would require further study beyond Wave 2 and potentially extensions of the LCAF implementation in COTS router.

A potential simple way to implement the {H} option is proposed for ICAO based on experiences in the validation exercises. The Foreign Report execution will use a LISP Priority of 254. This will not disable the reported link, just put it at the bottom of the priorities. If in the meanwhile this is the only remaining link since the others go down, then it is still possible to do retries. When the owner sees this Priority for its own link, then it could do a cross-check of connectivity. If the connectivity is already restored, then it can override this lowest priority LISP registration with a more up-to-date better registration.

This new LISP Priority scheme could not be implemented yet for the validation exercise, so it will be validated only later. However, it is a relatively simple modification.

It still recommended to use LISP Priority of 255 when the link owner detects a link down status on its own locally. This will block the traffic flow immediately. However, this status will be still visible for some time as an explicit “admin down” state. If this problem persists, then the registration will be removed totally from the MS/MR.

Using two different LISP Priority values for these two different failure scenarios will make easier to understand the state of the GB-LISP systems or analyse event log entries.

3.1.1.6.5 Monitoring RAT datalink performance

The Performance-based Multilink should maximise not only performance but also availability of the service. In fact, a datalink outage or datalink quality degradation can cause a drop in the level of datalink performance and its availability for specific FCI services.

In order to detect in a timely manner changes in the performance level supported by a datalink (degradations, outages, and recoveries), a link monitoring function shall be provided by the Radio Access Technology (RAT) link as an underlay service. This function also involves the capability to inform other entities of link quality changes (e.g., air notification to ground, or propagation of routing preference through the network). This function should provide a common awareness throughout the network of the acceptability of an end-to-end path for specific traffic.

The IP Mobility has no impact on the Airborne IPS functionality; according to the Ground Based LISP architecture, there are no routing protocols between the Airborne Router (A-R) and the A/G IPS Router. In other words, the GB-LISP Control plane messages, as well as GB-LISP encapsulated data messages, are not exchanged between the A-R and the AGMI Proxy, which is a functional block that can be deployed on different ground network elements of the Access Network (e.g., the A/G-R routers), depending on the architecture implemented by the Access Service Provider. The messages exchanged between the A-R and the AGMI Proxy are compliant to the IF9 AGMI protocol ([20]).

When two different services are transmitted over the same datalink, QoS configuration allows for traffic prioritization. More sophisticated techniques such as load balancing are also possible with performance-based multilink policy.

A datalink will not be authorised for the provision of an ATM service, whose required performance is above that considered to be guaranteed by the Access Network. Different services (e.g., ATS, AOC) should use different datalink depending on whether they are considered by the system to comply with the QoS parameters configured for the CoS assigned to the service.
A change in the datalink preferences shall be propagated in the routing policy through the network for affected applications, transparently to the End User (for example Pilot or ATCO) and according the required QoS (see Table 10).

REQ.14.77-TS-MLNK-0019 - Multilink QoS management
The FCI Multilink Management Function (MMF) for the A-R and Access Network Functional Blocks shall put in relationship the Service Type, the Class of Service (i.e., the Link Quality) and the DSCP value.

The DSCP determines the per-hop behaviour of the ground routers. However, the queue management shall require a configuration according to the required behaviour.
Strict priority queueing needs to be used on the ground routers to provide the required pre-emption capability.

REQ.14.77-TS-MLNK-0020 - Multilink policy and preferences management (path selection)
The FCI Multilink Management Function (MMF) for the A-R and Access Network Functional Blocks shall put in relationship the Service Type, the Class of Service (i.e. the Link Quality) and the "preference scope" defined by two components (see the AGMI protocol specification [20] and the IF6 ICD [22]):

- *the SubMNP*
- *the Traffic Class*

A change in the datalink preferences is communicated by the AGMI protocol to the ground. For more details refer to the AGMI protocol specification [20] and the IF6 ICD [22].
The Aircraft might change its datalink preferences based on the experienced performance of the connectivity.

FCI Use Cases

The following Use cases have already been defined in W1 and are now updated according to the new W2 requirements and Function Block definitions:

- **Use Case #1 – FCI A/G Multilink selection**
- **Use Case #2 – Ground LISP Basic Principles scenario**
- **Use Case #3 – Vertical Handover on A/G link break**
- **Use Case #4 – A/G Datalink Performance and QoS**
- **Use Case #5 – Packet Flow management – Uplink/Downlink**

3.1.2 FCI Use Cases

3.1.2.1 Use Case #1 – FCI A/G Multilink selection

Multilink is a concept where at least two future independent A/G datalinks are simultaneously available and operationally deployed in the airspace and are managed to comply with the performance requirements of the user applications.

The FCI systems architecture and ATN-IPS protocols allow to implement on the aircraft the following mechanisms:

- The link policy for downlink and uplink directions may be different and asymmetric. In this case, link selection for the A/G data exchange is managed by the ground routing protocols (uplink) and by the airborne router (downlink).
- Optionally, Multi-transmission of a same message over multiple link (simulcast)
- Optionally, Network–level mechanisms for detecting any loss of connection undetected by the lower layers, or any misbehaviour (corruption, excessive delays, etc) of the communication links, and for performing the link re-selection. This option could be a possible enhancement in case of radio link technologies where additional protocol overhead for failure detection is deemed acceptable[5]. For each RAT type an individual decision could be done depending on further studies.

These are radio links based on IP SATCOM, LDACS, AeroMACS and IP VDLM2 wireless technologies. Several Access Networks could be simultaneously available on both the airborne and ground side, e.g., multiple SATCOM links, and multiple LDACS links and IP VDLM2 datalink, according to how many CSPs offer their connectivity in a defined airspace.

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[5] This is only an option and its absence from the validation scope does not impact the completeness of the solution and its maturity level.

The two main functions on which the current FCI requirement document is focused are:

- Multilink Management Functions (MMF), this function includes the **policy decision point (PDP)** and the **Policy Enforcement Point (PEP)** is a logical function
- Mobility Service Endpoint (MSE);

Access Networks shall support the Multilink strategies by providing to Airborne Routers and A/G Routers the following **information events**:

- Registration/De-registration events, regarding each Aircraft entering or leaving the Access Network (IF9). The registration scenario is described in detail in the **NSV-4 FCI Airborne Registration to FCI Access Network** (see section 4.1.1.5.1 and Figure 38)
- Management of Multilink: status update events are received on the ground from the Airborne Router (see Notify DLs update to Ground network functions);

This paragraph describes how this functionality is split and managed among the above described functional sub-blocks.

These datasets have been exchanged by the A/G-R events (Provider is the A-R; Consumer are the AC-R and A/G-R:

- Datalink Status
- Datalink status update

Additional details (e.g. the protocol layer subdivision between functional sub-blocks) have been included in MEGA NSV-4 views.

- The **Airborne Router Functional Block** manages “Registration/De-Registration” events towards Access Networks **(IF9),** link quality evaluation and dynamic multi-link selection within the FCI, according to the **FCI Multilink policies** and procedures; then it manages data traffic distribution to/from the Access Networks on the basis of the “**Multilink Policy” selected** for each ATM service. The FCI Multilink Policy selection is described in the **NSV-4 – FCI Multilink Policy – Airborne** (see section 4.1.1.5.3 and Figure 40).

  The IP Mobility has no impact on the Airborne IPS functionality; according to the Ground Based LISP architecture, there are no routing protocols between the Airborne Router (A-R) and the Access Router (AC-R). In other words, GB-LISP control plane messages, as well as GB-LISP encapsulated data messages, are not exchanged between the two routers.

- AGMI Proxy manages “Registration/leave” aircraft events (through the IF9 interface) on the ground. These AGMI Proxy functions contribute to the Multilink implementation:
  - Airborne A-R Registration/De-registration events;
- **A/G IPS Routers**: they manage Multilink Monitoring function on the ground and the link quality monitoring coming from the Access Network (**IF3** and **IF9**); they are connected to the ground Mobility Service Endpoint(s) (MSEs, which in GB-LISP are the MS/MRs) through the interface IF6, to register the aircraft system reachability and to drive the global routing function allowing to reach the latter.

- These A/G functions contribute to the Multilink strategy implementation:
    a. Monitoring A/G multilink status
    b. Monitoring/Update Multilink Services Policy functionalities;
- **Mobility Service Endpoints (MSE)**: they manage GB-LISP Control Plane primitives (Map-Register, Map-Notify, Map-Request, Map-Reply); in the GB-LISP (LISP-SEC) “language”, the A/G IPS Router is the integration of ITR and ETR LISP devices. They also manage data traffic to/from the G/G Routers;

3.1.2.2 Use Case #2 - Ground Based LISP Basic Principles scenario

The scenario describes how the change of datalink status (Up/Down) or datalink quality, detected by the Airborne radio (LDACS, AeroMACS, IP SATCOM and IP VDLM2), causes an update in the datalink selected for A/G data transmission, according to the Multilink Service Policy (Administrative or Performance based) defined in the Airborne Router. The update of datalink selection also causes an update of the route metric on the Ground Based LISP Domain.

The scenario also includes a description of Mobility route updates managed by the MSE (MS/MR in case of GB-LISP), when radio joint/leave events have been generated by the Airborne Router. The ground route updates are also generated by link loss events by the AGMI Proxy on the IF9 or notified by the A-R Multilink monitoring functions.

As this use case is related to the route management, End Systems are not involved.

This scenario highlights a situation described in the **NSV-4 FCI Ground Based LISP Route Management** (see section 4.1.1.5.2 and Figure 39) on which:

- A “Link Quality” **change event,** detected by the Airborne radio (i.e., LDACS link quality event), causes an update on the Multilink Policy preference (as an example, Link Quality moves from "UP" to "BEST"), thus causing an update of link preference and a metric change on both the Airborne Router and the Ground (GB-LISP) Domain;

- When a **join event** on a new available radio link (i.e., SATCOM) is received by the A-R; an additional route to all Aircraft End Systems behind the Airborne Router is added into Multilink Monitoring function on the A/G and on the Ground Mobility management Entity MSE(or MS/MR LISP router);

- When a **leave event** on an available radio link (i.e., AeroMACS) is received by the A-R; this route to Aircraft End Systems behind the Airborne Router is removed from the ground Mobility management Endpoint (MS/MR) upon an "IF9 loss event detected by the relevant[6] AGMI Proxy".

The join/leave events start the registration/de-registration process of the Aircraft in the FCI Service, as described in the **NSV-4- FCI Airborne Registration/De-registration to Access network** (see section 4.1.1.5.1 and Figure 38**)**.

[6] There is an AGMI Proxy instance in each Access Network

The A/G-R translates routing information exchanged with the **Airborne Router via IF9 into LISP metric update**, via MAP-REGISTER primitive. Also, the role of GB-LISP Pub-Sub feature is highlighted, with the GB-LISP "Publish" message to all A/G-R that have been "subscribed" on every route metric change.

In case of leave event caused by a link break, route update procedures on ground are started by the Multilink Management function (MMF) after a message for DL changes has been notified by the Airborne Router to the Access Network. This event is detected also by the AGMI Proxy on the IF9.

The scenario and the route update procedures on the ground caused by link break or datalink route unavailability are described in **NSV-4 – FCI flow Management - Ground route change management** (see section 4.1.1.5.4 and Figure 41).

3.1.2.3 Use Case #3 - Vertical Handover on A/G link break

This scenario foresees an ATN packet exchange via Dialogue Service (DS) via SATCOM radio link and two active datalinks, SATCOM and AeroMACS. The event before the loss of SATCOM is the exchange of the n-th packet; then the second event is the notification to the Airborne Router, that sends the (n+1)-th packet through AeroMACS. In the scenario the following sequences of events are depicted:

- The A-R receives an event from the Airborne Radio that notifies the A/G Link connection (SATCOM).
- The A-R selects the DL available that matches the QoS policy defined on the A-R.

The Airborne Router selects the DLs according the defined Airborne Policy as described the NSV4 – FCI Multilink Policy - Airborne. In the meantime, the A-R router connected to SATCOM radio link notifies the datalink update to the ground AGMI Proxy. This event will be evaluated by the ground MMF and policy and can cause a "route metric update" from A/G-R to MS/MR and subsequent "publish" message towards the "subscribed" G/G-R according to the description reported in the Figure 39: NSV-4 - Ground Based LISP Route Management, section 4.1.1.5.2.

3.1.2.4 Use case #4 – A/G Datalink Performance and QoS

Access networks support the Multilink strategies by providing to Airborne Routers and A/G Routers the following information:

- Join / Leave events, regarding each Aircraft entering or leaving the Access Network;
- Datalink Performance and Policy.

This information allows the Airborne and G/G Routers to maintain the required Class of Service for each ATC/AOC connection according to the behaviour of the link. See the description included in the Airborne. During the data exchange phase over a datalink (i.e. over SATCOM), the MMF on the AGMI Proxy detects a DL Performance data with a reduction in Link Performance respect to the required for the QoS/ATN Priority established for the data exchange in progress.
Then, a map-register message changes the priority/weight parameters for this RLOC, and this is immediately notified to the G/G-R the route update. This use case is described in detail in section 4.1.1.5.2

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3.1.2.5 Use Case #5 - Packet Flow management –Uplink/Downlink

This Use Case highlights two different End Systems (ER ACC and Civil AU) exchanging data packets with the same aircraft. ER ACC exchanges Dialogue Service packets (CPDLC and/or ADS-C), while Civil AU exchanges SWIM PP information with the Aircraft. See these NSV-4 views for the details:

- **NSV-4 - Packet Flow management –Uplink** (see section 4.1.1.5.6 - Figure 43**)**
- **NSV4 - Packet Flow management –Downlink** (see section 4.1.1.5.6 - Figure 44)**;**Here, the Multilink Policy behaviour is to route higher priority packets (ATN DS, marked with DSCP=AF32) on LDACS (we assume that it has a better Link Quality) and lower priority SWIM PP ones (DSCP=AF42) on SATCOM (we assume that it as a worse Link Quality).

Then, a map-register message changes the priority/weight parameters for this RLOC, and this is immediately notified to the GG-R the route update.

According to the ML strategy defined on the GG-R, the GG-R routes data over the DL with the required QoS LDACS connectivity (i.e. LDACS) for the session started from the Ground ES.

- **G/G IPS Routers** provide the following functions for Multilink and IP Mobility implementation:
  - Multilink management on ground side, in terms of:
    - Applications of the FCI Multilink policies (that can be updated through the router management interface), according to the parameters and attributes exchanged with the ATN IPS ES(s) (through the IF5 interface)
    - Data flow management to/from A/G-R belonging to the Access Networks (through the IF4 interface), according to link quality metrics properly encoded in GB-LISP Control Plane messages;
  - Ground IP Mobility functionalities is done by the MSE (Mobility Service Endpoint), which in GB-LISP is the MS/MR, and which allows providing a highly scalable routing system within the GB-LISP domain.

3.1.3 Applicable standards and regulations

Foreseen applicable standards are highlighted as follows:

1. EUROCAE ED228A “Safety and Performance Requirements Standard for Baseline 2 ATS Data Communications (Baseline 2 SPR Standard)”. Rationale: this standard provides performance figures that FCI has to meet in order to be able to provide support to ATN B2 ([14])
2. ICAO doc. 9896 ED II "Manual on the Aeronautical Telecommunication Network (ATN) using Internet Protocol Suite (IPS) Standards and Protocols" ([3])
3. EUROCAE ED-262/RTCA DO-379 “Internet Protocol Suite Profiles” ([4])
4. RFC 6830 “The Locator/ID Separation Protocol (LISP)” ([27])
5. RFC6831 “The Locator/ID Separation Protocol (LISP) for Multicast Environments” ([28])
6. RFC6833 “Locator/ID Separation Protocol (LISP) Map-Server Interface” ([30])
7. RFC6833-bis “Locator/ID Separation Protocol (LISP) Control-Plane” ([31])
8. “Draft IETF LISP-SEC-12” ([36])

9. RFC8111 “LISP Delegated Database Tree (DDT)” ([33])
10. draft-ietf-ipsecme-g-ikev2-02 - “Group Key Management using IKEv2” ([34])
11. draft-ietf-lisp-pubsub-06 "Publish/Subscribe Functionality for LISP" ([35])

3.2 Capability Configurations required for the SESAR Solution

The following table summarizes the FCI capability configurations:

SESAR Solution ID and Title	Capability Configurations (CCs) (from EATMA)	Sub-Operating Environment(s) where the CCs operate	Nodes (from EATMA)	Stakeholders (from EATMA)
PJ14-W2-77-FCI Services	Communication Infrastructure	• Airport • En-Route • Network • Terminal Airspace	• Airport Operations • Airspace User Operations • ATS Operations (En Route, APP, TWR)	• ANSP Civil • ANSP Military • GA • AU Military • Airspace Users – Scheduled • Airspace Users - BA Fixed Wing • Airspace Users - FOC
PJ14-W2-77-FCI Services	Civil Aircraft		Aircraft	Pilot

Figure 16: List of Capability Configuration required for the SESAR Solution

3.3 Changes imposed by the SESAR Solution on the baseline Architecture

Enabler ID (from EATMA)	Enabler Title (from EATMA)	Changes
CTE-C04	Future Communication Infrastructure - ATN/IPS and Multilink	- **TS Routing Networking Equipment for A/G Datalink**: o Functional Blocks and Functions: ▪ **Access Router (AC-R)**; ▪ **A/G-R**; • Monitor Multilink status (MMF, PDP) • Register Airborne Mobile Network Prefix (MNP,PEP) • Route downlink packets (PEP) • Update Airborne Registration (PDP) • Update Mobility Policy metrics (PEP) • Update Routes (PEP) ▪ **AGMI Ground Proxy**: • Manage Multilink connections with Airborne (PDP) • Monitor Multilink status (MMF,PDP) • Notify Aircraft Registration • Notify Multilink updates to Airborne • Register Airborne Mobile Network Prefix (MNP) • Select A/G Datalink on Administrative Policy (Ground, PEP) • Select A/G Datalink on Performance Policy (Ground, PEP) • Update Mobility Policy metrics (PEP) • Update Routes (PEP)

		- **TS - Ground ATM Networks**: o Functional Blocks and functions: ▪ G/G-R: • Route downlink packets • Route uplink packets • Update Routes ▪ MSE (MS/MR) • Publish LISP routing update (via MAP-Notify) • Update Airborne Mobility • Update LISP Metric (via MAP-Register) ▪ **FB Gateway OSI-IPS** ▪ **FB Gateway IPS-OSI** - **TS CIV-MIL Gateways**[7]
A/C-95	FCI - Airborne part of ATN/IPS and Multilink	- **TS - Aircraft:** o Functional Blocks and functions: ▪ **FB - Airborne Router**: • Apply FCI Multilink Service Policy (PEP) • Forward Downlink Packets (PEP) • Forward Uplink Packets (PEP) • Monitor Air-Ground DLs (MMF,PDP) • Monitor Airborne A/G Multilink (registration, PDP) • Notify DLs update to Ground network

[7] This CC is not in the scope of Solution 77, nor is its validation. It has impacts on the MIL communication systems (i.e. link16,..) and can be validated only in a future project with coordination and availability of the MIL systems and links. Nevertheless, we cite it here to remind that CIV-MIL Interoperation is part of the FCI goals and should not be forgotten in the future evolution and deployment.

		- Select Datalink on Administrative Policy (PEP) - Select Datalink on Performance Policy (PEP) - Send Airborne A/G Multilink registration request ▪ **FB AGMI endpoint (airborne)** - Register Airborne Mobile Network Prefix (MNP) to the ground - Send A/G Link Preferences to the ground ▪ **FB Simple name lookup server** - To be described, according to ARINC PP858

Table 5: List of changes due to the FCI Solution

4 Technical Specifications

4.1 Functional architecture overview

FCI supports the flexible use of the four datalinks, which require the definition and specification of the Multilink function, as well as of the IP Mobility management solution and support for specific security features. Harmonised levels of service quality are identified and proposed, together with aspects such as performance management mechanisms.

In order to describe the FCI architecture in a structured manner, the ISO/IEC/IEEE 42010:2011 standard ([8]) is adopted in this TS/IRS, according to SESAR 2020 requirements guideline [1]. In particular, different actors, concerns, architecture viewpoints and architecture views are identified and described. The viewpoints are based on the following FCI aspects:

- "What": this aspect deals with tailoring of the overall FCI functional view (EATMA Functional Blocks) according to the FCI technical system use cases and purpose
- How": this aspect deals with the technical realization of functions (the "what"), according to the assessment of technical interoperability needs. In particular, the "how" is specified only when interoperability needs have been identified
- Performance and security requirements: this aspect deals with the non-functional requirements (NFRs) concerning the functions ("what"), the technical realization of the functions ("how") and the overall FCI.

NOTE: the document "FCI IF6 - ATN IPS AG-R to GB-LISP Interface Control Document" ([22]), which is an external appendix to this TS/IRS, specifies in detail the design of the Mobility & Multilink protocol exchanges (Message Sequence Charts, state Machines, etc.), covering the PJ14-W2-77 Validation Scope [see Appendix C]

4.1.1 Resource Connectivity view (one section per NSV-1)

The following diagram represents the resource connectivity view with all FCI relevant Configuration Capabilities and their interconnection.

The FCI NSV-1 includes these Configuration Capability (CC) duplicated from the MEGA library **phase B**; that host the required FCI Technical System and FB:

- **Civil Aircraft CC**;
- **Communication Infrastructure CC**;
- **SATCOM Space Segment;**
- **SATCOM Ground Segment;**
- **State AU Operations Centre;**
- **APP ACC;**
- **TWR.**

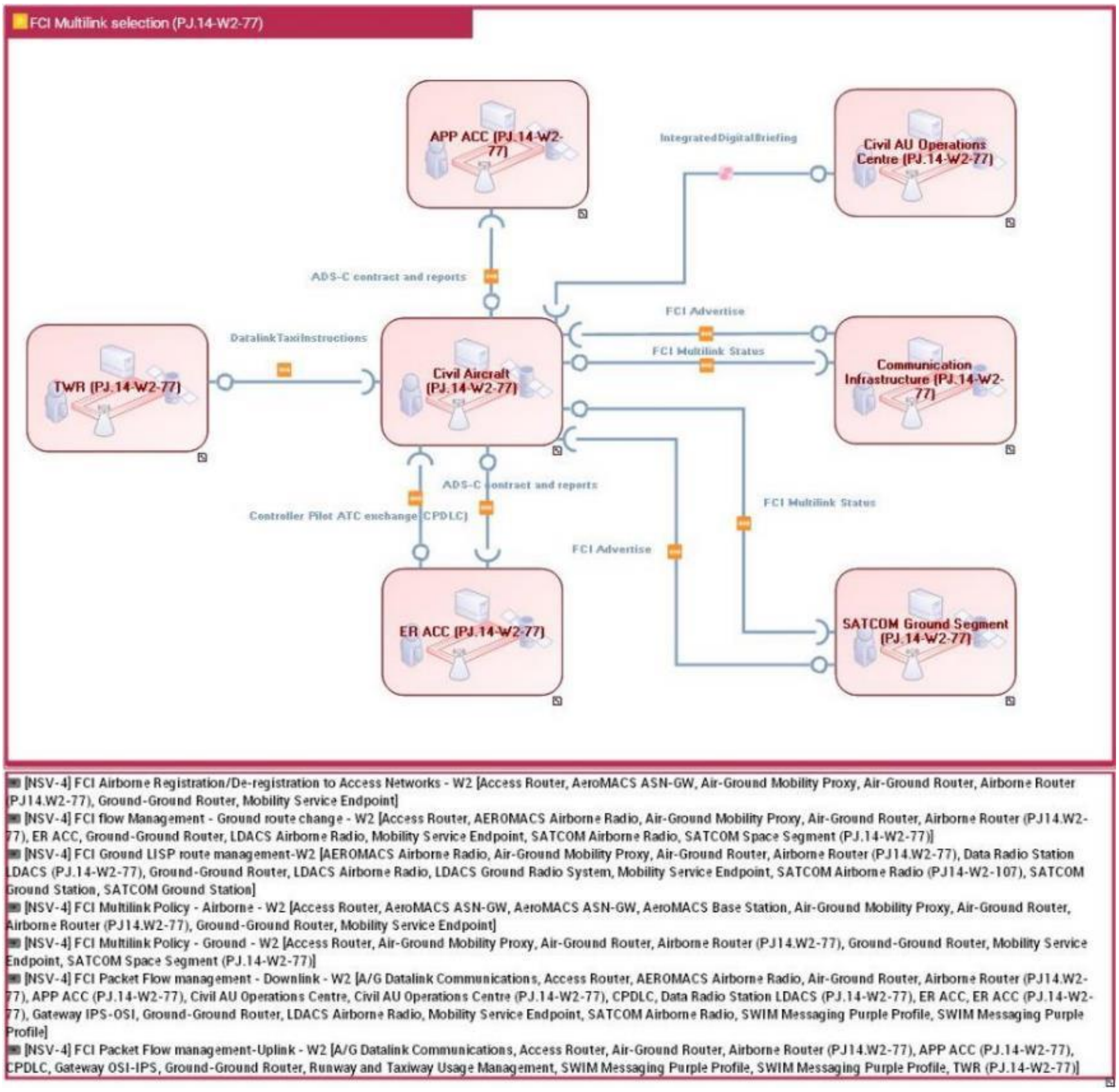

Figure 17: NSV-1 FCI Services - Resource Connectivity view

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4.1.1.1 Communication Infrastructure Capability Configuration

The following diagram represents the Communication Infrastructure CC, with all FCI relevant Technical System and their interconnection.

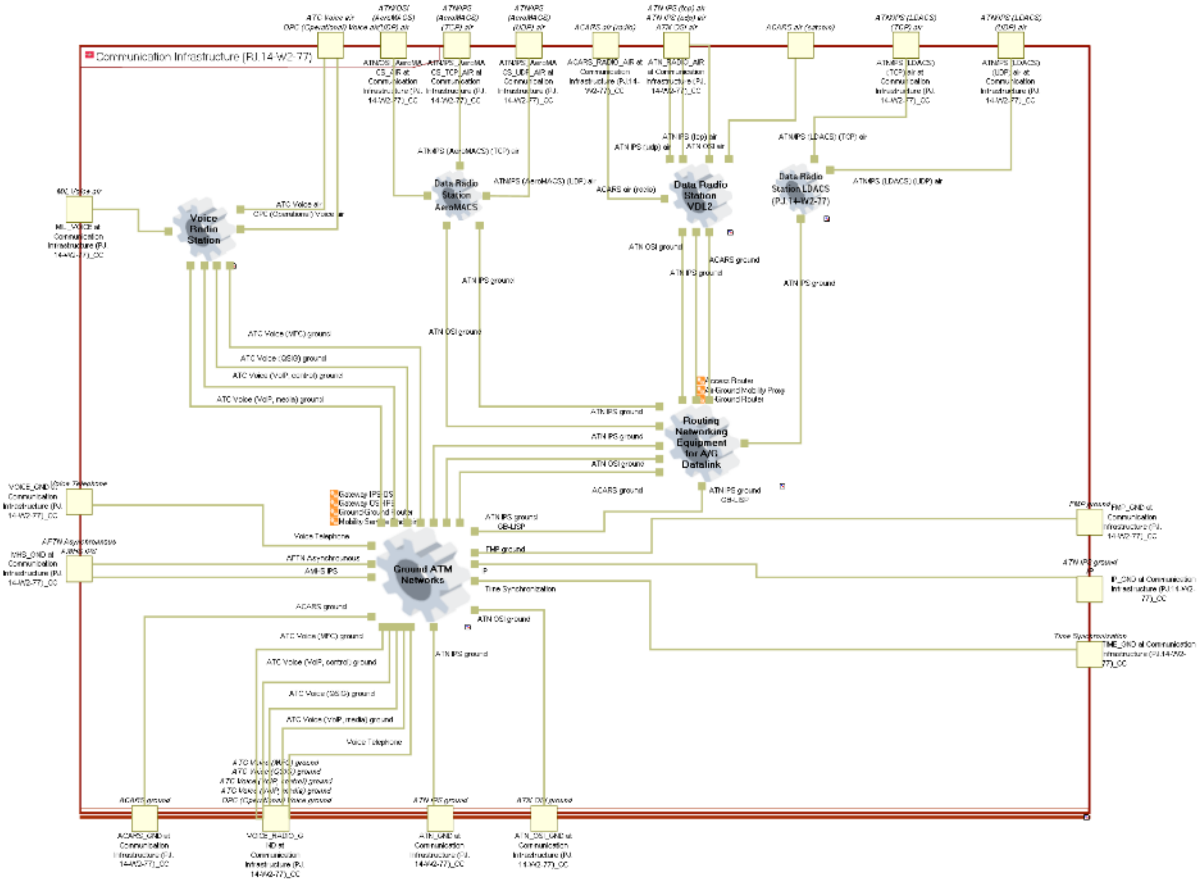

Figure 18: EATMA modelling of Communication Infrastructure CC

- Four data radio stations (LDACS, SATCOM, AeroMACS and IP VDLM2) are required to implement the FCI Multilink operational concept;
- Each Data Radio Station is connected to a dedicated access router (AC-R) on the Ground Access Network;
- Each AC-R has a Control Plane architecture that provides connectivity to a number of Ground-Ground Routers according to GB-LISP protocol;
- Each A/G-R has a Control Plane architecture that foresees connectivity to a number of Map Server / Map Resolver (MS/MR; only one in the diagram) for Airborne End Systems dynamic route creation / update / deletion;

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- The MS/MR (GB-LISP implementation of MSE Functional Block) operates at Control Plane level to receive route update notifications from A/G-R and from the "AGMI Proxy" instances of each Access Network (and also from G/G-R, for G/G communications) and it performs route update functionality towards G/G-R, according to the LISP Publish-Subscribe protocol;
- The G/G-R allows connectivity of Ground End Systems towards the FCI A/G access network and the connected Aircraft;
- The Gateway OSI-IPS allows connecting a legacy OSI-based ground End System to an IPS airborne End System through the FCI, using the "IF8" interface (and "IF5" interface towards the LISP infrastructure).) and vice versa, to connect an OSI-based aircraft to an IPS-based ground End System. In the case of OSI-based aircraft, the OSI-IPS Gateway connectivity is not through the IPS segment but through a legacy datalink OSI (e.g. it is performed through OSI VDLM2 and ATN/OSI); therefore, this interface is not shown in the diagram. The interface towards the IPS-based ground End System is managed through the "IF5" interface.
- Each ground component of the FCI is connected to a proper AAA server, to ensure robustness against cybersecurity attacks on the ground side. The AAA servers for the A/G links are present within each Data Radio Station (Access Network) diagram.

4.1.1.1.1 FCI Services Resource interactions

These FCI Services Resource interactions have been defined in the Civil Aircraft, the Communication Infrastructure CC and SATCOM Ground segment CC:

- The **FCI Advertise** resource interaction between CC:
  - Civil Aircraft CC (Consumer) and
  - Communication Infrastructure CC (Producer)
  - SATCOM Ground segment CC (Producer)

- **The FCI Multilink Status** resource interaction" between:
  - Communication Infrastructure (Consumer)
  - SATCOM Ground segment CC (Consumer)
  - Civil Aircraft (Producer).

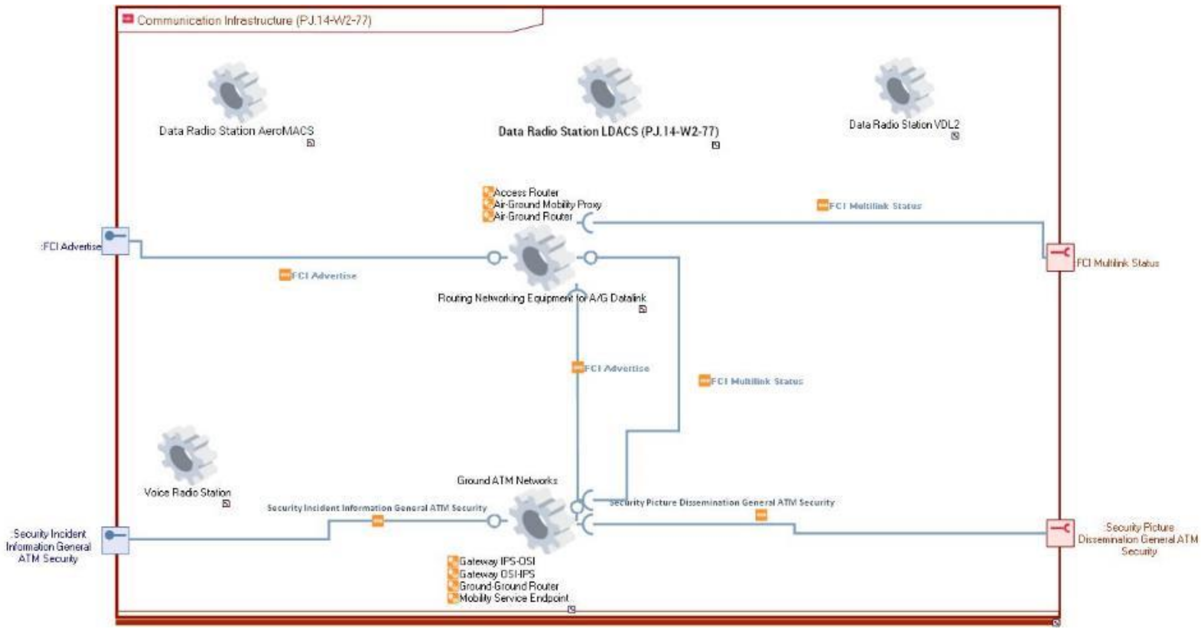
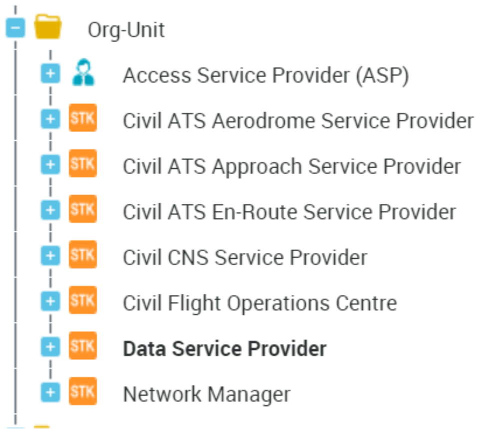


Figure 19: Communication Infrastructure - Resource Capability Configuration

These Stakeholders Organization Unit have been added (see Annex B for the description):



These FCI Functional Blocks have been added in the Technical systems:

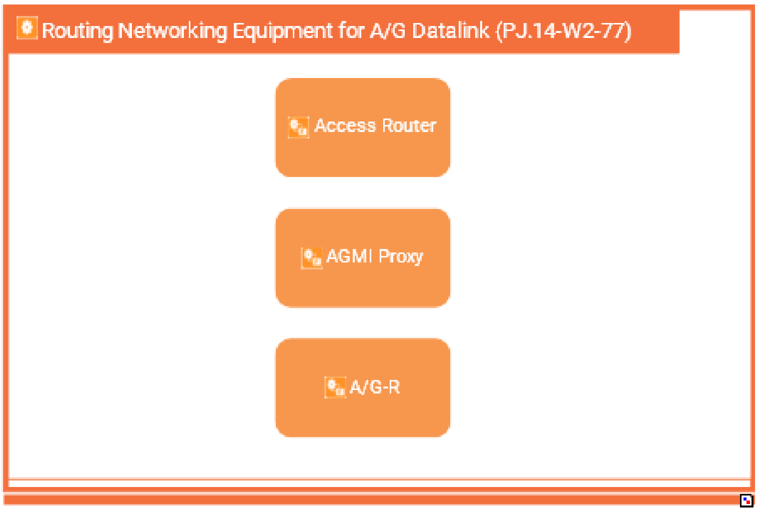


Figure 20: FB of Routing Networking Equipment for A/G Datalink TS

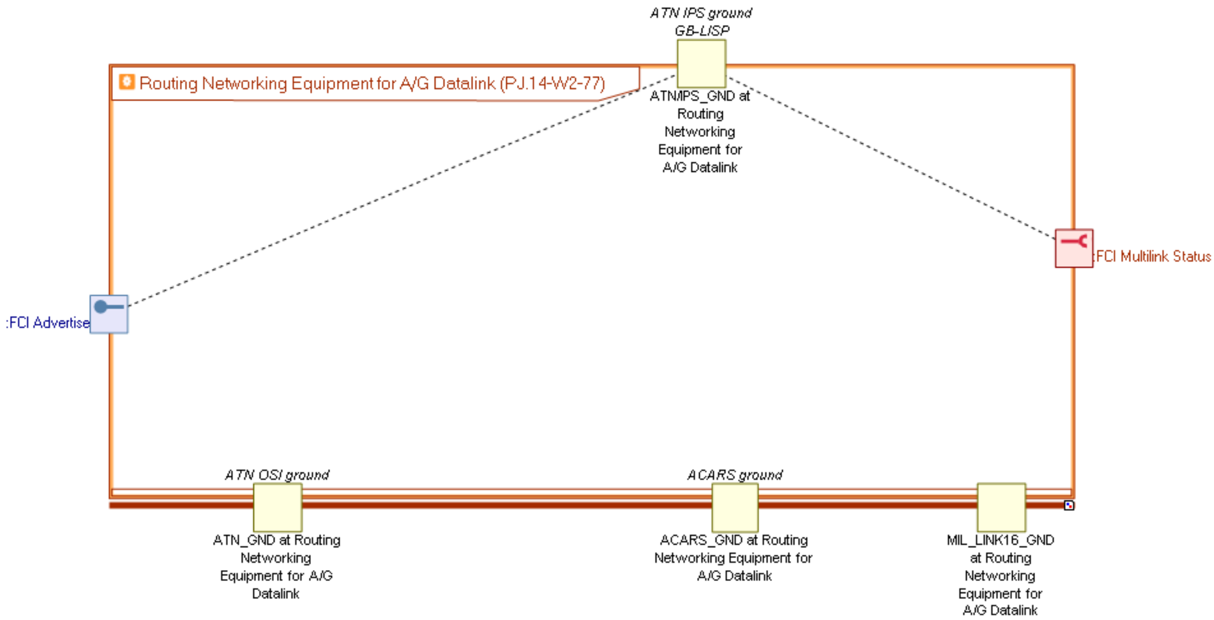


Figure 21: Resources and Ports of Routing Networking Equipment for A/G Datalink TS

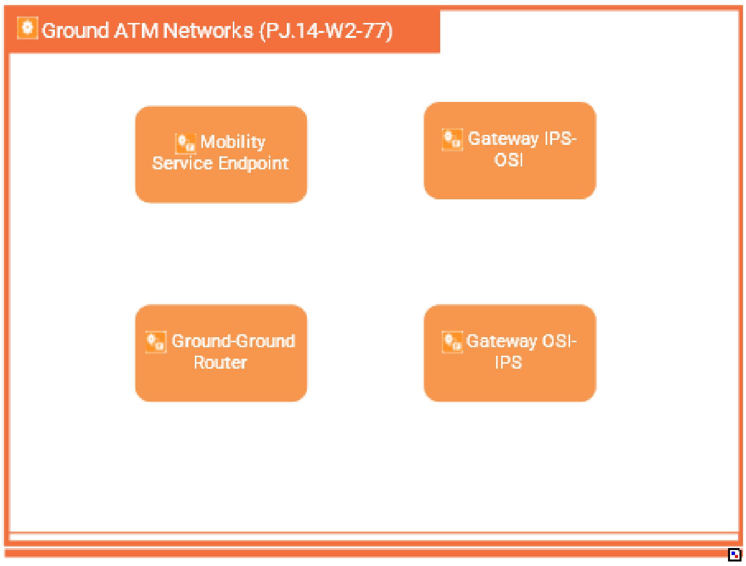


Figure 22: Functional Block of Ground ATM Networks TS

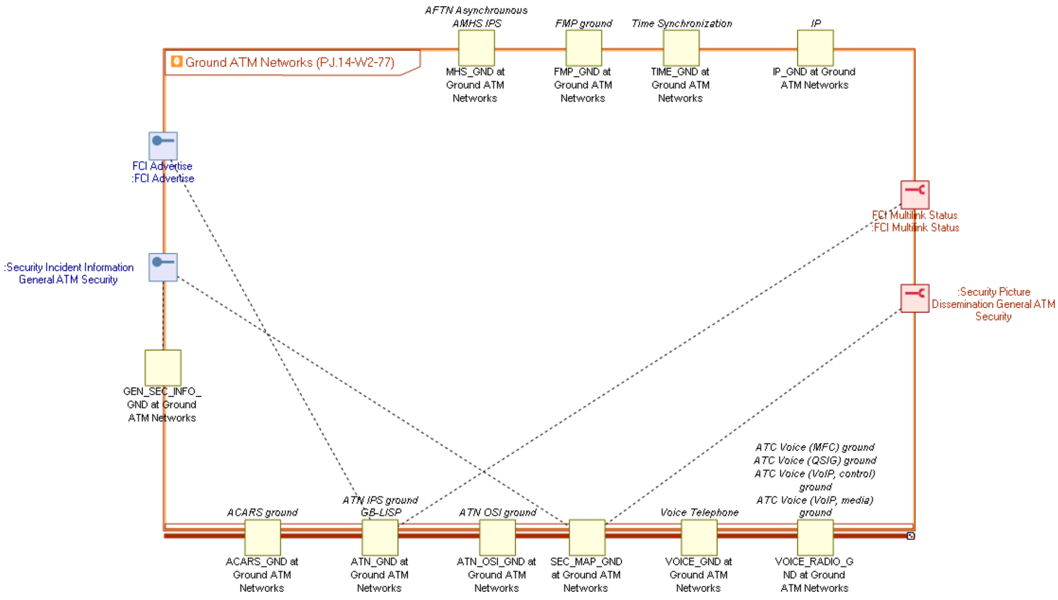


Figure 23: Resources and Ports of Ground ATM Networks TS

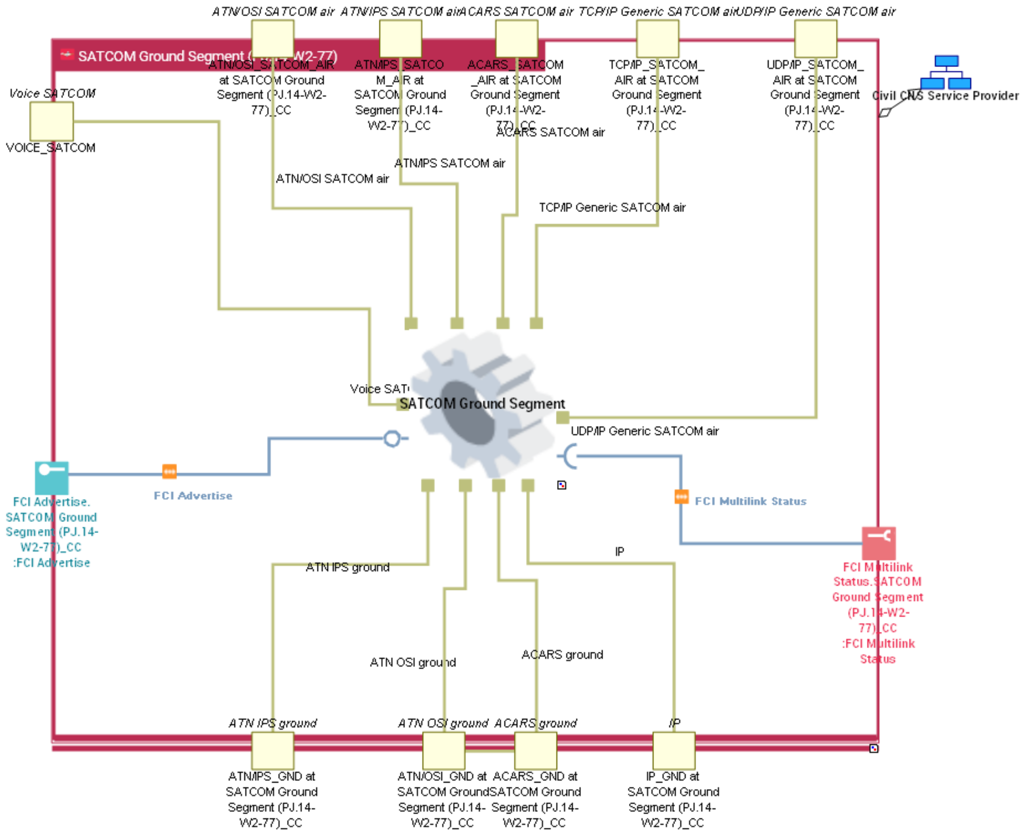


Figure 24: SATCOM Ground Segment - Resource Capability Configuration

4.1.1.2 Civil Aircraft Capability Configuration

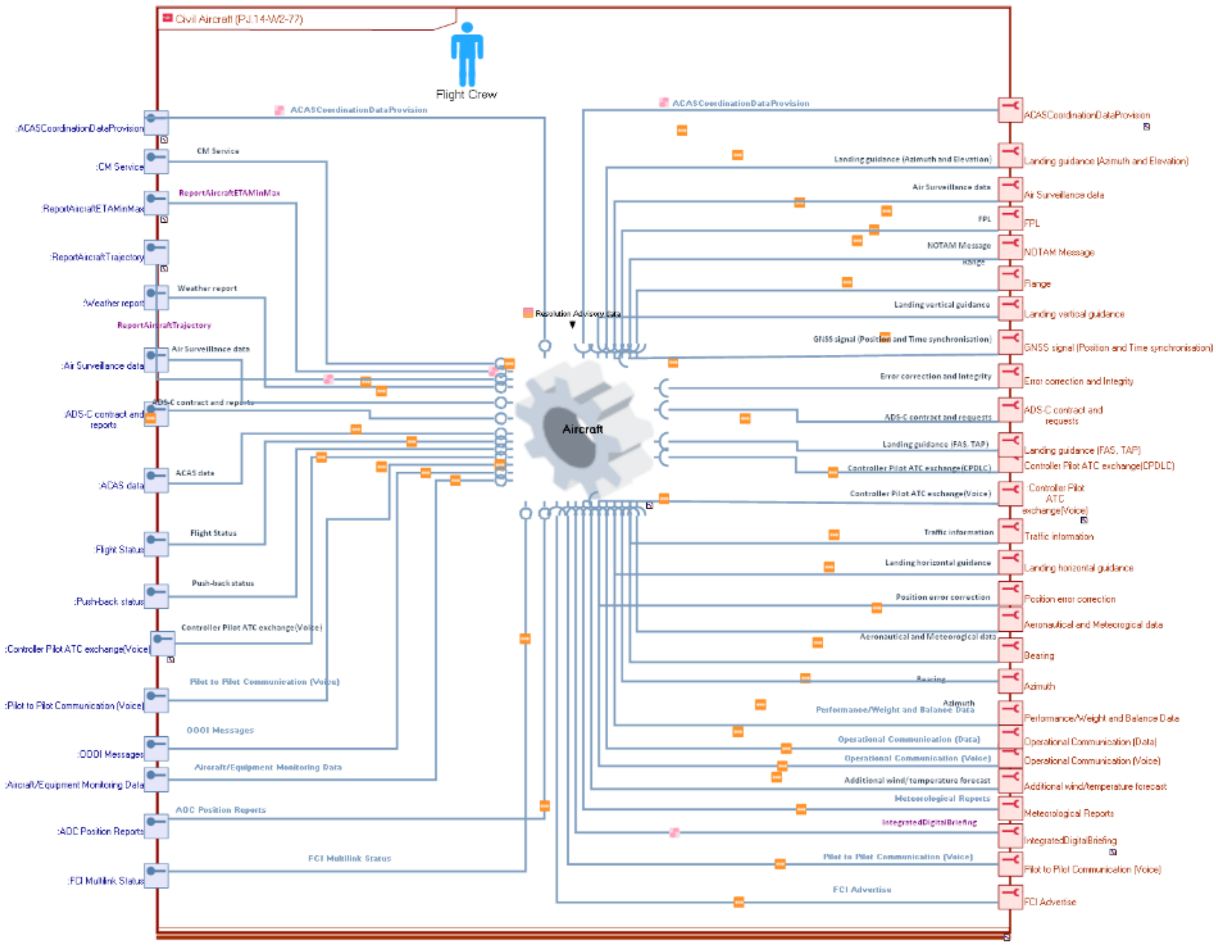


Figure 25: Civil Aircraft - Resource Capability Configuration

These FCI Services Resource interactions have been added:

- **(Civil Aircraft CC Resource architecture) FCI Multilink Status** Resource interaction connection in CC with Aircraft;

- **(Civil Aircraft CC Resource architecture) FCI Advertise Multilink Resource interaction connection in CC with Aircraft;**

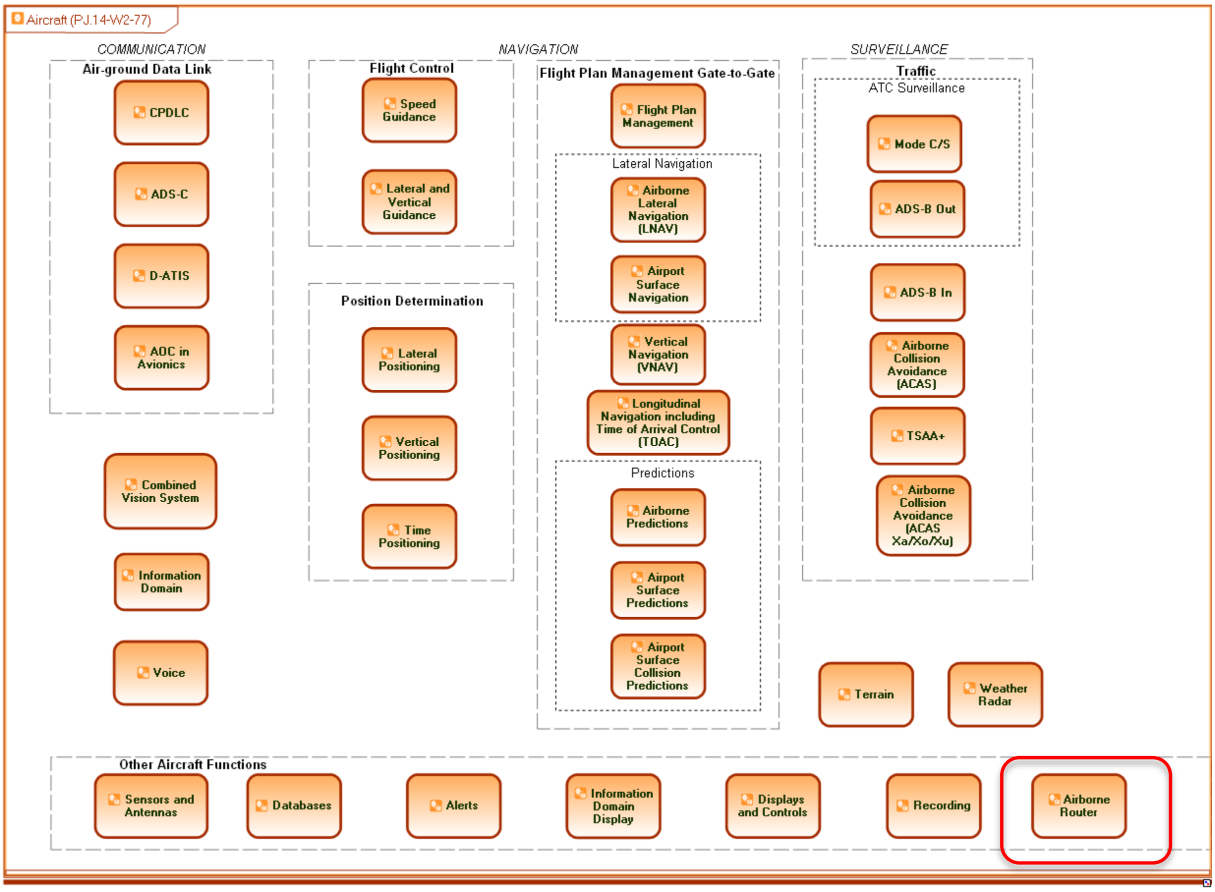
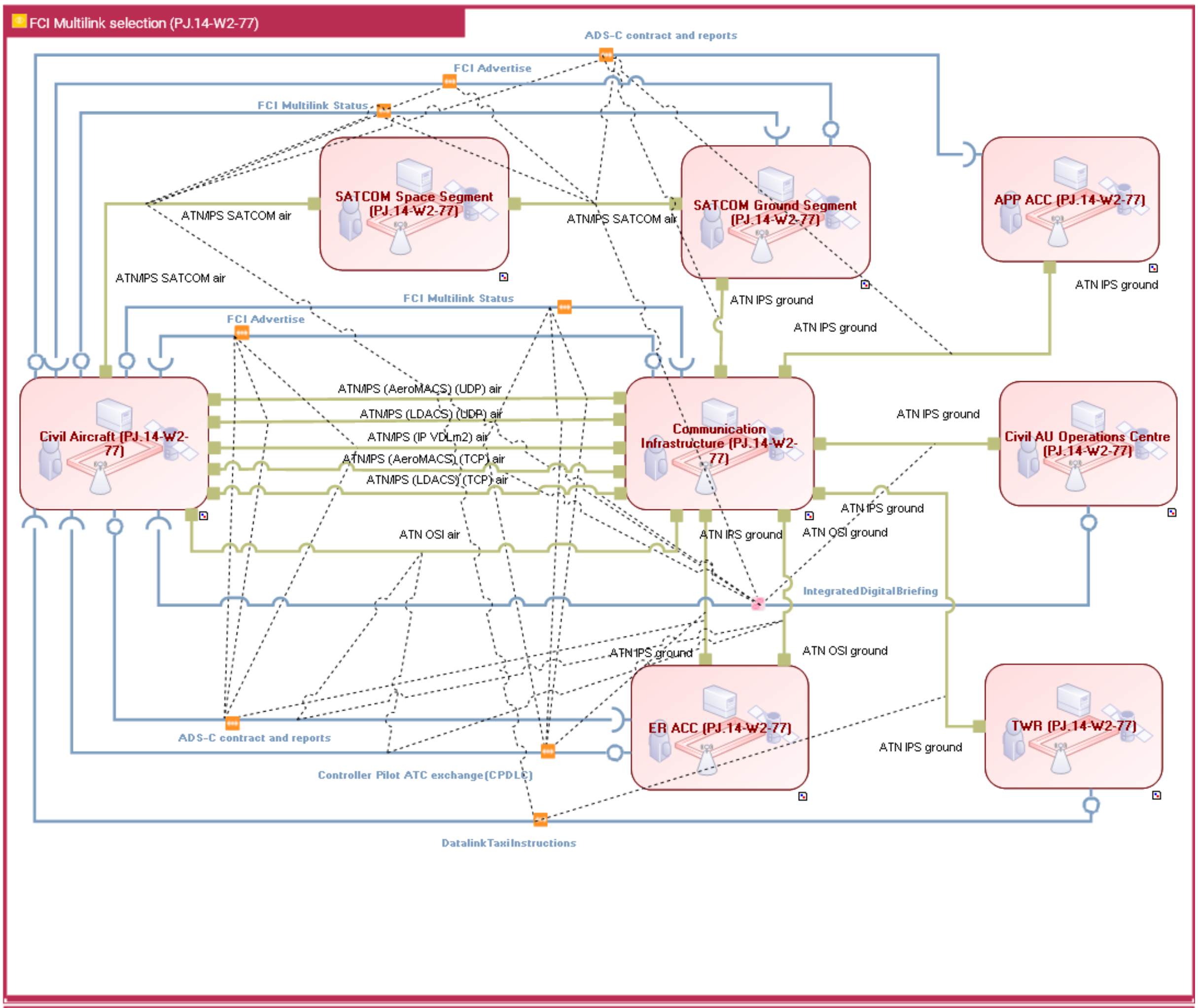


Figure 26: Civil Aircraft Technical System and Airborne Router Functional Block

4.1.1.3 FCI Infrastructure connectivity model [NSV-2]

The following diagram represents the FCI Infrastructure connectivity model with all FCI relevant Configuration Capabilities and their port and standards interconnections.



[NSV-4] FCI Airborne Registration/De-registration to Access Networks - W2 [Access Router, AeroMACS ASN-GW, AGMI endpoint - Airborne (PJ14.W2-77), Air-Ground Mobility Proxy, Air-Ground Router, Airborne Router (PJ14.W2-77), Ground-Ground Router, Mobility Service Endpoint, Simple Name Lookup (PJ.14-W2-77)]
[NSV-4] FCI flow Management - Ground route change - W2 [Access Router, AEROMACS Airborne Radio, Air-Ground Mobility Proxy, Air-Ground Router, Airborne Router (PJ14.W2-77), ER ACC, Ground-Ground Router, LDACS Airborne Radio, Mobility Service Endpoint, SATCOM Airborne Radio, SATCOM Space Segment (PJ.14-W2-77)]
[NSV-4] FCI Ground LISP route management-W2 [AEROMACS Airborne Radio, Air-Ground Mobility Proxy, Air-Ground Router, Airborne Router (PJ14.W2-77), Data Radio Station LDACS (PJ.14-W2-77), Ground-Ground Router, LDACS Airborne Radio, LDACS Ground Radio System, Mobility Service Endpoint, SATCOM Airborne Radio (PJ14-W2-107), SATCOM Ground Station, SATCOM Ground Station]
[NSV-4] FCI Multilink Policy - Airborne - W2 [Access Router, AeroMACS ASN-GW, AeroMACS ASN-GW, AeroMACS Base Station, AGMI endpoint - Airborne (PJ14.W2-77), Air-Ground Mobility Proxy, Air-Ground Router, Airborne Router (PJ14.W2-77), Ground-Ground Router, Mobility Service Endpoint]
[NSV-4] FCI Multilink Policy - Ground - W2 [Access Router, Air-Ground Mobility Proxy, Air-Ground Router, Airborne Router (PJ14.W2-77), Ground-Ground Router, Mobility Service Endpoint, SATCOM Space Segment (PJ.14-W2-77)]
[NSV-4] FCI Packet Flow management - Downlink - W2 [A/G Datalink Communications, Access Router, AEROMACS Airborne Radio, Air-Ground Router, Airborne Router (PJ14.W2-77), APP ACC (PJ.14-W2-77), Civil AU Operations Centre, Civil AU Operations Centre (PJ.14-W2-77), CPDLC, Data Radio Station LDACS (PJ.14-W2-77), ER ACC, ER ACC (PJ.14-W2-77), Gateway IPS-OSI, Ground-Ground Router, LDACS Airborne Radio, Mobility Service Endpoint, SATCOM Airborne Radio, SWIM Messaging Purple Profile, SWIM Messaging Purple Profile]
[NSV-4] FCI Packet Flow management-Uplink - W2 [A/G Datalink Communications, Access Router, Air-Ground Router, Airborne Router (PJ14.W2-77), APP ACC (PJ.14-W2-77), CPDLC, Gateway OSI-IPS, Ground-Ground Router, Runway and Taxiway Usage Management, SWIM Messaging Purple Profile, SWIM Messaging Purple Profile, TWR (PJ.14-W2-77)]

Figure 27: FCI Services Infrastructure connectivity model [NSV-2]

4.1.1.4 Resource Infrastructure view (of the NSV-2)

The following diagram represents the EATMA representation of the FCI.

These Technical Systems belong to the CC Communication Infrastructure:

- Data Radio Station LDACS,
- Data Radio Station AEROMACS;
- Data Radio Station VDL2

The Data Radio Station AEROMACS was already included in the CC Communication Infrastructure common library B;

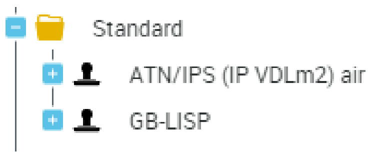
The ATN/IPS connection has been added among the Data Radio Stations and Routing Networking Equipment for A/G Datalink.

These ports ATN/IPS UDP and TCP have been added to the Communication Infrastructure CC:

- ATN/IPS (LDACS) (TCP) air
- ATN/IPS (LDACS) (UDP) air
- ATN/IPS (VDLm2) air

The Gateway IPS-OSI and the Gateway OSI-IPS have been included as functional block in the Ground ATM Network Technical System (TS).

These New Standard has been inserted in the FCI model:



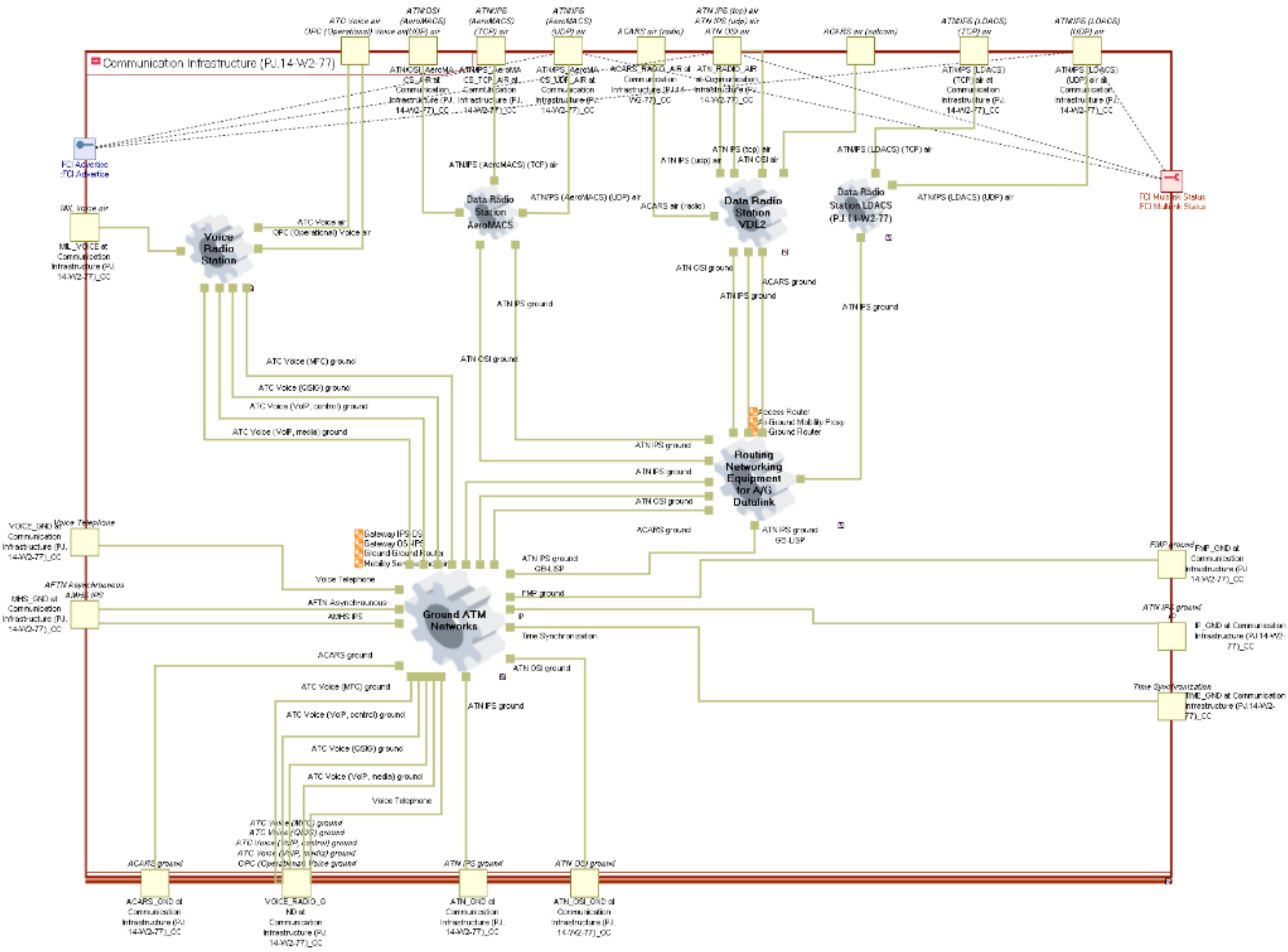


Figure 28: Technical Systems and Ports of Communication Infrastructure CC

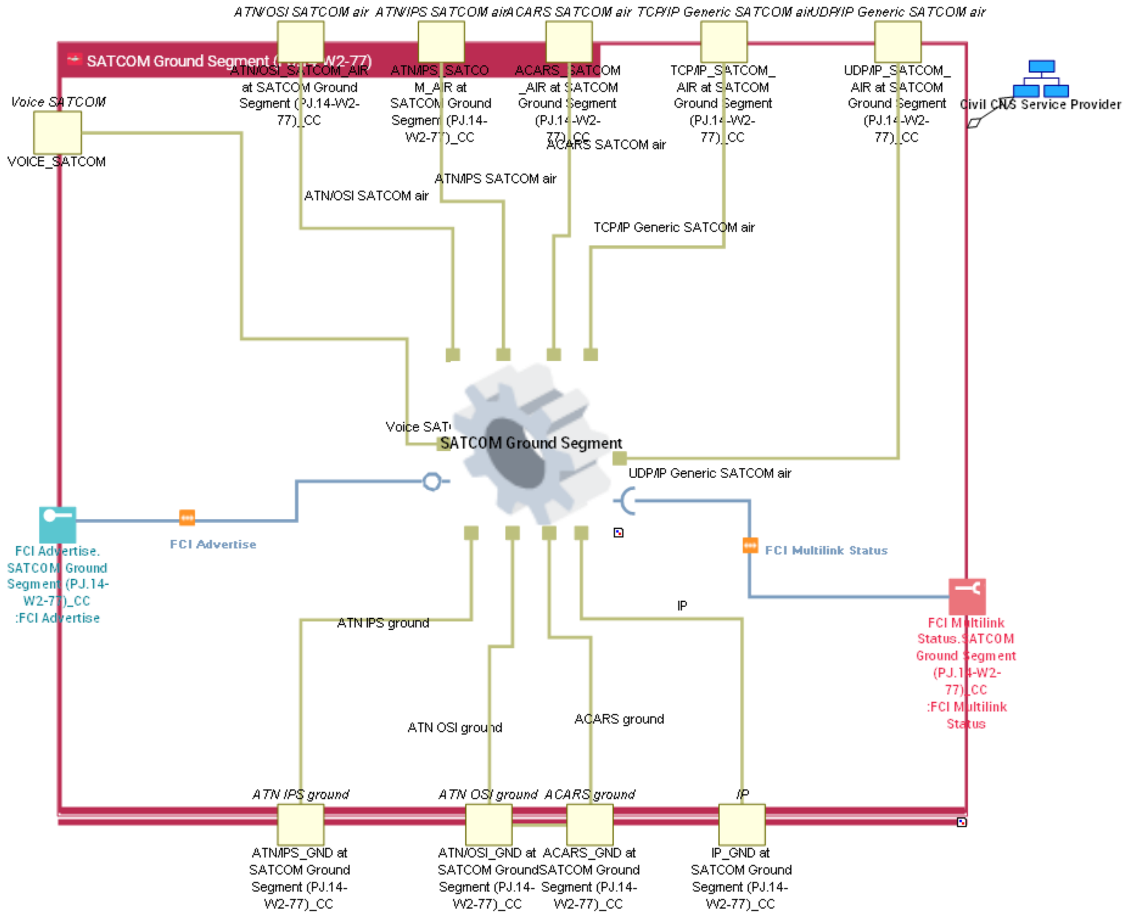


Figure 29: Technical Systems and Ports of SATCOM Ground CC

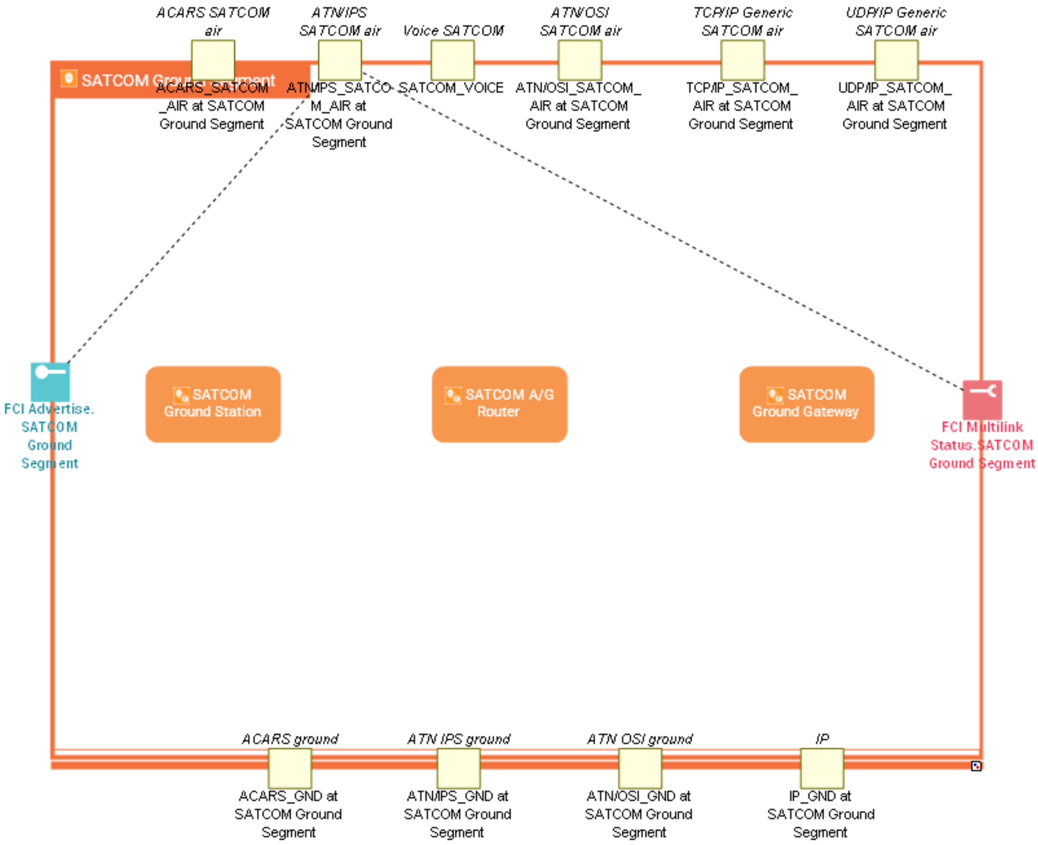


Figure 30: Functional Block and Ports of SATCOM Ground CC

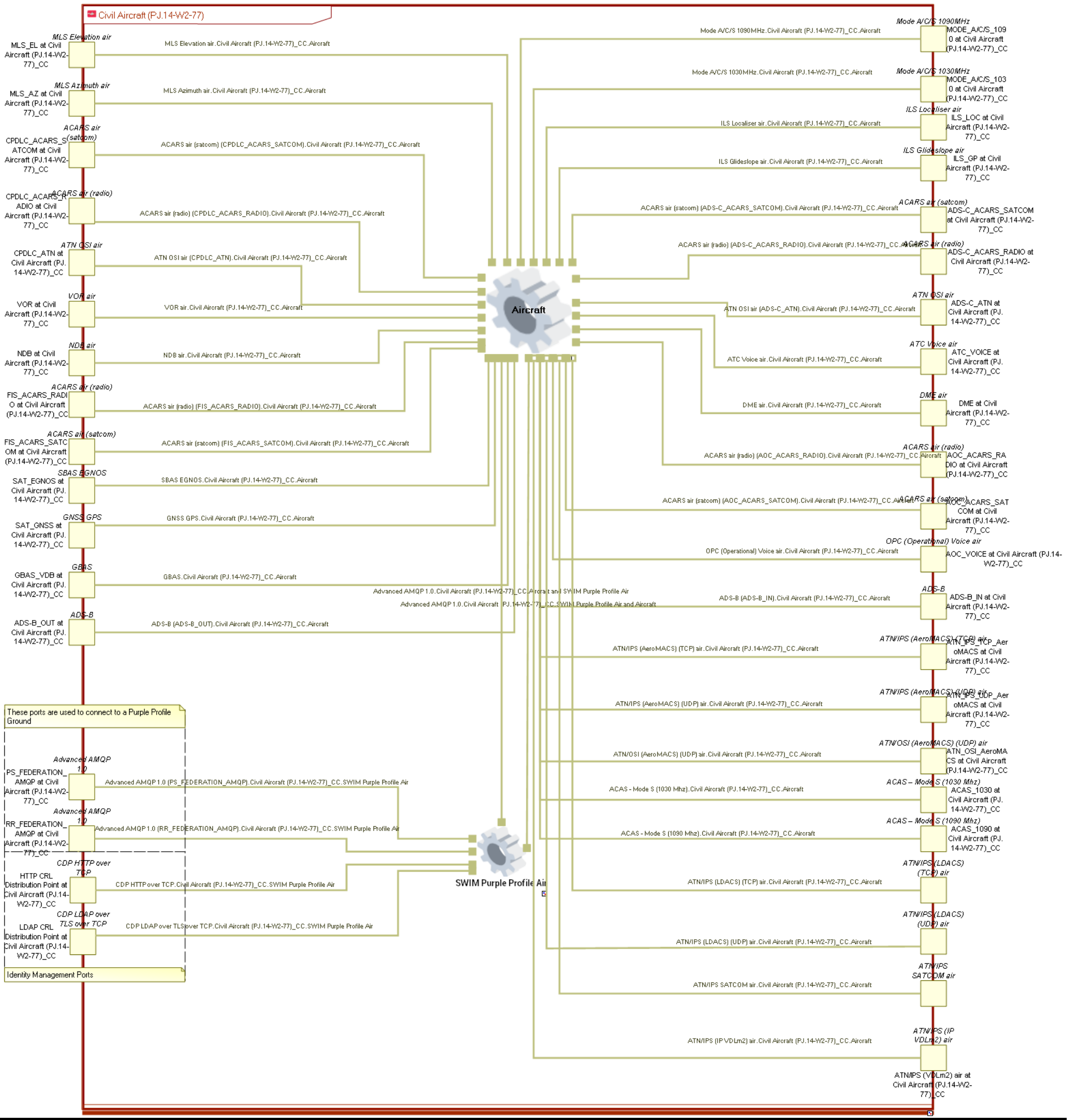


Figure 31: Technical Systems and Ports of Civil Aircraft CC

- These ports have been added to the Aircraft Technical System:
    - ATN/IPS (LDACS) (TCP) air at Civil Aircraft (PJ.14-W2-77)
    - ATN/IPS (LDACS) (UDP) air at Civil Aircraft (PJ.14-W2-77)
    - ATN/IPS SATCOM air at Civil Aircraft (PJ.14-W2-77)
    - ATN/IPS (VDLm2) air at Civil Aircraft (PJ.14-W2-77)

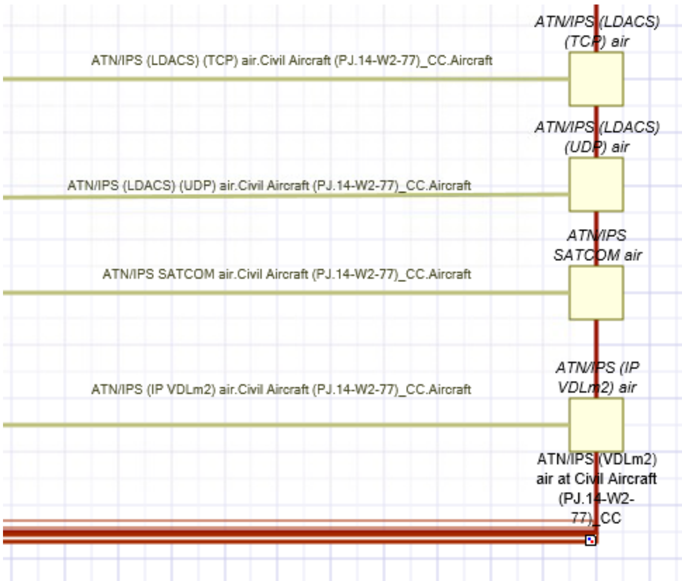


Figure 32:Port details - Technical Systems and Ports of Civil Aircraft CC

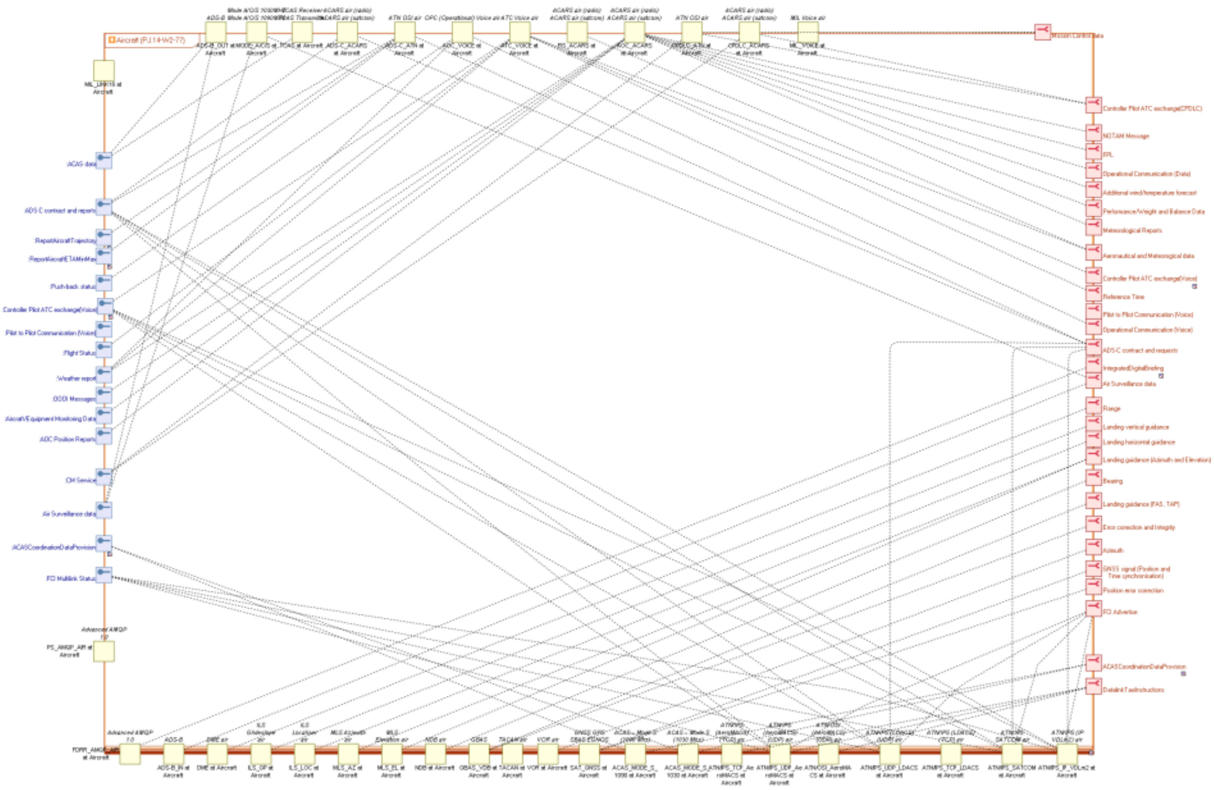


Figure 33: Resource and Ports of Civil Aircraft CC

- These ports have been added to the Civil **Aircraft CC**:
  - ATN/IPS (LDACS) (TCP) air at Civil Aircraft (PJ.14-W2-77)
  - ATN/IPS (LDACS) (UDP) air at Civil Aircraft (PJ.14-W2-77)
  - ATN/IPS SATCOM air at Civil Aircraft (PJ.14-W2-77)
  - ATN/IPS (VDLm2) air at Civil Aircraft (PJ.14-W2-77)

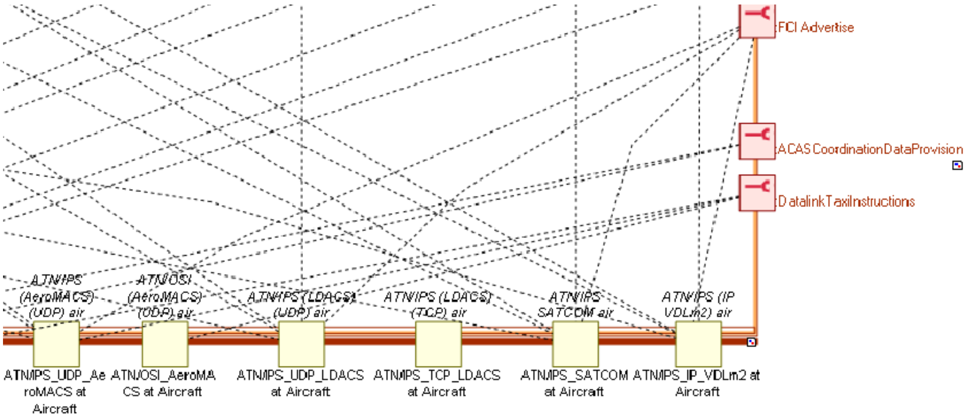


Figure 34: Resource and Ports details of Civil Aircraft CC

FCI Functional Blocks

The following diagram is a high-level representation of the FCI functional sub-blocks decomposition, together with their relevant interfaces:

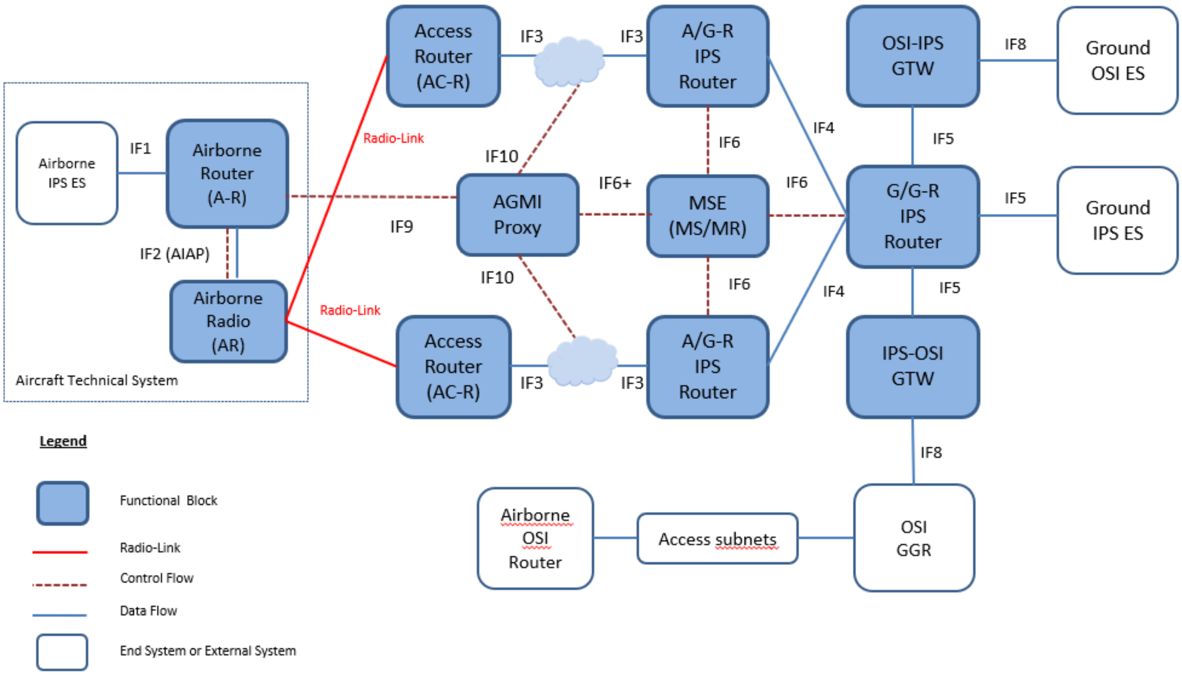


Figure 35: FCI Block Diagram

The sub-blocks evidenced in blue are the FCI Constituents, while the other ones are the sub-blocks which the FCI is interfaced to. The **Airborne IPS Router**[8] is responsible of:

- Managing the Radio Transponders that are part of the Access Networks through the IF2 interface, in terms of data and control information exchange;
- Multilink strategies implementation, including the exchange of control information with A/G IPS Routers for Multilink implementation through the interface IF9;
- Interfacing with the Airborne End System via interface IF1 for both data exchange and control information

The **Access Networks** for the four technologies (LDACS, SATCOM, AeroMACS and IP VDLM2) are part of the FCI and include the following components:

- Airborne Station;
- Ground Radio System;

[8] According to ARINC PP858 ([21]), the Airborne Router is a functional component of the Airborne IPS System, which is a wider subsystem including more than just the routing function.

- ATN A/G-IPS Router (Air-Ground Router)
- Access Router (AC-R) and ground Network connectivity (between the Ground Radio System and the A/G IPS-Router). Note that the AC-R is a functional component of the Access Network following the same philosophy as the ATN-OSI, the Access Networks are bounded on the ground by proper A/G IPS Routers. The boundary between Aircraft Domain and Ground Domain is represented by the aircraft antenna systems (not shown in fig. 6) that are part of the Access Networks

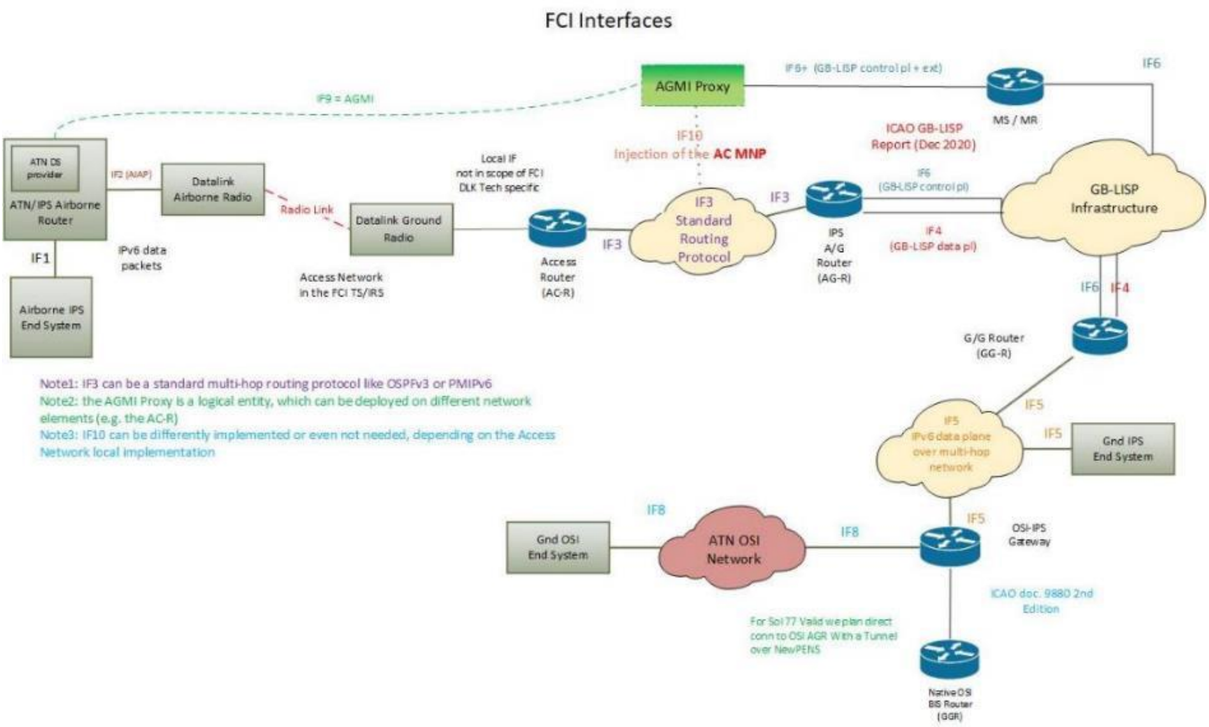


Figure 36: FCI Interfaces Diagram

***Note:** even if the A/G IPS Router is part of the Access Networks, the **"IF3"** interface is explicitly referenced in the diagram.* IF3 is a "standard IPv6 multi-hop routing protocol", like OSPFv3 and PMIPv6*.*

MS/MR: According to the FCI architectural assumptions and studies about IP Mobility that have been documented in par. 5.1.2, since the IPS multi-homing, traffic engineering and routing functions are managed by the GB-LISP protocol, the FCI foresees the presence of the two LISP functional sub-blocks that are named "Map Server" and "Map Resolver", highlighted in the block "MS/MR". These functional sub-blocks are responsible for the route management for data exchange, according to the GB-LISP protocol and for the exchange of route information with A/G IPS Routers and G/G IPS Routers via the IF6 interface.

G/G IPS Routers: unlike A/G-IPS Routers, these are not bonded to any specific Air-Ground Access Network. They actively manage Multilink strategies on ground side, exchanging relevant information with both the MS/MR via IF6 interface (Control Plane) and the A/G IPS Routers via the IF4 interface (Data Plane). They also exchange Control and Data information with Ground End Systems via the IF5 interface. The G/G IPS Routers can interface the Airborne directly through the A/G IPS Routers, or through another G/G IPS Router.

OSI-IPS GTW: On Ground side, the two “Ground ES” sub-blocks represent the possible connectivity scenarios that have to be managed by the FCI:

- Ground IPS ES connected to an Airborne IPS ES;
- Ground OSI ES connected to an Airborne IPS ES;
- Ground IPS ES connected to an Airborne OSI ES.

This connectivity model, using proper **OSI-IPS Gateways**, allows managing the transition between ATN-OSI and ATN-IPS systems in all foreseeable deployment scenarios.

OSI-IPS Gateways, as well as **IPS-OSI Gateways**, exchange control and data information with the Ground IPS End Systems via the IF5 interface, with the Ground OSI End Systems via the IF8.

4.1.1.5 Resource Orchestration view (all NSV-4s linked to the NSV-1)

These resources NSV-4 have been added to the FCI MEGA model:

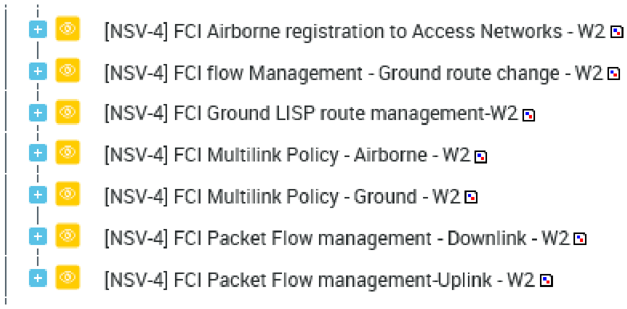


Figure 37: FCI NSV-4 Views in MEGA

4.1.1.5.1 **NSV-4 - FCI Airborne Registration/De-registration to Access Network.**

Pre-conditions:

- The Airborne has successful established a connection with the Access Network (i.e. AeroMACS, LDACS, IP SATCOM and IP VDLM2);
- The Airborne router (A-R) has received a RAT message (IF2) related to a new datalink connection. The datalink communication is in the state “UP” (or Connected) with its ground Access Network.

In this scenario, the Aircraft registers its MNP (Mobile Network Prefix) to the ground and the ground network confirms validity of the MNP to the Aircraft.

The system view describes the interaction between the Airborne IPS System and the FCI AGMI Proxy [20], when the Airborne Router detects (on the IF2) a datalink status changes; these messages sequence flow between the Airborne and the Communication Infrastructure will be exchanged in the scenario:

- The **Airborne IPS System** generates the A/G **request** (AGMI interface) when a datalink status changes or when **routing preferences** of the Airborne IPS System change.
- The function “Send Airborne A/G Multilink registration request” to the datalink Access network (i.e. AeroMACS AC-R);

- When the **FCI AGMI Proxy** receives an AGMI request, it sends an MSE update request bearing this information to the Ground Based-Mobility Functions and waits for an MSE update response; (AC-R: Function: Manage Multilink connections with Airborne);
- The MSE update response is then transformed into an AGMI response and **sent back** to the Airborne IPS System over the A/G link (function Update Airborne Registration);
- The AGMI Proxy sends back to the Airborne Router the registration acknowledgement (function: Notify Aircraft Registration).

The Aircraft sends an A/G registration message to the AGMI Proxy that contains these data (AirborneRegistrationRequest data in NSV-4):

- Provider ID;
- Datalink Type (LDACS, IP SATCOM, AeroMACS or IP VDLM2);
- The Aircraft Mobile Network Prefix (MNP), unique globally routable IPv6 prefix, administratively assigned to an aircraft.

When the FCI AGMI Proxy receives an A/G request (AGMI interface) from an Airborne IPS System, it configures the aircraft MNP in the Access Network (if the access network needs it, for example by configuring appropriate routes in the Access Router), it selects an MSE (unless the destination IP address in the AGMI request designates a particular MSE) and it sends an MSE update requests message to the MSE to inject the aircraft MNP in the GB-LISP Ground Internetwork for the required mobility routing functions.

The FCI AGMI Proxy then constructs an A/G response (AGMI interface) (setting the Response to reflect acceptance or rejection by the MSE) and sends the response message to the Airborne IPS System. The AGMI Proxy then distributes these routes within the access network using the IF10 interface to inject the routes within the IF3 routing function (e.g. OSPFv3, or PMIPv6) to enable forwarding packets to the aircraft.

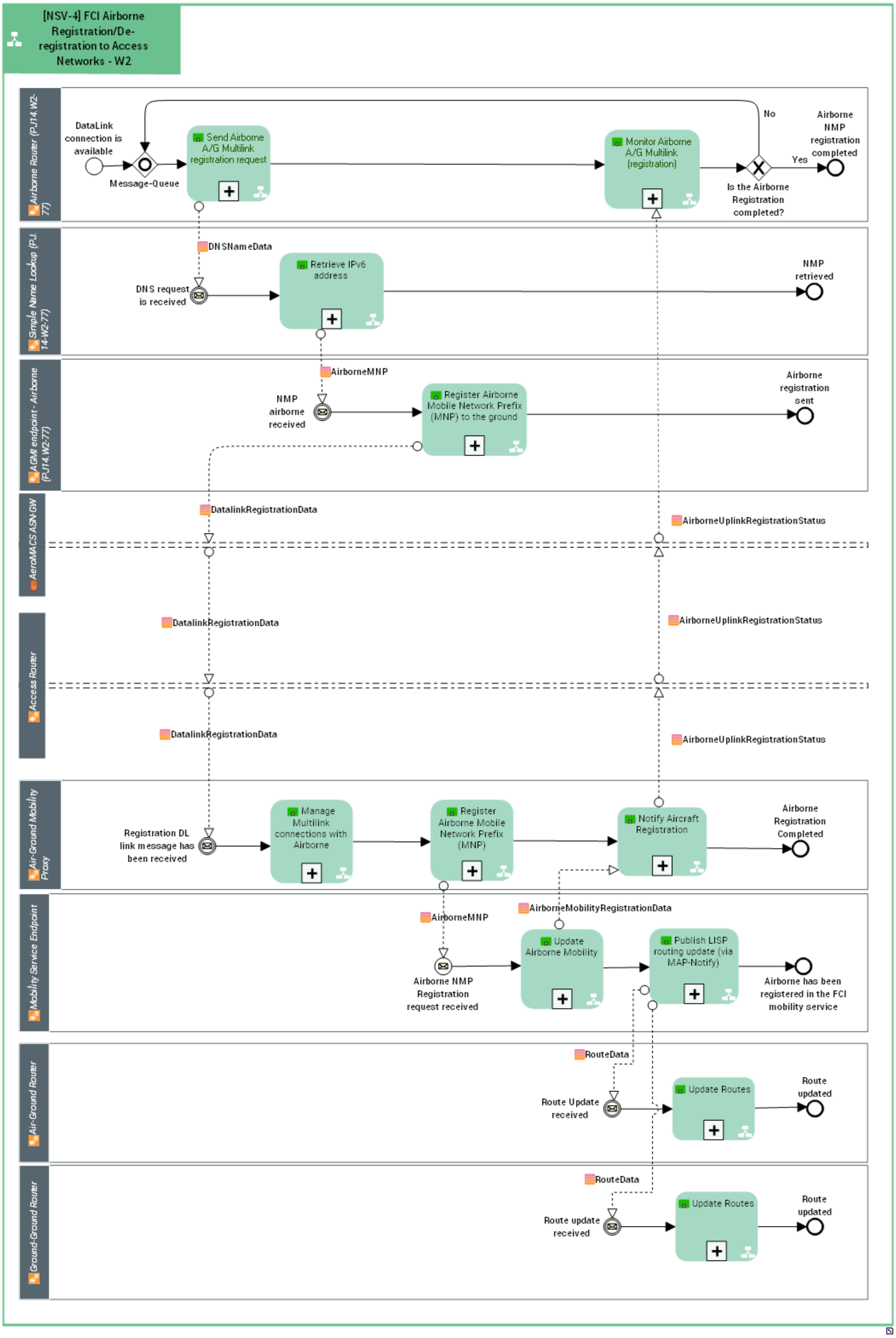


Figure 38: NSV-4 - Airborne Registration to FCI Access Networks service

4.1.1.5.2 NSV-4 – Ground Based LISP Route Management

The scenario describes how the change of Link Quality detected by the Airborne radio (LDACS, AeroMACS, IP SATCOM and IP VDLM2) causes an update in datalink selected for A/G data transmission according to the Multilink Service Policy defined on the Airborne Router. The update of datalink selection may also cause an update the route metric on the Ground Based LISP Domain.

The scenario also includes description of Mobility Service Endpoint (that includes MS/MR functional block for GB-LISP) route updates when radio (RAT) joint/leave events have been received by the Airborne Router. The MSE (MS/MR in the case of GB-LISP) route update is also generated by the link loss events detected by the AGMI Proxy on the IF9.

As this use case is related to the route management, End Systems are not involved.

This scenario highlights a situation on which:

- There is a change in the Link Quality value detected by the Airborne Router for the LDACS Airborne radio, that causes an update of Multilink Policy (Administrative or Performance based) in route metric (as an example, Link Quality moves from "UP" to "BEST" as recommended in the RAT requirements), thus causing the metric to change on both Airborne Router and LISP Domain;

- There is a join event on IP SATCOM radio link; in this case an additional route to all Aircraft End Systems behind the Airborne Router is added into Mobility Service Endpoint (MS/MR);

- There is a leave event on AeroMACS radio link; in this case this route to Aircraft End Systems behind the Airborne Router is removed from MSE (MS/MR) upon a link loss event detected by the AGMI Proxy on the IF9.

(NB - to simplify the Use Case, the function that manages ***registration and deregistration events*** *is the same that manages the DLs Update to ground after a* ***change caused by the Multilink Policy (administrative or performance) update*** *in other words, we are considering registration/de-registration events as particular cases of datalink status update).*

Airborne Router functions descriptions:

- The A-R "Monitoring Airborne DLs" function controls and updates the DLs status (Up/Down) with the message exchanged by each of the Airborne RAT;
- The A-R apply the "FCI Multilink Service policy" to selects the active DLs for the A/G communication. The Multilink services policy applies the requirements described in the par. and with the policy functions flow described in the NSV-4 – FCI Multilink Policy – Airborne.
- The A-R notify DLs update status to the Ground network through all A/G active datalink connections. For instance, in the scenario described the active datalink available are LDACS and SATCOM since the AeroMACS RAT has notified a "Leave" status connections with the ground Access Network (A/G link breakdown).

The diagram also highlights the role of the A/G-R that translates routing information exchanged with **Airborne Router via IF9 into GB-LISP metric update**, via the MAP-REGISTER primitive. Also, the role of the LISP Pub-Sub protocol, with LISP "Publish" message to all A/G-R that have been "subscribed" on every route metric change, is highlighted.

In case of leave event caused by a link break, route update procedures on ground is started by the Multilink Management function (MMF) after that a message for DL changes has been notified by the Airborne Router to the Access networks. This event is detected also by the AGMI Proxy on the IF9.

The scenario and procedures of route update on the ground caused by link break or datalink route unavailability are described in **NSV-4 – FCI flow Management - Ground route change (**Figure 41**).**

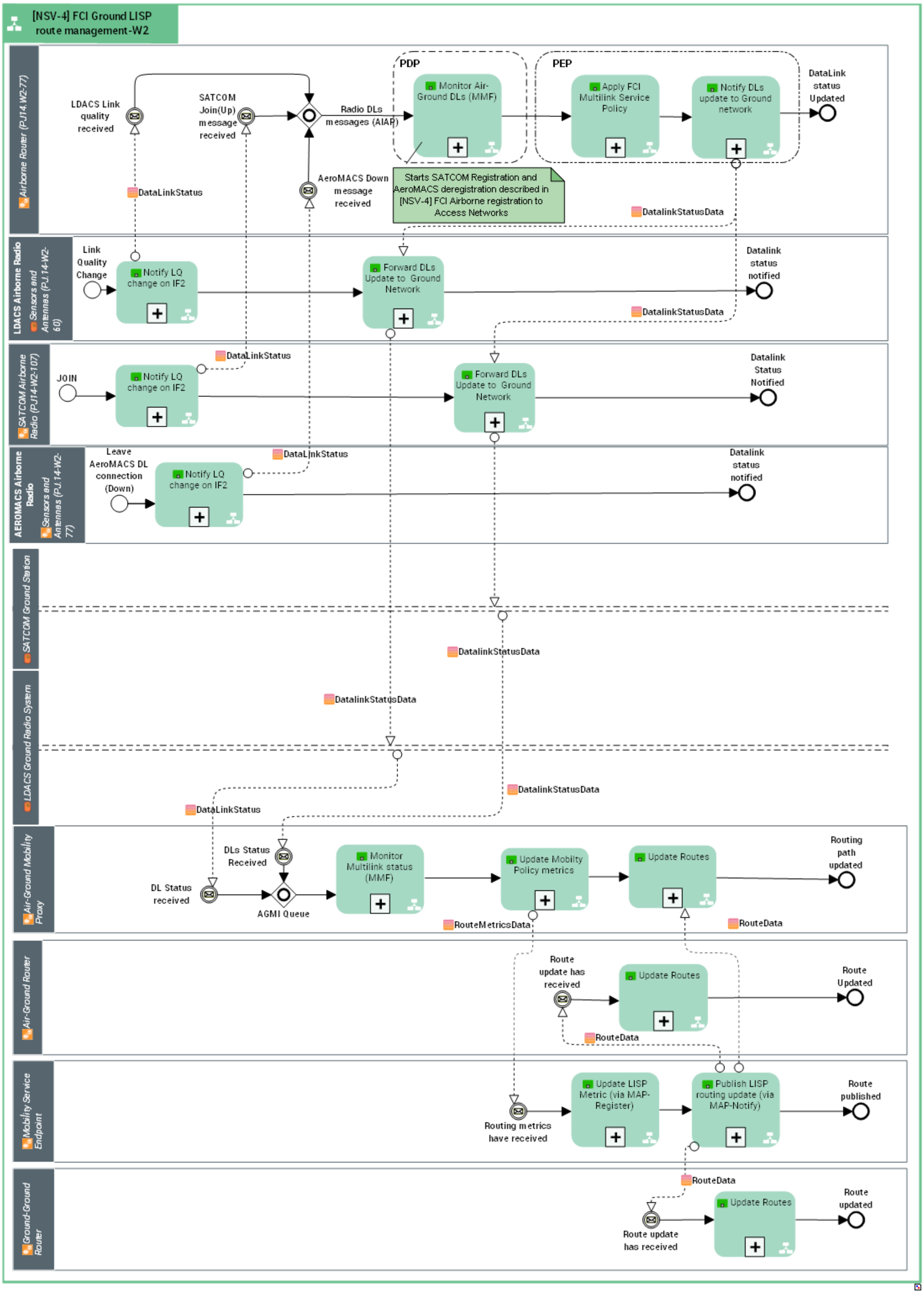


Figure 39: NSV-4 - Ground Based LISP Route Management

4.1.1.5.3 NSV4 – FCI Multilink Policy - Airborne

Pre-conditions:

- The Airborne A/G datalink is connected to the correspondent Access Network (i.e. Airborne RAT SATCOM is in “UP” status on the A-R);
- The Airborne Datalink is successful registered in the FCI ground network (see **NSV-4- FCI Airborne Registration/De-registration to Access network network (see par. 4.1.1.5.1 and** Figure 38**)**.

This NSV-4 function view shows the A/G DLs selection and updated caused by the Multilink Service Policy according to the Policy requirements described in the par. 3.1.1.4.3 - FCI Service Policy selection. The performance-based multilink can be combined with administrative policy criteria. As a result, among the acceptable datalinks in terms of performance, the End User or service provider may still select a preferred link among the available Datalink options that satisfy Service performance and QoS.

The FCI Multilink Management (MMF) Policy function (on the Aircraft and Ground ATN Network technical systems) shall select the datalink Access Network services among the available DLs by applying in this exclusive order those functions:

- **Select DLs-Performance** function that allow to select the list of datalinks according to the defined performance policy);
- **Select DLs-Administrative** (Select Datalink on Administrative Policy) function that allow to select the DLs according to the predefined Administrative policy.

Therefore, the **Select DLs-Administrative function** shall use as input the List of datalinks identified by the **Select DLs-Performance function**.

These activities on the A-R function block are executed after the Policy change criteria has been identified the MMF:

- Selects Datalink based on Performance Policy function;
- If the Policy change also impacts the Administrative policy the “Selects Datalink on Administrative Policy function shall be applied;
- The new DLs selection for A/G DLs communications is sent to the A/G Monitoring Multilink function;
- The ground MMF evaluates the impacts on the data routes and applies the Mobility route update with the Mobility Service Endpoint (MSE);
- The A/G-R translates routing information exchanged with **Airborne Router via IF9 into LISP metric update**, via MAP-REGISTER primitive. Also, the role of GB-LISP Pub-Sub standards is to "Publish" message to all A/G-R that have been "subscribed" on every route metric change.

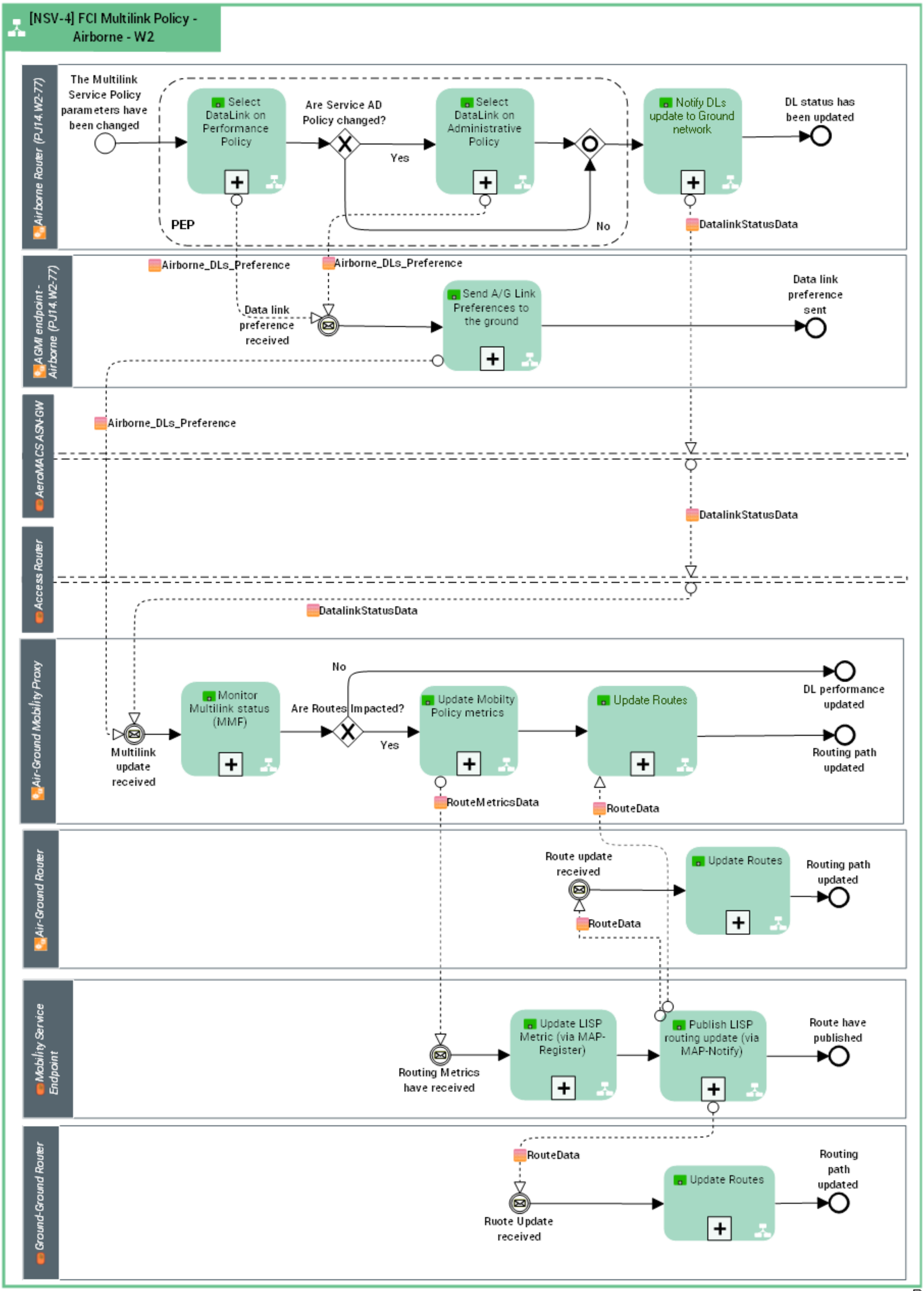


Figure 40: NSV-4 – FCI Multilink Policy – Airborne

4.1.1.5.4 NSV-4 – FCI flow Management - Ground route change management

In case of leave event caused by a link break route update procedures on ground is started by the Multilink Management function (MMF) after that a message for DL changes has been notified by the Airborne Router to the Access network. This event is detected also by the AGMI Proxy on the IF9.

The scenario and procedures of route update on the ground caused by link break or datalink route unavailability is described in NSV-4 – FCI flow Management - Ground route change management.

Preconditions:

- The MSE (MS/MR in the case of GB-LISP) receives an event by the Airborne that notify the unavailability of DL paths, i.e. the LDACS path to communicate on the A/G LDACS datalinks isn't available.
- The previous event can be caused either by the A/G link break or by the ground route path unavailability.

These activities have been executed:

- on the MSE function block:
  - The Mobility Service Endpoint (MSE) applies the Mobility route update;
  - The role of GB-LISP Pub-Sub standards is to "Publish" message to all A/G-R that have been "subscribed" on every route metric change.
- The G/G R and the A/G-R function block receives the route updates and applies the route change (on the xTR GB-LISP function);
- The MMF monitoring function on the A/C-R communicates to the Access Networks the GB-LISP metric update.
- The AGMI Proxy MMF translates routing information to communicate the new Datalink status ("DatalinkStatusData") to the Airborne Router via (IF9) AGMI protocol. The A/G uplink update will be selected according the configured policy. In the scenario the uplink updated is done via SATCOM Access Network.

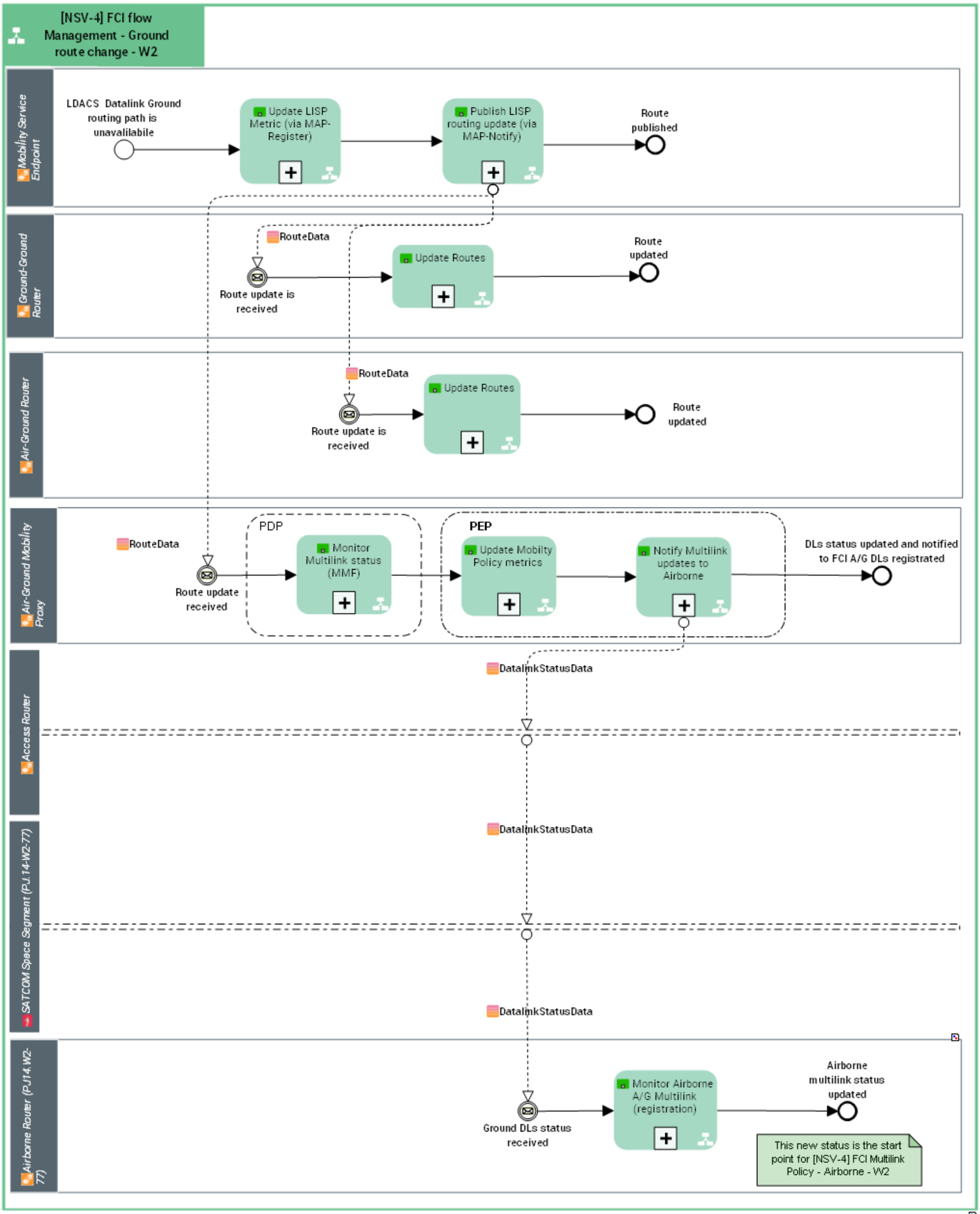


Figure 41: NSV-4 – FCI flow Management - Ground route change

4.1.1.5.5 NSV-4 – FCI Multilink Policy – Ground

In case of ground policy change the route update procedures on ground is started by the Multilink Management function (MMF) after that a message for DL changes has been notified by the Airborne Router to the Access network. This event is detected also by the AGMI Proxy on the IF9.

Preconditions:

- The MSE (MS/MR in the case of GB-LISP) receives an event by the Airborne that notify the unavailability of DL paths, i.e. the LDACS path to communicate on the A/G LDACS datalinks isn't available.

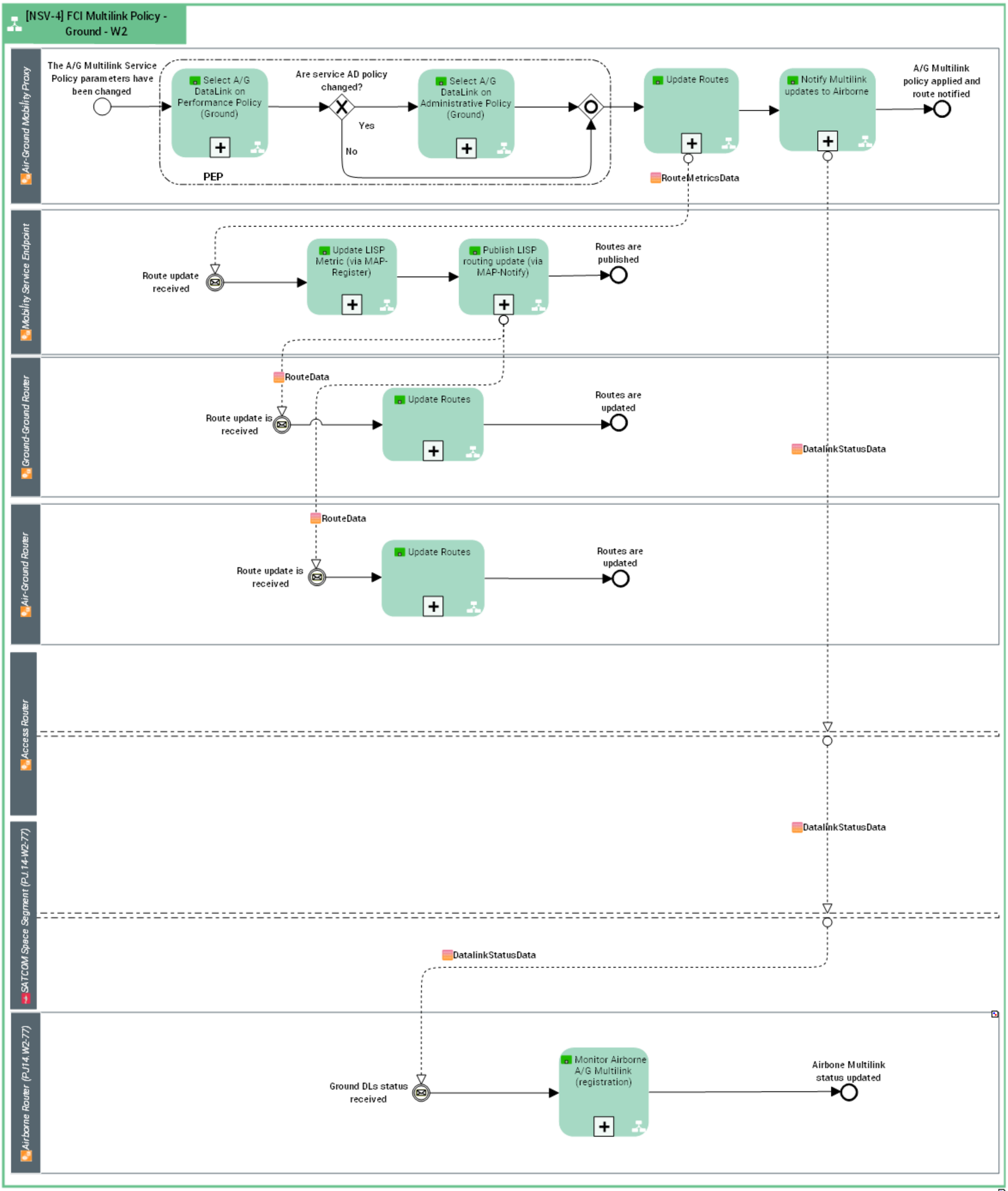


Figure 42: NSV-4 – FCI Multilink Policy – Ground

4.1.1.5.6 NSV-4 - Packet Flow management --UPLINK

This Use Case highlights different End Systems (belonging to ER ACC, civil AU, TWR and APP) exchanging data packets with the same aircraft. ER ACC, TWR and APP ACC exchanges Dialogue Service packets (CPDLC and/or ADS-C), while Civil AU exchanges SWIM PP information with Aircraft. Here, the Multilink function behaviour is to route higher priority packets (ATN DS, marked with DSCP=) on LDACS (we assume that it has a better Link Quality) and lower priority SWIM PP ones (DSCP=AF32) on SATCOM (we assume that it as a worse Link Quality).

Note that this can happen if:

- There is a pre-defined policy on Airborne Router based on link preference (e.g. SWIM on SATCOM and ATS B2 on LDACS); or:
- Both services were managed on SATCOM radio link, but upon a SATCOM degradation the policy moved higher priority traffic on the other radio link (LDACS in this case) showing a proper Link Quality for its DSCP value.

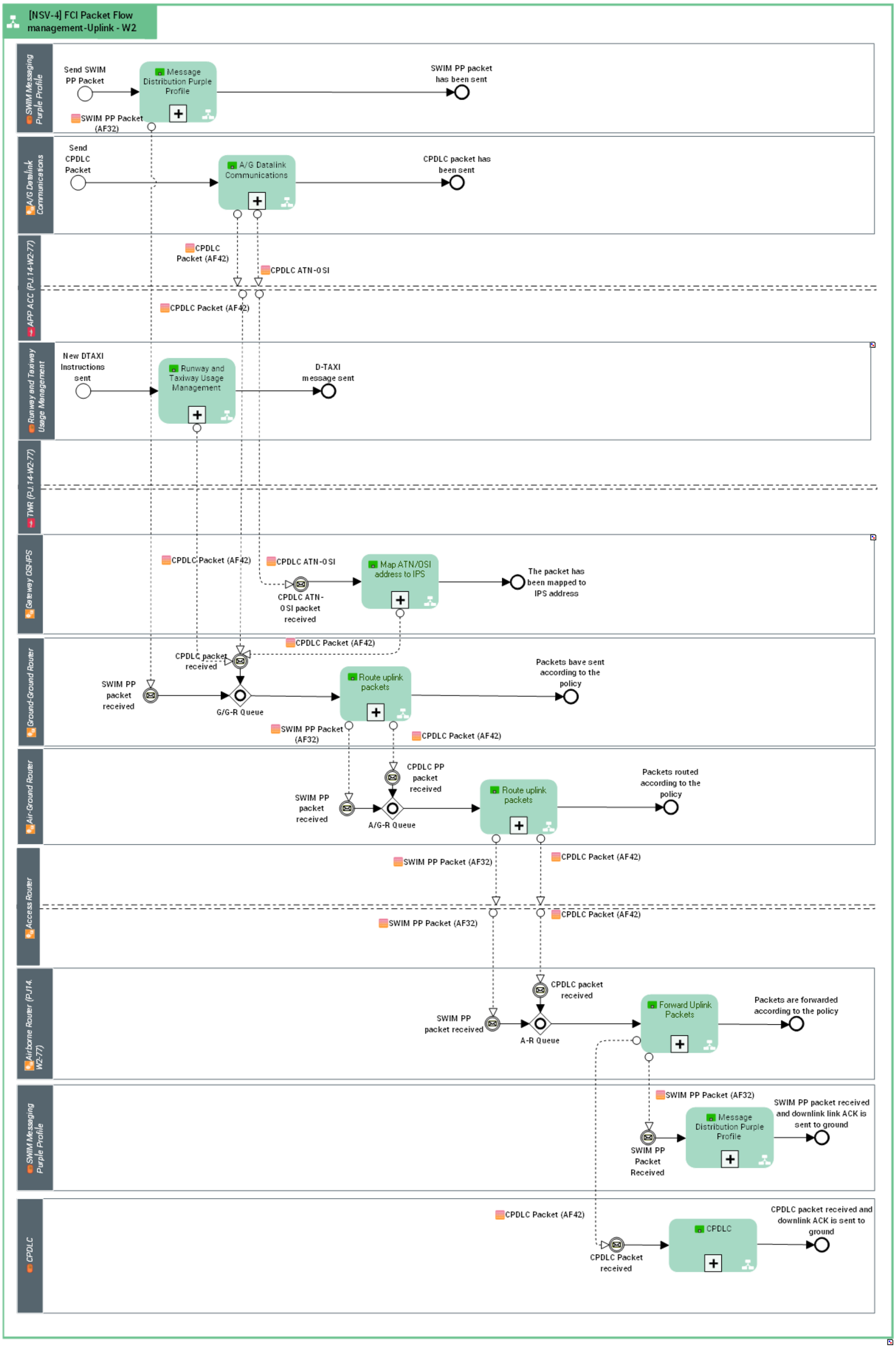


Figure 43: NSV-4 - Packet Flow management --UPLINK

The figure below is equal to the previous NSV-4 but in downlink communication.

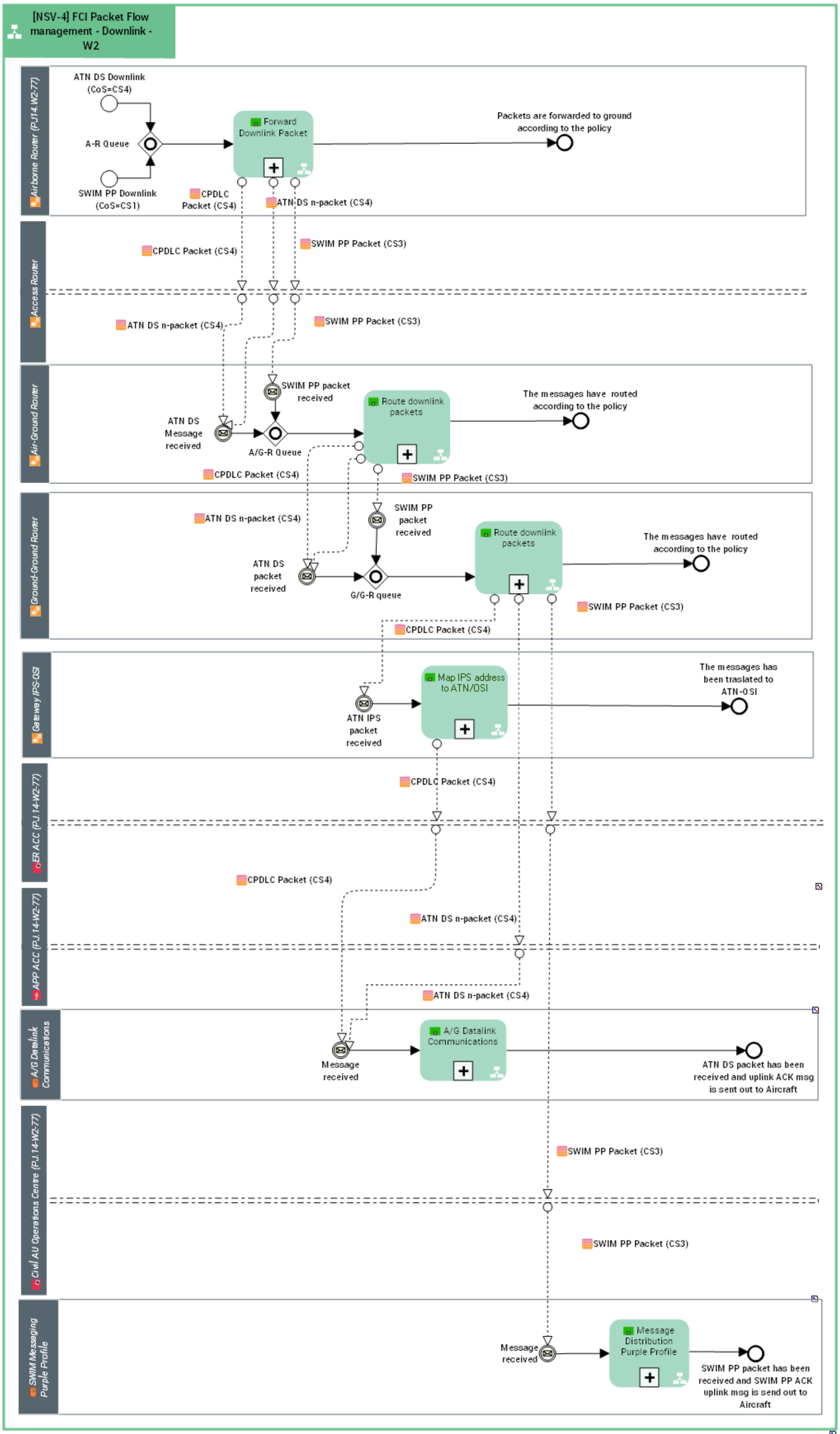


Figure 44: NSV-4 - Packet Flow management –DOWNLINK

4.1.2 Resource Composition

These are the Configuration Capability that host the main change required FCI Technical System and Functional Block:

- **Civil Aircraft CC**;
- **Communication Infrastructure CC;**
- SATCOM Ground segment CC

These FCI Services Resource interactions have been defined in the Civil Aircraft:

- The **FCI Advertise** resource interaction between CC:
  - Civil Aircraft CC (Consumer) and
  - Communication Infrastructure CC (Producer)
  - SATCOM Ground segment CC (Producer)

- **The FCI Multilink Status** resource interaction" between:
  - Communication Infrastructure (Consumer)
  - SATCOM Ground segment CC (Consumer)
  - Civil Aircraft (Producer).

Communication Infrastructure CC

The Technical System, the Functional Block and the Function involved in the FCI Services are described in the Table 5: List of changes due to the FCI Solution**.**

Civil Aircraft CC

These functions have defined for **Airborne** FB that belong to **Aircraft** technical system and he Civil Aircraft CC (see also Table 5):

- Apply FCI Multilink Service Policy
- Forward Downlink Packets
- Forward Uplink Packets
- Monitor Air-Ground DLs (MMF)
- Monitor Airborne A/G Multilink (registration)
- Notify DLs update to Ground network
- Select Datalink on Administrative Policy
- Select Datalink on Performance Policy
- Send Airborne A/G Multilink registration request.

SATCOM GROUND Segment Configuration Capability

The SATCOM GROUND CC includes the SATCOM Ground Segment Technical System that implements the required FCI function described in the Table 5: List of changes due to the FCI Solution.

4.1.3 Service view

Not Applicable.

4.2 Functional and non-Functional Requirements

The FCI network functions have been mapped on the EATMA Functional Block and described in the specific functional requirements. The functional requirements reported in the TS-IRS are based on the outcome delivered on TRL4 W1 project activities but most of them are changed as required by the new requirements or ConOps scenarios. In the par Appendix E all deleted requirements have been tracked and a rationale for the deletion has been reported.

4.2.1 FCI General Requirements

[REQ]

Identifier	REQ.14.77-TS-GENR-0001
Title	FCI Supported Protocol
Requirement	FCI shall support the following protocols: - ATS-B2 - SWIM A/G (Purple Profile - safety and non-safety); - -
Status	< validated>
Rationale	As agreed and stated in task01 delivery “D5.1.600 - PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services”.,
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	
<ALLOCATED_TO>	<System>	

Identifier	REQ.14.77-TS-GENR-0001a
Title	FCI Supported Services
Requirement	FCI shall support the following services: - Airlines Operational Communications- AIS/AIM services - AIS/AIM services - MET services - Flight Data Services - G/G Digital Voice. The G/G Digital Voice service is only focussed on the connection between ATCO and RPAS operator.
Status	< validated>
Rationale	As agreed and stated in task01 delivery "D5.1.600 - PJ.14-W2-77 TRL6 Overall Concept of Operation FCI Services".,
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	
<ALLOCATED_TO>	<System>	

[REQ]

Identifier	REQ.14.77-TS-GENR-0002
Title	Support for future services
Requirement	FCI shall be able to support: - New ATS-B3;
Status	<validated>
Rationale	This Deliverable aims at defining a proposal of for ATN B3 service performance requirements (see Table 8 and Table 9)
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier

< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	
<ALLOCATED_TO>	<System>	

Identifier	REQ.14.77-TS-GENR-0002a
Title	Support for future services
Requirement	FCI shall be able to support: - A/G digital voice[9]
Status	<in progress>
Rationale	This Deliverable aims at defining an A/G Digital Voice performance requirements. Digital Voice was validated with LDACS in the scope of PJ.33-W3-02 and reached TRL4. To our assessment, this has in the end verified the capability of the FCI network infrastructure to fully support an implementation of A/G digital voice and, therefore, we see no direct impact on the maturity of the FCI as network infrastructure. We keep the REQ.14.77-TS-GENR-0002a status as “in progress” only because this validation has been done in another Solution (PJ33-W3-02) with a lower maturity level.
Category	<Functional>

NOTE: we recommend for a future stage

- to split this requirement into
    - Voice as Backup Contingency, where the Voice network must be diverse and separate from the Datalink network (e.g. fallback after cyber attack to FCI)
    - Generic Voice, which instead can be transported over the Datalink Network
- to define for each Digital Voice Types different specific Safety Performance Requirements (this is not covered currently by EUROCAE ED-228A, [14])
- to apportion these requirements down to each datalink Access Network

[9] As the research is still ongoing in projects PJ14-W2-107 for what concerns SATVOICE and in PJ33-W3-02 LDACS Complement for what concerns DV on LDACS, in this Initial TS/IRS of FCI Services we do include A/G DV as a “future service”. It is acknowledged that the FCI will also need to support the implementation options of A/G Digital Voice the mentioned research will in the end select.

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	
<ALLOCATED_TO>	<System>	

[REQ]

Identifier	REQ.14.77-TS-GENR-0003
Title	FCI Supported Services - Unicast
Requirement	The FCI shall support both unicast connectionless services (e.g. UDP) as well as unicast connection-oriented services (e.g. TCP)
Status	<validated>
Rationale	Transport layers for ATN-IPS (e.g. Dialogue Service) can be both connectionless and connection oriented. SWIM transport layer is based the connection-oriented TCP protocol
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	
<ALLOCATED_TO>	<System>	

[REQ]

Identifier	REQ.14.77-TS-GENR-0004
Title	FCI Supported Services - Multicast
Requirement	The FCI shall support multicast services over the Ground-Ground Links according to: RFC 3810 (MLDv2, [43]) RFC 4607 (SSM, [44])
Status	<validated>

Rationale	These protocols are required by SWIM Blue Profile standards specification. Within PJ14-W2-SOL77 project timeframe at today, there is no evidence of AOC services requiring layer 3 multicast connectivity. If during the evolution of the project any such evidence were to become available, this requirement will be ready to support it.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	
<ALLOCATED_TO>	<System>	

[REQ]

Identifier	REQ.14.77-TS-GENR-0005
Title	FCI Addressing
Requirement	The FCI shall support IPv6 addressing and numbering plans, according to ICAO doc. 9896 ED II [3], subsequent and subsequent and according to the ICAO WG-I report (see [39] -GB-LISP Mobility solution for ATN/IPS)
Status	<validated>
Rationale	Needed to support interoperability with Air and Ground End Systems
Category	<Functional>, <Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
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< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	
<ALLOCATED_TO>	<System>	

[REQ]

Identifier	REQ.14.77-TS-GENR-0006
Title	FCI compatibility towards ATN-OSI networks
Requirement	FCI shall support the following connectivity scenarios towards OSI network elements: 1) Ground ATN-OSI ES connected to an Airborne IPS ES; 2) Ground ATN- IPS ES connected to an OSI network towards an Airborne ATN-OSI ES
Status	<validated>
Rationale	Both scenarios require OSI-IPS and IPS-OSI Gateways on the ground.
Category	<Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	

<ALLOCATED_TO>	<System>	

4.2.2 FCI IP Mobility Requirements

[REQ]

Identifier	REQ.14.77-TS-IPMB-0001
Title	Ground Based LISP
Requirement	The FCI IP Mobility shall be based on the "Ground Based LISP" solution, according to the ICAO WG-I report (See GB-LISP Mobility solution for ATN/IPS [39]) that specify the GB-LISP profile specification and the related RFC standards, and on the IF6 Interface Control Document [22], which contains a detailed specification of the Mobility concepts (Message Sequence Charts, etc.).
Status	<validated>
Rationale	The ICAO WG-I report [39] summarizes (see par. 5) what is required by the GB-LISP profile implementation that is in the scope with this solution. In fact, General LISP defines many roles, but GB-LISP might not require the implementation of all possible roles.
Category	<Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	
<ALLOCATED_TO>	<System>	Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-IPMB-0002
Title	Ground Based LISP support to multi-homing
Requirement	The GB-LISP infrastructure shall support simultaneous mapping of one mobile network prefix (MNP) to multiple RLOCs.
Status	<validated>

Rationale	The main tasks of GB-LISP are to announce reachability of IPv6 addresses by registering these addresses as EIDs with their RLOCs in the LISP mapping system (MR/MS). The Airborne EIDs (IPv6 MNP addresses) are registered with LISP priority values, which allow selection of the preferred path (tunnel) to reach a given EID in case of multihoming.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	
<ALLOCATED_TO>	<System>	Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-IPMB-0003
Title	GB-LISP Route Metrics – general
Requirement	GB-LISP route metrics shall be based on Link Preference estimation (see [22]).
Status	<validated>
Rationale	This allows performing route optimization based on performance requirements
Category	<Functional>, Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	
<ALLOCATED_TO>	<System>	Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-IPMB-0006
Title	GB-LISP Route Management - metric change
Requirement	The Airborne DLs preference received by the AGMI Proxy via the AGMI interface IF9 and, consequently, on the A/G-R Router, shall be sent by the MMF to the MS/MR through a MAP-Register / MAP-Notify LISP message exchange, in order to change the route metric.
Status	<validated>
Rationale	Route metric definition depends on Link preference towards LISP route metric association (see also req. REQ.14.77-TS-IPMB-0008)
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04 and A/C-95
<ALLOCATED_TO>	<Functional block>	A-R, AC-R
<ALLOCATED_TO>	<System>	Aircraft, Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-IPMB-0007
Title	GB-LISP Route Management - metric change notification
Requirement	When the link preferences of a specific EID change, the MS/MR shall send route metric updates to all xTRs (G/G-Routers) that have been "subscribed" to the MS/MR via GB-LISP "Publish" Control Plane message.
Status	<validated>
Rationale	Any changes to the registration state for the destination EID will be published promptly to the RTR using the pub/sub mechanisms.
Category	<Functional>, <Interoperability>, <Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, MSE (MS/MR), A/G-R

<ALLOCATED_TO>	<System>	Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-IPMB-0008
Title	Link Quality Mapping on Route Metric
Requirement	The mapping between Link Preference and LISP route metric shall be uniform throughout the FCI, according to the following proposed association: **LINK QUALITY -> IGP METRIC and LISP PRIORITY** GOOD -> IGP METRIC=0 and LISP PRIORITY=0 MEDIUM ->IGP METRIC=1 and LISP PRIORITY=1 BEST EFFORT -> IGP METRIC=2 and PRIORITY=2 DISCONNECTED: The preference will be removed from the MS/MR GB-LISP.
Status	<validated>
Rationale	In GB-LISP, the priority is an incremental number, with the lowest been the highest priority; in case of equal priorities then another parameter is used (the Weight) to load balance the traffic.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	MSE (MS/MR), A/G-R
<ALLOCATED_TO>	<System>	Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-IPMB-0009
Title	DL selection Policy for Ground End User
Requirement	It shall be possible to define the link selection policies for uplink and downlink per ground end user. •
Status	<validated>
Rationale	Link preferences should respond to preferences or constraints from the current ATSP or the Airspace User.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	G/G-R, MSE
<ALLOCATED_TO>	<System>	Ground ATM Networks

Identifier	REQ.14.77-TS-IPMB-0009a
Title	DL selection Policy for MNP and Traffic Class
Requirement	The Airborne router shall be able to apply link selection policies on basis of the following criteria ([20]): • SubMNP • Traffic Class
Status	<validated>
Rationale	Link preferences should respond to preferences or constraints from the current ATSP or the Airspace User.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	AR

<ALLOCATED_TO>	<System>	Ground ATM Networks

Identifier	REQ.14.77-TS-IPMB-0009b
Title	DL selection Policy per source basis
Requirement	The Ground system shall be able to apply link selection policies on per source basis.
Status	<validated>
Rationale	Link preferences should respond to preferences or constraints from the current ATSP or the Airspace User.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	G/G-R, MSE
<ALLOCATED_TO>	<System>	Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-IPMB-0010
Title	Route metric monitoring
Requirement	In order to speed-up the Route Metrics update on ground side for optimizing GB-LISP operations, the Multilink Management function (MMF) shall update in terms of DL preference the AGMI Proxy via the interface IF9 (AGMI) , and consequently the A/G-R.
Status	<validated>
Rationale	This avoids the use of "RLOC Probing" messages on LISP side, which are too slow (tens of seconds) for some Classes of Services.
Category	<Interface>, <Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, A/G-R, G/G-R, MSE (MS/MR)
<ALLOCATED_TO>	<System>	Ground ATM Networks

4.2.3 FCI Multilink requirements

[REQ]

Identifier	REQ.14.77-TS-MLNK-0001
Title	Multilink Administrative Policy Selection
Requirement	FCI shall allow the definition of a common set of pre-defined link selection policies for multiple ATSP and Airspace Users.
Status	<validated>
Rationale	The selection of alternative datalinks among available radio access technologies for an IPS equipped aircraft shall follow the preferences and constraints defined by the Administrative (AD) Policies. These Administrative Policies can also obey to commercial or regulatory reasons.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	A-R, A/G-R
<ALLOCATED_TO>	<System>	Aircraft, Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-MLNK-0002
Title	Multilink Administrative Policy criteria
Requirement	For each End User (ATSU or AU) and a specific Geographical Area the FCI shall allow to configure on the Multilink Management Function (MMF) the Administrative datalinks Policy per FCI Service (ATS, AOC, AIS/AIM, MET, Flight Data, Digital Voice[10]) and aircraft Flight Phases.
Status	<validated>
Rationale	Policies set by national regulators can be mandatory (e.g. datalink not certified for use in a certain geographical area) or recommended and must be endorsed by AUs and ATSPs in the applicable region.
Category	<Functional>, <Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	A-R, A/G-R
<ALLOCATED_TO>	<Function>	MMF
<ALLOCATED_TO>	<System>	Aircraft, Ground ATM Networks

[10] The PJ14-W2-77 Validations shall address only the datalink services, as for A/G Digital Voice the outcome is dependent on the research activities conducted in PJ14-W2-107 concerning SATVOICE and in PJ33-W3-02 concerning LDACS VOICE.

[REQ]

Identifier	REQ.14.77-TS-MLNK-0003
Title	Multilink Administrative Policy and End User Preferences
Requirement	The End User Multilink preferences and constraints should be evaluated as specific attributes (or weights) and added to the Administrative datalink Preference W-AD(x).
Status	<validated>
Rationale	Link preferences should respond to preferences or constraints from the current ATSP or the Airspace User and criteria such as commercial opportunities, End User Preferences or other reasons relevant for an FCI stakeholder.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	A-R, A/G-R
<ALLOCATED_TO>	<Function>	MMF
<ALLOCATED_TO>	<System>	Aircraft, Ground ATM Networks

Identifier	REQ.14.77-TS-MLNK-0003b
Title	Multilink End User Preferences
Requirement	The End User Multilink preferences and constraints should include at a minimum these attributes values: - Provider DL rate (DRx); - Specific End User DL preference (EUx) (i.e. preferred DL backup); - Other end user parameters (OE) (i.e. data and time of operations).
Status	<validated>
Rationale	Link preferences should respond to preferences or constraints from the current ATSP or the Airspace User and criteria such as commercial opportunities, End User Preferences or other reasons relevant for an FCI stakeholder.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	A-R, A/G-R
<ALLOCATED_TO>	<Function>	MMF
<ALLOCATED_TO>	<System>	Aircraft, Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-MLNK-0004
Title	Multilink Policy Configuration
Requirement	The Multilink Administrative and Performance Policy shall be configurable on the aircraft and on the ground network technical systems.
Status	<validated>
Rationale	The Administrative and Performance policy configured on the FCI shall be consistent for A/G datalink communication started on the airborne technical system (downlink connections) or by the ground network (Uplink connections).
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	A-R, A/G-R
<ALLOCATED_TO>	<Function>	MMF
<ALLOCATED_TO>	<System>	Aircraft, Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-MLNK-0005
Title	Multilink AD Policy management
Requirement	The FCI shall configure the values of Administrative datalink Preferences (W-AD) as input for the Multilink Management Function (MMF).
Status	<validated>

Rationale	The Administrative Policy configured on the FCI shall be consistent and coherent for Service session started by the airborne technical System (downlink connections) or by the ground network (Uplink connections).
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	A-R, A/G-R
<ALLOCATED_TO>	<Function>	MMF
<ALLOCATED_TO>	<System>	Aircraft, Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-MLNK-0018
Title	Performance- based Multilink combined with Administrative Policy
Requirement	The FCI Multilink Management (MMF) Policy function (on the Aircraft and Ground technical systems) shall select the datalink Access Network services among the available DLs by applying in this exclusive order, these functions: • Select DLs-Performance function that allow to select the list of datalinks according to the defined performance policy); • Select DLs-Administrative (Select Datalink on Administrative Policy) function that allow to select the DLs according to the predefined Administrative policy.
Status	<validated>
Rationale	Link re-selection shall be applied for some datalinks, which do not support the performance levels required for some ATM services. Therefore, the FCI should automatically select the available datalink that support all ATM services at their required performance.
Category	<Functional>, <Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier

< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	A-R, A/G-R
<ALLOCATED_TO>	<Function>	MMF
<ALLOCATED_TO>	<System>	Aircraft, Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-MLNK-0019
Title	Multilink QoS management
Requirement	The FCI Multilink Management Function (MMF) for the A-R and Access Router (AC-R) Functional Block shall put in relationship the Service Type, the Class of Service (i.e. the Link Quality) and the DSCP value.
Status	<validated>
Rationale	The DSCP determines the per-hop behaviour of the ground routers. However, the queue management shall require a configuration according to the required behaviour. Strict priority queueing needs to be used on the ground routers to provide the required pre-emption capability.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	A-R, AC-R
<ALLOCATED_TO>	<Function>	MMF
<ALLOCATED_TO>	<System>	Aircraft, Ground ATM Networks

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[REQ]

Identifier	REQ.14.77-TS-MLNK-0020
Title	Multilink policy and preferences management (path selection)
Requirement	The FCI Multilink Management Function (MMF) for the A-R and Access Router (AC-R) Functional Blocks shall put in relationship the Service Type, the Class of Service (i.e. the Link Quality) and the "preference scope" defined by two components (see the AGMI protocol specification [20] and the IF6 ICD [22]): • the SubMNP • the Traffic Class
Status	<validated>
Rationale	A change in the datalink preferences is communicated by the AGMI protocol to the ground. For more details refer to the AGMI protocol specification [20] and the IF6 ICD [22]. The Aircraft might change its datalink preferences based on the experienced performance of the connectivity.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	A/G-R, AC-R
<ALLOCATED_TO>	<Function>	MMF
<ALLOCATED_TO>	<System>	Aircraft, Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-MLNK-0022
Title	Multilink Policy and GB-LISP metrics
Requirement	Multilink Policy parameters (Administrative and performance based) shall be mapped on the LISP "Priority" field.
Status	<validated>
Rationale	In order to drive G/G-R in selecting the Air-Ground link, according to the Multilink Policy.
Category	<Functional>, <Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	A-R, AC-R
<ALLOCATED_TO>	<Function>	MMF
<ALLOCATED_TO>	<System>	Aircraft, Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-MLNK-0023
Title	Exchange A/G datalink status to the AGMI Proxy
Requirement	A-R datalink status information shall be propagated from Aircraft to the AGMI Proxy through the AGMI (IF9) interface.
Status	<validated>
Rationale	The Airborne datalink status information exchanged with the AGMI Proxy will allow the update of GB-LISP route metrics according to the Multilink Policy rules.
Category	<Functional>, <Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	A-R, AC-R
<ALLOCATED_TO>	<Function>	MMF
<ALLOCATED_TO>	<System>	Aircraft, Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-MLNK-0027
Title	Radio Link Quality and A-R Metric definition
Requirement	The Airborne radio shall send to the A-R Link Quality information coded into four "values": 1) GOOD (nominal performance) 2) MEDIUM (degraded but known performance) 3) BEST EFFORT (degraded but unknown performance) 4) DISCONNECTED (after a "leave" event)
Status	<validated>
Rationale	This configuration maps "radio measurements" and LQ values definition that shall be used as input to multilink policy to drive the datalink selection for A/G data communication. Note that these assumptions are also included: "GOOD" is equivalent to Link Status = "UP" "DISCONNECTED" is equivalent to Link status = “DOWN” Note 2: for the IP VDLM2 datalink, only the two link statuses GOOD and DISCONNECTED are expected to be available and, therefore, are going to be tested in the PJ14-W2-77 Validations[11]
Category	<Functional>, <Performance>

[11] While in the current connection-oriented VDLM2 implementation operational in the field the Signal Quality measurement done by the airborne VHF Data Radio (a scale of [0-15] with 15 being the best quality) could support link statuses such as “BEST EFFORT” and “MEDIUM”, in the connectionless VDLM2 design being discussed at the AEEC DLK Subcommittee in support of IP traffic, the VDLM2 Ground Stations (VGS) will not have a point-to-point link with the aircraft anymore, but the latter will receive all VGSs in coverage as “the same broadcast address”; in such a scenario, the single SQP coming from one GS will become an unreliable measurement, not suited to quantify the Link Quality anymore (the “link” is not point-to-point link anymore). Therefore, we expect that in the future operational IP VDLM2 implementations, only the link status Up/Down (GOOD/DISCONNECTED) will effectively be supported.

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	MMF
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-MLNK-0028
Title	Radio Data link congestion
Requirement	The Airborne Radio should indicate data congestion to the Airborne Router for Performance Management control strategy.
Status	<validated>
Rationale	This data information exchanged between the radio and the A-R can be helpful, in order to command the router to manage multilink Policy for data transmission.
Category	<Functional>, <Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	AR, A-R
<ALLOCATED_TO>	<Function>	MMF
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-MLNK-0030
Title	Link Quality Metric Definition - AeroMACS
Requirement	The LQ metric proposer for AeroMACS conversion table shall follow this table conversion: LINK QUALITY to CINR (dB) • GOOD > 20 • MEDIUM for CINR in the range [11 - 20] • BEST EFFORT for CINR in the range [3 - 11] • DISCONNECTED < 3
Status	<validated>
Rationale	These values has been proposed according to AeroMACS radio measurements.
Category	<Functional>, <Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	AR, A-R
<ALLOCATED_TO>	<Function>	MMF
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-MLNK-0031
Title	Link Quality metric definition - SATCOM
Requirement	SATCOM equipment shall use its built-in three-levels LQ estimation: - LINK QUALITY - • GOOD Normal (Join) • BEST EFFORT Degraded • DISCONNECTED (Leave)
Status	<validated>
Rationale	Value agreed with PJ14.02.02 in W1 and reviewed in W2 with SOL 107.

Category	<Functional>, <Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	AR, A-R
<ALLOCATED_TO>	<Function>	MMF
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-MLNK-0034
Title	Link Quality metric definition – VDLM2
Requirement	VDLM2 equipment shall use its built-in three-levels LQ estimation: LINK QUALITY - • GOOD Normal (Join) • DISCONNECTED (Leave)
Status	<validated>
Rationale	While in the current connection-oriented VDLM2 implementation operational in the field the Signal Quality measurement done by the airborne VHF Data Radio (a scale of [0-15] with 15 being the best quality) could support link statuses such as “BEST EFFORT” and “MEDIUM”, in the connectionless VDLM2 design being discussed at the AEEC DLK Subcommittee in support of IP traffic, the VDLM2 Ground Stations (VGS) will not have a point-to-point link with the aircraft anymore, but the latter will receive all VGSs in coverage as “the same broadcast address”; in such a scenario, the single SQP coming from one GS will become an unreliable measurement, not suited to quantify the Link Quality anymore (the “link” is not point-to-point link anymore). Therefore, we expect that in the future operational IP VDLM2 implementations, only the link status Up/Down (GOOD/DISCONNECTED) will effectively be supported.
Category	<Functional>, <Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	AR, A-R
<ALLOCATED_TO>	<Function>	MMF
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-MLNK-0032
Title	Link Quality Metric Definition - LDACS
Requirement	For LDACS, conversion table should be based on SNR and the conversion table shall be: LINK QUALITY - SNR (dB): • GOOD > 20 • MEDIUM for the range [14 - 20] • BEST EFFORT for the range [5 - 14] • DISCONNECTED < 5
Status	< validated>
Rationale	Value agreed in W2 with SOL 60.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	AR, A-R
<ALLOCATED_TO>	<Function>	MMF
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-MLNK-0033
Title	Link Status update
Requirement	Airborne Radio shall send to the A-R the status of the radio link via IF2 interface.
Status	<validated>
Rationale	The A-R uses these informants as input for Multilink policy management.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	AR, A-R
<ALLOCATED_TO>	<Function>	MMF
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-MLNK-0033a
Title	Link Status
Requirement	The radio link status shall be “UP or DOWN".
Status	<validated>
Rationale	The A-R uses these informants as input for Multilink policy management.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	AR, A-R
<ALLOCATED_TO>	<Function>	MMF
<ALLOCATED_TO>	<System>	Aircraft

4.2.4 FCI Interface Requirements

[REQ]

Identifier	REQ.14.77-TS-ESIF-0001
Title	IF1 interface A-R IPv6 data packets
Requirement	Airborne ES shall exchange with the A-R IPv6 data packets (data plane).
Status	<validated>
Rationale	The Airborne ES exchange IPv6 data packets in the FCI.
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	IF1
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-ESIF-0001a
Title	IF1 interface requirement for the FCI
Requirement	The DSCP value associated to the Airborne ES applications shall be sent to the A-R For Multilink operations.
Status	<validated>
Rationale	As a consequence of Multilink architecture, where each ATC/AOC/SWIM application has its own DSCP value, which is in turn associated to the proper QoS (Queue Management)
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	IF1
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-ESIF-0002
Title	IF5 interface requirements for the FCI
Requirement	The Ground End System (ES) shall exchange with the G/G-R IPv6 data packets over a multi-hop IPv6 network (data plane).
Status	<validated>
Rationale	IP mobility aspects (control plane) should be “transparent” to the ground end users. An IPS ES shouldn´t be obligated to be connected using IF5 to an IPS G/G Router that implements IP mobility functions, but it should be allowed to the existing/future end-user network routers that should not be required to implement any IP mobility functions/capabilities.
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	G/G-R
<ALLOCATED_TO>	<Function>	IF5
<ALLOCATED_TO>	<System>	Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-INT2-0005
Title	IF2 interface general requirements
Requirement	The Airborne Router (A-R) and Airborne Radio (AR) shall exchange on the IF2 both control and data plane traffic.
Status	<validated>
Rationale	The Airborne Router needs to manage radio status information, routing information and route data Please refer to AIAP interface control document for more details [19]
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	IF2
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-INT2-0007
Title	IF2 interface - Control Messages for link and airborne radio status
Requirement	The control messages shall be exchanged between the A-R and the Airborne Radio to monitoring link status and the health status of the Airborne Radio.
Status	<validated>
Rationale	The Airborne Router needs to manage the Airborne Radio status information. Please refer to AIAP interface control document for more details [19]
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	IF2
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-INT2-0008
Title	IF2 interface – control messages JOIN and LEAVE messages
Requirement	The control messages JOIN (LEAVE) shall be unsolicited messages transmitted from the Airborne Radio to the Airborne Router when it has established (closed) an authenticated connection with the ground system.
Status	<validated>
Rationale	Please refer to AIAP interface control document for more details [19].
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	IF2
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-INT2-0011
Title	IF2 interface - status message content
Requirement	The status messages shall contain the following information: - Datalink ID - Datalink status, containing Link Quality information
Status	<validated>
Rationale	Airborne router needs to manage radio status information. Details are available in the AIAP interface control document [19].
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R

<ALLOCATED_TO>	<Function>	IF2
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-INT2-0012
Title	IF2 interface - Status message exchange criteria
Requirement	There shall be a periodic health message exchange between A-R and Airborne Radio with a configurable periodicity.
Status	<validated>
Rationale	In order to let the A-R understand, whether the Airborne Radio is correctly working. Details are available in the AIAP interface control document [19]
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	IF2
<ALLOCATED_TO>	<System>	Aircraft

Identifier	REQ.14.77-TS-INT2-0012a
Title	IF2 interface - Status message criteria
Requirement	The Airborne Router (Airborne Radio) shall consider the Airborne Radio (Airborne Router) unavailable after a number of failed message reception (es. three failed receptions).
Status	<validated>
Rationale	In order to let the A-R understand, whether the Airborne Radio is correctly working. Details are available in the AIAP interface control document [19]
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	IF2
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-INT2-0015
Title	IF2 interface - Control Panel
Requirement	IF2 Control Plane messages shall be exchanged through a different interface than the Data Plane one.
Status	<validated>
Rationale	An Airborne Radio interface can provide one or two physical connections, as well as different IPv6 address typology (Link local or Global Unicast). Details are available in the AIAP interface control document [19].
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	A-R,
<ALLOCATED_TO>	<Function>	IF2
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-INT3-0017
Title	IF3 interface description
Requirement	IF3 interface shall connect the AC-R to the Air Ground Router.
Status	<validated>
Rationale	The AC-R is the "IP point of attachment" of the Access Network Ground Radio System to the rest of the FCI.

Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, A/G-R
<ALLOCATED_TO>	<Function>	IF3
<ALLOCATED_TO>	<System>	Ground ATN network

[REQ]

Identifier	REQ.14.77-TS-INT3-0018
Title	IF3 interface message types
Requirement	IF3 shall manage the following message types: a) DATA message exchange; b)) IPv6 multi-hop control plane message (i.e. an IPv6 multi-hop routing protocol)
Status	<validated>
Rationale	These messages are required for the FCI Multilink Management Function (MMF) and data exchange. FCI does not have to select a specific protocol for Interface IF3, but rather the requirement is that IF3 shall be an IPv6 multi-hop routing protocol (e.g. OSPFv3, PMIPv6, etc.)
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, A/G-R
<ALLOCATED_TO>	<Function>	IF3
<ALLOCATED_TO>	<System>	Ground ATN network

[REQ]

Identifier	REQ.14.77-TS-INT9-0021
Title	IF9 interface - definition
Requirement	The IF9 interface, which implements the Air-Ground Mobility Interface (AGMI) specified in ICD [20], shall allow the A-R and the AGMI Proxy to exchange control plane messages in support of Mobility and Multilink functions.
Status	<validated>
Rationale	This interface is fundamental to implement the Multilink functionality, while optimizing mobility routing operation. In the initial FCI architecture it had been assumed that the first hop router for the A-R is the ground Access Router (AC-R). It is now acknowledged, that there can be Access Network architecture/implementations, where this assumption is not correct. This is acceptable and is not an issue for the FCI. The AGMI allows the A-R to exchange multilink and mobility related information with the ground AGMI Proxy and, consequently, by means of the additional IF3 (where necessary[12]), with the A/G-R.
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	A-R, AGMI Proxy
<ALLOCATED_TO>	<Function>	IF9
<ALLOCATED_TO>	<System>	Aircraft, Ground ATN network

[12] It is envisaged that in some Access Networks the provider may choose to collapse the two functions of Access Router and Air/Ground Router into a single subsystem. In such a scenario, the IF3 is not needed, as the two functions are in execution on the same "box".

[REQ]

Identifier	REQ.14.77-TS-INT9-0023
Title	IF9 interface - scope
Requirement	This interface shall allow indirect logical communication between the Airborne Router and the A/G Router, via the AGMI Proxy logical entity and, where necessary, via the additional connectivity segment provided by the IF3 (AC-R to A/G-R interface), in order to support: - Route establishment, by announcing the aircraft IPv6 AOC and ATC End System Mobile Network Prefix (MNP); - Transfer to the A/G-R of the Link Preference information; - Transfer to the A/G-R of the Link Status updates, as detected by the A-R. - A safety net mechanism, to allow the Airborne Router a "last resort" detection of loss of connectivity in one Access Network, when not previously detected by the corresponding airborne radio.
Status	<validated>
Rationale	The interface allows the Airborne registration in the FCI services and A/G multilink management and DLs status update with the access network.
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	A-R, AGMI Proxy
<ALLOCATED_TO>	<Function>	IF9
<ALLOCATED_TO>	<System>	Aircraft, Ground ATN network

[REQ]

Identifier	REQ.14.77-TS-INT9-0041
Title	IF9 Interface features - Addressing
Requirement	The A-R shall use an "a-priori" known IPv6 anycast address to contact the Access networks on the AGMI interface ([20]).
Status	<validated>
Rationale	For Layer 2 radio equipment, IPv6 link local addresses can be used. For Layer 3 radio equipment, an IPv6 "anycast" address. "Subnet-Router" anycast address is pre-defined and contains a subnet prefix which identifies a specific link.
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	A-R, AGMI Proxy
<ALLOCATED_TO>	<Function>	IF9
<ALLOCATED_TO>	<System>	Aircraft, Ground ATN network

[REQ]

Identifier	REQ.14.77-TS-INT4-0029
Title	IF4 interface features
Requirement	IF4 shall interface: - A/G Routers to G/G Routers; - G/G Routers to G/G Routers by means of GB-LISP standard [39], for Data plane information exchange.
Status	<validated>
Rationale	Pls refer to Figure 35: FCI Block Diagram
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	A/G-R, G/G-R

<ALLOCATED_TO>	<Function>	IF4
<ALLOCATED_TO>	<System>	Ground ATN network

[REQ]

Identifier	REQ.14.77-TS-INT4-0030
Title	IF4 interface features - Underlying protocols
Requirement	. The IF4 shall support the GP-LISP protocol.
Status	<validated>
Rationale	The connectivity shall be based on IPv4 or IPv6 protocols, over which "LISP tunnels" shall be provided.
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	A/G-R, G/G-R
<ALLOCATED_TO>	<Function>	IF4
<ALLOCATED_TO>	<System>	Ground ATN network

[REQ]

Identifier	REQ.14.77-TS-INT6-0033
Title	IF6 interface features
Requirement	IF6 shall interface the AGMI Proxy, the A/G Routers and G/G Routers towards MS/MR by means of GB-LISP standard, as well as and LISP Pub-Sub for Control plane information exchange according to ICAO WG-I report (See GB-LISP Mobility solution for ATN/IPS [39]).
Status	<validated>
Rationale	It is the control plane interface that allows route information exchange between FCI ground routers according to the ICAO WG-I report (See ref [39] -GB-LISP Mobility solution for ATN/IPS) that specify the GB-LISP profile specification and the standards.
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AGMI Proxy, A/G-R, G/G-R
<ALLOCATED_TO>	<Function>	IF6
<ALLOCATED_TO>	<System>	Ground ATN network

[REQ]

Identifier	REQ.14.77-TS-INT6-0034
Title	IF6 interface features - Underlying protocols
Requirement	The connectivity shall be based on IPv4 as well as IPv6 protocols
Status	<validated>
Rationale	LISP is an “overlay technology” that can be supported by any IP-based network according to the ICAO WG-I report (GB-LISP Mobility solution for ATN/IPS [39]) that specify the GB-LISP profile specification and the standards.
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AGMI Proxy, A/G-R, G/G-R
<ALLOCATED_TO>	<Function>	IF6
<ALLOCATED_TO>	<System>	Ground ATN network

Identifier	REQ.14.77-TS-INT10-0001
Title	IF10 interface features
Requirement	IF10 shall interface the ground logical entity “AGMI Proxy” with the IF3 Routing Function, in order to allow the AGMI Proxy injection into IF3 of the Aircraft MNP and the Link Preferences[13].
Status	<validated>
Rationale	(Pls refer to Figure 35: FCI Block Diagram) The AGMI protocol is terminated on the ground by the AGMI Proxy, which is a logical entity that can be deployed on different network elements (e.g. the AC-R is one possible deployment choice, but it is not the only one). An Access Service Provider (ASP) shall have the flexibility to decide where to deploy the AGMI Proxy, based on its preferred architectural design of the Access Network. NOTE: the AGMI Proxy could also be deployed outside the Access Network and in a network element belonging to the GB-LISP administrative domain.
Category	<Interface>

REQ Trace]

Relationship	Linked Element Type	Identifier

[13] The implementation of IF10 is left open for the Access Service Provider (in case the AGMI Proxy is deployed in the Access Network) or for the Communication Service Provider (in case the AGMI Proxy is deployed in the GB-LISP administrative domain) to choose, depending on the specificities of the platform chosen for deployment of the AGMI Proxy.

< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, A/G-R, AGMI Proxy
<ALLOCATED_TO>	<Function>	IF10
<ALLOCATED_TO>	<System>	Ground ATN network

4.2.5 OSI - IPS Gateways Specific Requirements

[REQ]

Identifier	REQ.14.77-TS-GTWs-0001
Title	OSI-IPS Gateway: general
Requirement	The OSI-IPS DS Gateway shall operate as a ground component interfacing the FCI with an external ATN-OSI network.
Status	<validated>
Rationale	The Figure 35: FCI Block Diagram shows two Gateways, in order to highlight the two different functions of this component
Category	<Functional>, <Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	OSI-IPS DS GTW
<ALLOCATED_TO>	<Function>	IF5, IF8
<ALLOCATED_TO>	<System>	Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-GTWs-0002
Title	OSI-IPS DS Gateway: architecture
Requirement	The GTW shall act at the Dialog Service level, terminating protocol stacks up to Dialog Service on both the air-ground side and on the ground side, extracting DS PDUs from each side and forwarding to the other side.
Status	<validated>
Rationale	This was in contrast to the first release of the Wave 1 PJ14.02.04 FRD Deliverable, regarding the ATN-OSI A/C accommodation into IPS ground network. The FRD has been updated. The OSI-IPS Gateway system is being standardized by the AEEC IPS Subcommittee in Project Paper 858,[21]
Category	<Design>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	OSI-IPS DS GTW
<ALLOCATED_TO>	<Function>	IF5, IF8
<ALLOCATED_TO>	<System>	Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-GTWs-0003
Title	OSI-IPS DS GTW configurations
Requirement	The OSI-IPS DS GTW shall interoperate with ATN-OSI and ATN-IPS networks, supporting two configurations: 1) OSI-IPS Configuration to accommodate ATN/OSI aircraft to an ATN/IPS DLS. 2) OSI-IPS Configuration to accommodate ATN/IPS aircraft to an ATN/OSI DLS.
Status	<validated>
Rationale	Pls refer to Figure 35: FCI Block Diagram
Category	<Functional>, <Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	OSI-IPS DS GTW
<ALLOCATED_TO>	<Function>	IF5, IF8
<ALLOCATED_TO>	<System>	Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-GTWs-0003a
Title	OSI-IPS DS GTW configurations for ATN/IPS DLS
Requirement	The OSI-IPS Configuration that accommodated ATN/OSI aircraft protocol to an ATN/IPS DLS protocol shall implement these configuration on the interfaces: - OSI interface acts as a proxy DLS, - IPS interface acts as a proxy for the aircraft connections.
Status	<validated>
Rationale	Pls refer to Figure 35: FCI Block Diagram
Category	<Functional>, <Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	OSI-IPS DS GTW
<ALLOCATED_TO>	<Function>	IF5, IF8
<ALLOCATED_TO>	<System>	Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-GTWs-0003b
Title	OSI-IPS DS GTW configuration for ATN/OSI DLS
Requirement	The OSI-IPS Configuration that accommodated ATN/IPS aircraft protocol to an ATN/OSI DLS protocol shall implement these configuration on the interfaces: - The IPS interface acts as a proxy DLS, - the OSI interface acts as a proxy for the aircraft connections.
Status	<validated>
Rationale	Pls refer to Figure 35: FCI Block Diagram
Category	<Functional>, <Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77

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< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	OSI-IPS DS GTW
<ALLOCATED_TO>	<Function>	IF5, IF8
<ALLOCATED_TO>	<System>	Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-GTWs-0004
Title	OSI-IPS DS GTW as a Network Component
Requirement	The OSI-IPS App GTW shall operate as a network component in the CSP or ANSP domain.
Status	<validated>
Rationale	OSI-IPS GTW operates at IPS DS level, whichever domain will host it
Category	<Design>, <Architecture>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	OSI-IPS DS GTW
<ALLOCATED_TO>	<Function>	IF5, IF8
<ALLOCATED_TO>	<System>	Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-GTWs-0005
Title	OSI-IPS DS GTW Transparency
Requirement	The OSI-IPS App GTW shall provide a network interface that supports bi-directional dialogue exchange, in such a way that any ES in one of the network domains can reach those in the other domain without any modification in the ES functions.
Status	<validated>
Rationale	In order to support seamless transition from OSI to IPS routing domains
Category	<Functional>,<Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	OSI-IPS DS GTW
<ALLOCATED_TO>	<Function>	IF5, IF8
<ALLOCATED_TO>	<System>	Ground ATM Networks

[REQ]

Identifier	REQ.14.77-TS-GTWs-0006
Title	OSI-IPS DS GTW IPS Standard
Requirement	The OSI-IPS App GTW shall conform, on the ATN-IPS side, to ICAO Doc. 9896 Ed. 2 ([3]) and subsequent.
Status	<validated>
Rationale	In order to enforce interoperability with End Systems
Category	<Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	OSI-IPS DS GTW
<ALLOCATED_TO>	<Function>	IF5
<ALLOCATED_TO>	<System>	Ground ATM Networks

[REQ]

Identifier	REQ- 14.77-TS-GTWs-0007
Title	OSI-IPS DS GTW IPS: interface to ATN-OSI Domain (IF8)
Requirement	OSI-IPS Gateway shall provide interface to OSI Boundary Intermediate Systems (BIS), according to ICAO doc.9880 Ed 2 ([6]).
Status	<validated>
Rationale	It is assumed that the OSI-IPS GTW behaves as an ATN-OSI End System towards the OSI Domain.
Category	<Interoperability>, <Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	OSI-IPS DS GTW
<ALLOCATED_TO>	<Function>	IF8
<ALLOCATED_TO>	<System>	Ground ATM Networks

[REQ]

Identifier	REQ-14.77-TS-GTWs-0008
Title	OSI-IPS DS GTW IPS: interface to IPS Domain (IF5)
Requirement	OSI-IPS Gateway shall provide interface to IPS G/G-R according to IF5 specifications.
Status	<validated>
Rationale	It is assumed that the OSI Gateway behaves as an IPS End System towards the IPS Domain.
Category	<Interface>, <Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	OSI-IPS DS GTW
<ALLOCATED_TO>	<Function>	IF5
<ALLOCATED_TO>	<System>	Ground ATM Networks

4.2.6 Airborne Router Requirements

[REQ]

Identifier	REQ.14.77-TS-ABRT-0001
Title	Interface with ATN Applications
Requirement	The ATN/IPS Airborne Router shall provide a Dialogue Service Interface (DSI) for ATN applications according to ICAO 9896 specification ED II ([3]) and subsequent.
Status	<validated>
Rationale	The FCI shall interface with the IP stacks following ATN/IPS Dialogue Service, as per ICAO 9896 (see ConOps req. REQ-14-W2-77-OP-003).

Category	<Functional>, <Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	IF1
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-ABRT-0002
Title	Interface with AOC & SWIM applications
Requirement	The ATN/IPS Airborne Router shall provide IPv6 communication services to the AOC & SWIM applications located in the ACD domain.
Status	<validated>
Rationale	In order to support End Systems interoperability
Category	<Functional>, Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	IF1
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-ABRT-0003
Title	IPv6 protocol stack support
Requirement	The ATN/IPS Airborne Router shall implement the IPv6 protocol stack as specified by the standardization bodies: ICAO Doc 9896 ed. 3 ([3]), RTCA SC-223/EUROCAE WG108 IPS Profiles ([4]).
Status	<validated>

Rationale	The conformity to the standards guarantees the Airborne Functional Blocks interoperability.
Category	<Functional>, Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	IF1, IF2, IF9
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-ABRT-0004
Title	A/G Datalink status monitoring
Requirement	The ATN/IPS Airborne Router shall monitor the status of all installed air-ground datalinks suitable for ATN-IPS communication.
Status	<validated>
Rationale	Mandatory for Multilink operations.
Category	<Functional>, <Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	MMF
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-ABRT-0010
Title	Multiple air-ground datalink usage
Requirement	The ATN/IPS Airborne Router shall be able to select different air-ground datalinks for different application data of different Class of Service at the same time.

Status	<validated>
Rationale	According to basic Multilink principles specified in the Multilink requirements REQ.14.77-TS-MLNK-0019 and REQ.14.77-TS-MLNK-0020..
Category	<Functional>, <Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	MMF
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-ABRT-0011
Title	Air-ground routing
Requirement	The ATN/IPS Airborne Router shall route airborne originated data to its ground destination via selected air-ground datalink.
Status	<validated>
Rationale	Mandatory requirement for Multilink
Category	<Functional>, <Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	MMF
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-ABRT-0012
Title	Ground-air routing
Requirement	The ATN/IPS Airborne Router shall route ground originated data to a corresponding airborne application.
Status	<validated>
Rationale	It is expected that multiple Airborne End Systems, supporting different applications, shall be reachable via the A-R.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	APP Routing
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-ABRT-0013
Title	Class of Service recognition
Requirement	The ATN/IPS Airborne Router shall be able to differentiate the Class of Service of the application data.
Status	<validated>
Rationale	According to DSCP values reported in Table 10.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	CoS, QoS
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-ABRT-0014
Title	Prioritization
Requirement	The ATN/IPS Airborne Router shall apply prioritization mechanisms to the application data based on their Class of Service.
Status	<validated>
Rationale	Pls refer to Table 10.
Category	<Functional>, <Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	CoS, QoS
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-ABRT-0018
Title	Addressing on the A-R datalink interfaces
Requirement	The ATN/IPS Airborne Router shall allow configuration of the IPv6 Link Local address, of the IPv6 AGMI anycast address and the (global) unicast address belonging to the Aircraft Mobile Network Prefix (MNP).
Status	<validated>
Rationale	The Aircraft datalink registration on the Mobility Service Entity allows the A-R to manage and select the Multilink A/G connections.
Category	<Functional>

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[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	IF1, IF2, IF9
<ALLOCATED_TO>	<System>	Aircraft

4.2.7 FCI Security Requirements

[REQ]

Identifier	REQ.14.77-TS--SEC-0001
Title	A/G - G/G communication
Requirement	The following Security provisions shall be implemented to protect the integrity of the tunnel connections listed here below. **1)/ G/G to G/G to A/G data (T02 - LISP data):** - > GetVPN/Cisco (G-IKEv2, [34]) suggested -> end-to-end encryption (plane to G/G) - open - > IPsec tunnel – (max. 50, with scalability limitation) **2/ G/G and A/G to Mapping Server (T04 - LISP control):** -> integrity protected with LISP Sec (map request, map request forward, map reply), without Sec problem with map reply, - only pre shared secrets + LISP Sec will be mandatory in future other options (if confidentiality is needed): -> IPsec tunnel (max. 50, with scalability limitation); -> DTLS tunnel (max. 50, with scalability limitation); Note: for G/G or /A/G (LISP XTR router) to MS - LISP publish subscribe, LISP request & reply from server (direct to requester!), possibility over TLS/IPsec used with PKI + confidentiality and integrity are achieved + in this case no G/G to A/G control plane communication **3)/ G/G to A/G control plane:** - > GetVPN/Cisco (G-IKEv2, [34]) suggested - > IPsec tunnel –(max. 50, with scalability limitation)

Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk)
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, A/G-R, G/G-R, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW
<ALLOCATED_TO>	<Function>	IF4, IF6
<ALLOCATED_TO>	<System>	Ground ATM Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0003
Title	IPS security architecture
Requirement	To support a defence-in-depth security strategy, the baseline requirement for the overall IPS security architecture is that a minimum of two layers of security shall be incorporated into the design to protect communications from Intentional Unauthorized Electronic Interference (IUEI, as defined in RTCA DO-326A and EUROCAE ED-202A).
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk)
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04

<ALLOCATED_TO>	<Functional block>	AC-R, A/G-R, G/G-R, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATM Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0004
Title	Airborne IPS System security services
Requirement	The Airborne IPS System shall support a mode of operation that provides authentication, message integrity, and message confidentiality services.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk)
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-SEC-0005
Title	Airborne IPS System security - DoS protection
Requirement	The Airborne IPS System shall protect itself from denial-of-service attacks originating from the ground.
Status	<validated>

Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk)
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-SEC-0005a
Title	Airborne IPS System security - DoS protection
Requirement	The Airborne IPS should be capable of implementing a rate limit function for UDP, TCP, and ICMP flood attacks.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk)
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-SEC-0007
Title	General Security Principles: MITM protection
Requirement	In order to protect the FCI against MITM attacks over the whole FCI Perimeter, the integrity of layer 3 messages exchanged on both Control and Data Planes shall be protected with mutual authentication procedures
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk)
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	AR, A-R, AC-R, A/G-R, G/G-R, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Aircraft, Ground ATM Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0008
Title	General Security Principles: penetration attacks protection
Requirement	The FCI should be protected against attacks that use software vulnerability by applying Security Best Practices of which the following are some examples: - Limiting the IP ports open; - Using Access Control List; - Performing packet inspection Firewall functions are foreseen to be used on FCI perimeter
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk)
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, A/G-R, G/G-R, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATM Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0009
Title	FCI Air Interface hardening - Authentication server
Requirement	The Airborne IPS System or the Airborne Radio[14] shall authenticate towards the Access Network Ground Infrastructure by means of Certificate management through the proper AAA server belonging to each Access Network.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk)
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	AR, A-R
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Aircraft

[14] Depending on the Datalink Technology, the Authentication may be done at the radio link layer or at a higher protocol layer

[REQ]

Identifier	REQ.14.77-TS-SEC-0010
Title	FCI Minimum Set of Security Controls
Requirement	All FCI components shall implement security controls following best security practices as delineated in MSSC (Minimum Set of Security Controls).
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk)
Category	<Functional>, <Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	AR, A-R, AC-R, A/G-R, G/G-R, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Aircraft, Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0011
Title	Airborne Firewall functionality
Requirement	The ATN/IPS Airborne Router shall implement a firewall filtering function on the interfaces with Airborne Radios (IF2).
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk)
Category	<Functional>,<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95

<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-SEC-0012
Title	IF2 interface – security
Requirement	A firewall function shall provide an IPv6 / ports Access Control List and perform packet inspection functions to discover potential intrusion
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk)
Category	<Interface>, <Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-SEC-0013
Title	IF3 interface - security
Requirement	IF3 shall be secured against MITM attacks. supported by: Examples: a) A firewall function, implementing the Access Control List and managing connectivity across the various IP ports, between the AC-R and the A/G-R; a) b) An IPsec tunnel (with IKEv2 protocol) to protect control and data plane from MITM attacks
Status	<validated>

Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk)
Category	<Interface>, <Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, A/G-R
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0014
Title	IF9 message security
Requirement	IF9 messages shall be protected against MITM attacks by the underlying interface protocols, i.e.: - The A/G radio link, which is expected to be authenticated by system specific authentication mechanisms; - The G/G link supported by IF3, for which an encryption protection like IPsec is expected (considering the scalability limits of IPsec to be of no concern), multi hop routing protocol integrity is necessary).
Status	<validated>
Rationale	Since IF9 messages are encapsulated within the underlying interface protocols, implementation of the Security protection in these protocols is assumed to be sufficient to guarantee the end-to-end protection for the IF9 control messages. Note: AGMI was not evaluated in the PJ14-W2-77 SecRA, hence this requirement REQ.14.77-TS-SEC-0014 assumes that sufficient protection is guaranteed by the underlaying protocols. For the Long-term Mobility solution, a further evaluation shall be needed, to assess whether specific security measures in the AGMI protocol are needed
Category	<Interface>, <Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, A/G-R
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0015
Title	IF_S_1 interface
Requirement	IF_S_1 shall allow connecting Access Network users and components to its specific AAA Server for authentication functions
Status	<validated>
Rationale	See Assumption AS14 in the PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk)
Category	<Security>, <Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, G/G-R, A/G-R
<ALLOCATED_TO>	<Function>	IF_S_1
<ALLOCATED_TO>	<System>	Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS- SEC-0016
Title	IF_S_2 interface
Requirement	IF_S_2 shall allow LISP components to manage X.509 certificates for authentication and encryption procedures, according to G-IKEv2 standard ([34]).
Status	<validated>

Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>, <Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, G/G-R, A/G-R
<ALLOCATED_TO>	<Function>	IF_S_2
<ALLOCATED_TO>	<System>	Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0017
Title	Security control and management
Requirement	Proper security control and security management practices shall be implemented on the FCI, including: - Configuration and operational audits - Secure monitoring and management - Attack monitoring and correction, and patch management - Self-protection and network security design practices
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	AR, A-R, AC-R, G/G-R, A/G-R
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Aircraft, Ground ATN Network

4.2.7.1 Network Design Security Controls

[REQ]

Identifier	REQ.14.77-TS-SEC-0018
Title	Air/Ground Link Switch in DoS Scenario
Requirement	It shall be possible in multi-link scenario to change to other air-ground link in case of detected DoS attack (e.g. overloading of the link capacity)
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	A-R, AC-R, G/G-R, A/G-R
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Aircraft, Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0019
Title	Packet Filtering Firewall
Requirement	A packet filtering firewall before the targeted link shall be in place.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	A-R, AC-R, A/G-R
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Aircraft, Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0020
Title	No Network Single Point of Failure
Requirement	The FCI network shall be designed without single points of failure..
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, G/G-R, A/G-R, AGMI Proxy, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0020a
Title	No Network Single Point of Failure
Requirement	The FCI network shall be designed to automated failover for all elements in the ground infrastructure.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, G/G-R, A/G-R, AGMI Proxy, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0021
Title	Diversity in Infrastructure
Requirement	Diversity in infrastructure elements shall be in place (considering parallel DoS attack on the same type of redundant device).
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04

<ALLOCATED_TO>	<Functional block>	AC-R, G/G-R, A/G-R, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0022
Title	DDoS Protection Service
Requirement	DDoS protection service in the global mobility backbone shall be implemented.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, G/G-R, A/G-R, MSE (MS/MR)
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0023
Title	ISP Redundancy in Infrastructure Connections
Requirement	Redundancy in infrastructure connections to the network by the ISP provider (different ports) shall be in place.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	Underlay Transp. Infrastructure
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0024
Title	Geographically Separated MSEs
Requirement	Multiple geographically separated mapping servers (MSEs) shall be in place in the network.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	MSE (MS/MR)
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0025
Title	Change of Global Mobility Service Provider
Requirement	Change to a different global mobility service provider shall be possible.
Status	<in progress>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, G/G-R, A/G-R, MSE (MS/MR)
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

4.2.7.2 Implementation of Tunnel Security Functions

[REQ]

Identifier	REQ.14.77-TS-SEC-0026
Title	Integrity Protection of GB-LISP Data Plane
Requirement	T#02[15]: GB-LISP data shall be integrity protected in transit, e.g. by means of protocols such as Cisco GetVPN (G-IKEv2, [34]). Responsibility lies with the CSP (mobility provider).
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, G/G-R, A/G-R
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

[15] The identification of the Tunnels and their naming is defined in the Security Risk Assessment picture "FCI Zone Model", which is part of the confidential Security material developed in the PJ14-W2-77 SecRA.

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[REQ]

Identifier	REQ.14.77-TS-SEC-0027
Title	Integrity Protection of Network Management Traffic
Requirement	T#03: Network Management for routers in the ISP network shall be protected for integrity (including non-repudiation) and confidentiality, e.g. by means of SSH connections to network devices. Responsibility lies with the CSP and ISP. Recommendation: for Availability considerations, out of band management via separated communication infrastructure (assumption), e.g. private LTE network, should be used.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	Ground Support Systems, Underlay Transp. Infrastructure
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0027a
Title	Availability of Network Management Traffic
Requirement	The FCI availability should be increased by using separated communication infrastructure (e.g. private LTE network) that allow out of band management.
Status	<in progress>

Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk). This is a Recommendation (should), which would further improve the Availability performance of the FCI beyond the compliance to the Availability requirements specified in ED-228A ([14]). It is not mandatory for achieving the TRL6 maturity.
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	Ground Support Systems, Underlay Transp. Infrastructure
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0028
Title	Integrity Protection of GB-LISP Control Plane
Requirement	T#04: the GB-LISP control plane integrity protection shall be realised with LISP-SEC ([36]). Responsibility lies with the CSP.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, G/G-R, A/G-R, AGMI Proxy, MSE (MS/MR)
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0029
Title	Integrity Protection of AGMI Control Plane Protocol
Requirement	T#05: AGMI control plane shall be integrity protected Responsibility lies with the CSP.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, G/G-R, A/G-R
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

4.2.7.3 Implementation of Perimeter Security Functions

[REQ]

Identifier	REQ.14.77-TS-SEC-0030
Title	G/G Router ACL towards ISP network
Requirement	P#01[16]: protection mechanism that helps get unwanted traffic away from the LISP router originating from the ISP to G/G Router, either in G/G Router self /ACL or separate element one hop before the router, shall be implemented. Responsibility lies with the CSP.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	G/G-R
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

[16] The identification of the Perimeters and their naming is defined in the Security Risk Assessment picture “FCI Zone Model”, which is part of the confidential Security material developed in the PJ14-W2-77 SecRA.

[REQ]

Identifier	REQ.14.77-TS-SEC-0030a
Title	G/G Router ACL towards ISP network
Requirement	LISP routers shall accept IP traffic only from other LISP entities. Responsibility lies with the CSP.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	G/G-R
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0031
Title	G/G Router protection towards ANSP network
Requirement	P#02: protection against non-legitimate traffic (packets with destination addresses in the ICAO EID space) inserting from ANSP network into the GB-LISP domain shall be implemented. Responsibility lies with the CSP.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77

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< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	G/G-R
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

4.2.7.4 Anomaly Detection

[REQ]

Identifier	REQ.14.77-TS-SEC-0032
Title	Automated DoS Alarm
Requirement	Automated DoS detection shall be in place including automated threshold alarm(s) (e.g. overloading of the air ground link capacity).
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

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[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, G/G-R, A/G-R, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0033
Title	Intrusion Detection of physical access to network devices
Requirement	Correlation between physical access to the device consoles (physical access log), boot events (administratively planned) and change management approval (boot approval) shall be in place, to detect unauthorized and unplanned access.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, G/G-R, A/G-R, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0034
Title	Automated Alarm for Network Management Access
Requirement	Each ground network element shall generate an alarm to the Network Management for every single SSH login.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, G/G-R, A/G-R, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW, Ground Support Systems, Ground DNS server, Underlay Transp. Infrastructure
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0034a
Title	Automated Alarm for Network Management Access
Requirement	The Network Management should be integrated with the change management system to recognise non-authorised activity (e.g. if ongoing access activity was not planned or not approved in the change management system)
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, G/G-R, A/G-R, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW, Ground Support Systems, Ground DNS server, Underlay Transp. Infrastructure
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

4.2.7.5 Network Configuration Security Functions

[REQ]

Identifier	REQ.14.77-TS-SEC-0035
Title	Traffic Shaping
Requirement	Traffic shaping shall be in place to control the volume of traffic being sent into a network in a specified period – mitigation in case of DoS.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier

< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	A-R, AC-R, G/G-R, A/G-R, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Aircraft, Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0036
Title	Traffic Policing
Requirement	Traffic policing shall be in place to monitoring the reception of network traffic for compliance with a traffic contract and taking steps to enforce that contract (e.g. discarding traffic) - mitigation in case of DoS
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	A-R, AC-R, G/G-R, A/G-R, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Aircraft, Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0037
Title	Strict Priority Queuing
Requirement	Strict priority queuing shall be implemented to protect critical traffic from lower priority traffic by pre-emption (see Table 10).
Status	<validated>

Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	A-R, AC-R, G/G-R, A/G-R, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Aircraft, Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0038
Title	FCI Network Management System
Requirement	Devices shall be connected to the NMS
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, G/G-R, A/G-R, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW, Underlay Transp. Infrastructure
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0038a
Title	Normal Configuration Operation only via Network Management System
Requirement	Devices normal configuration operations shall be performed only via the Network Management System (NMS).
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, G/G-R, A/G-R, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW, Underlay Transp. Infrastructure
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0038b
Title	NMS Normal Configuration Operation via SSH protocol Network Management System
Requirement	Devices shall be connected to the Network Management System (NMS) via SSH only for exceptional cases (trigger alarm): i. A mandatory centralised AAA server shall be used for SSH sessions ii. Source IP Addresses from where the SSH session can be accepted shall be limited iii. Two-factor authentication for SSH access shall be implemented
Status	<validated>

Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, G/G-R, A/G-R, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW, Underlay Transp. Infrastructure
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0039
Title	Policy Rules for Configuration of the MSE (MS/MR)
Requirement	Policy rules in the mapping system, for authorisation of mapping actions, including alarm in case of illegal mapping actions, shall be in place (policy requires trust in the XTR authenticity).
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	MSE (MS/MR)
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

4.2.7.6 DoS Protection

[REQ]

Identifier	REQ.14.77-TS-SEC-0040
Title	DoS alarm to ATC controller
Requirement	In case of extended DoS attack, alarm to the Air Traffic Control operators shall be issued to notify that backup contingency plan. Responsibility lies with ANSPs and the Airspace Users.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	Airborne IPS System, AC-R, G/G-R, A/G-R, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW, Underlay Transp. Infrastructure
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Aircraft, Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0040a
Title	DoS alarm and Analog voice backup contingency plan
Requirement	In case of extended DoS attack, after the alarm to the Air Traffic Control operators that backup contingency plan shall be activated with change to analogue voice. Responsibility lies with ANSPs and the Airspace Users.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier

< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	Airborne IPS System, AC-R, G/G-R, A/G-R, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW, Underlay Transp. Infrastructure
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Aircraft, Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SEC-0041
Title	Alternative Transport Infrastructure
Requirement	As optional mitigation for DoS situation, the use of an alternative (independent) transport infrastructure, which does not rely on the same IPS segment shall be in place (we assume some degradation of the service).
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	Underlay Transp. Infrastructure
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

4.2.7.7 Airborne Security Functions

[REQ]

Identifier	REQ.14.77-TS-SEC-0042
Title	Airborne Router CPU Capacity
Requirement	Enough capacity to process all interfaces with full load plus a safety margin shall be available at the Airborne Router. Example: If all interfaces run at full speed, the CPU load will still be under 80%.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-SEC-0043
Title	Rate limiting of A-R workload
Requirement	Provided the A-R CPU has enough capacity, rate limited workload shall be processable, to mitigate the impact of a DoS scenario
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

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[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-SEC-0044
Title	Manual switch off of ATN/IPS communication
Requirement	For the airborne part, means of incident response are very limited. At least, the cockpit crew should be capable of isolating datalink communication (via manually switching off ATN/IPS communication means) to prevent threat propagation.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	Airborne IPS System
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-SEC-0045
Title	Data flow segregation by ACD (Aircraft Control Domain) Local Network
Requirement	In case of a shared network, data flow segregation by means of ACD shall prevent communications among systems that is not allowed (e.g. through virtual links configuration). Note: by using point-to-point ARINC 429 buses, segregation is intrinsically guaranteed.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	Airborne IPS System
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Aircraft

4.2.7.8 Traffic Monitoring and Re-allocation

[REQ]

Identifier	REQ.14.77-TS-SEC-0046
Title	Traffic Monitoring
Requirement	Traffic monitoring shall be in place to move control traffic from the server under attack towards a diverse system a. logging for security related events (e.g. reboot) shall trigger an alarm b. logs shall be stored as evidence and user shall be aware about this fact (e.g. full recording of SSH sessions – for deterrent and investigation purpose) c. online sessions shall be supervised with possibility to stop not authorised activity Note: complete removal of DoS attack is possible only by catching the attacker (monitoring etc.) and cooperation with law enforcement.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, G/G-R, A/G-R, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW, Underlay Transp. Infrastructure
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

4.2.7.9 Physical Security

[REQ]

Identifier	REQ.14.77-TS-SEC-0047
Title	Physical Security of operational equipment
Requirement	Physical security (e.g.: surveillance cameras) shall be implemented for rack doors, room doors. Correlation with entry card (physical access) with log-in and boot event shall be in place.
Status	< validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	AC-R, G/G-R, A/G-R, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW, Underlay Transp. Infrastructure, Ground Support Systems, Ground DNS server
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

4.2.7.10 Network Operation and Security Operation Centres

[REQ]

Identifier	REQ.14.77-TS-SEC-0048
Title	Security Zone Separation of NOC and SOC
Requirement	The Network Operation Centre and the Security Operation Centre shall be separated in security zones (at least logical separation of duty via segregation in the roles) including rights and privileges for e.g. logs auditing and setting communication paths between the logical zones.
Status	<validated>
Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	Ground Support Systems, Ground DNS server
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Ground ATN Network

4.2.7.11 Security Assurance Activities

Requirement removed to Assumptions.

4.2.7.12 Graceful Degradation of Air/Ground Communication

[REQ]

Identifier	REQ.14.77-TS-SEC-0050
Title	Degradation of required air-ground communication performance or unavailability of ATN/IPS communication
Requirement	Critical air-ground communication (e.g. for ATC) shall fall back to alternative means of communication (e.g. analogue ATC voice communication) in case of degradation of required air-ground communication performance or unavailability of A/G FCI communications.
Status	<in progress>

Rationale	Please refer to the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk). This requirement is not a requirement directly for the FCI but rather for the ATC Operators; it addresses the need, that suitable operational procedures are put in place, which make use of communication means external to the FCI, to recover communication in case the FCI is put out of order by cyber attacks. As such, it is not a requirement that can be validated within the validation exercises of the FCI itself.
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04, A/C-95
<ALLOCATED_TO>	<Functional block>	A-R, AC-R, G/G-R, A/G-R, MSE (MS/MR), IPS Gateway, CIV_MIL Gateway, Hyper connected ATM GW, Underlay Transp. Infrastructure, Ground Support Systems, Ground DNS server
<ALLOCATED_TO>	<Function>	SEC
<ALLOCATED_TO>	<System>	Aircraft, Ground ATN Network

4.2.8 FCI Performance Requirements

[REQ]

Identifier	REQ.14.77-TS-PERF-0001
Title	FCI performance Requirements for ATS-B2 services
Requirement	FCI shall provide for ATS-B2 services the E2E performance[17] (QoS, CoS, Latency) described below: In **Short & Medium** Term, as reported in Table 6 and Table 7 below; In **Long Term**, to support future ATS-B3 services, as described in the Table 8 and Table 9 below.
Status	<validated>

[17] Only the RCTP/RSTP apportioned quotes for the Transaction Times (ET and $TT_{95\%}$) and Data Delivery Times (OT and $DT_{95\%}$) are applicable to the network infrastructure (i.e. no Initiator/Responder times)

Rationale	According to ED-228A ([14]), in the medium term the ATS-B2 supports and covers several ATC Services (4DTRAD, IM, SA, etc.) that are performed by the joint use of CPDLC and ADS-C. See also sections 4.1.1 and 4.1.2 in the FCI ConOps ([2]).
Category	<Performance>, <Safety>

Short & Medium Term Performance:

According to ED-228A ([14]), the following table collects the performance requirements for ATS B2, subdivided for ATSU, CSP and Airborne segments (see also section 4.2.10 and related subsections):

	RCP130/A1		RCP240/A1		RCP400/A1		RCP400/A2	
Parameter	**ET**	**$TT_{95\%}$**	**ET**	**$TT_{95\%}$**	**ET**	**$TT_{95\%}$**	**ET**	**$TT_{95\%}$**
Transaction Time (Sec)	130	67	240	210	400	350	400	350
Continuity (C)	0.999	0.95	0.999	0.95	0.999	0.95	0.999	0.95
Availability (A)	0.989		0.989 (safety) 0.9899 (efficiency)		0.989			
Integrity (I)	1E-5/FH		1E-5/FH		1E-5/FH			
Defined Allocations for RCP130, RCP240 and RCP400 Note 4								
	RCP130/A1		**RCP240/A1**		**RCP400/A1**		**RCP400/A2**	
Parameter	**ET**	**$TT_{95\%}$**	**ET**	**$TT_{95\%}$**	**ET**	**$TT_{95\%}$**	**ET**	**$TT_{95\%}$**
Transaction Time (Sec)								
Initiator	30	13	30	30	30	30	30	13
RCMP	120	60	210	180	370	320	380	174
Responder	100	44	60	60	60	60	371	161
RCTP	32	20	150	120	310	260	32	20
$RCTP_{ATSP}$	23	14	n/a	n/a	n/a	n/a	23	14
$RCTP_{ATSU}$	14 Note 1	6 Note 1	15	10	15	10	14 Note 1	6 Note 1
$RCTP_{CSP}$	18 Note 1	10 Note 1	120	100	280	240	18 Note 1	10 Note 1
$RCTP_{AIRCRAFT}$	23	10	15	10	15	10	23	10
Continuity (C)								
$C_{ATSU, CSP, and Aircraft}$ (See *Note 2*)	0.999	0.95	0.999	0.95	0.999	0.95	0.999	0.95
Availability (A)								

A_{ATSU}	0.9995	n/a	n/a	0.9995
A_{CSP}	0.9995	0.999 (safety) 0.9999 (efficiency)	0.999	0.9995
$A_{Aircraft}$	0.99	0.99	0.99	0.99
Unplanned outage duration limit $_{ATSU\ \&\ CSP/SSP}$ (min)	6	10 (CSP only)	20	6
Max number of service unplanned outages$_{ATSU}$ (per year)	40	n/a	n/a	40
Max number of service unplanned outages$_{CSP/SSP}$ (per year)	40	48 (safety) 4 (efficiency)	24	40
Maximum accumulated service unplanned outage time$_{ATSU}$ (min/year)	240	n/a	n/a	240
Maximum accumulated service unplanned outage time$_{CSP/SSP}$ (min/year)	240	520 (safety) 52 (efficiency)	520	240
Unplanned service outage notification delay$_{ATSU\ \&\ CSP/SSP}$ (min)	5	5	10	5
Integrity (I)				
I_{ATSU}	1E-5/FH	1E-5/FH	1E-5/FH	1E-5/FH
I_{CSP}	not specified (*Note 3*)			
$I_{AIRCRAFT}$	1E-5/FH	1E-5/FH	1E-5/FH	1E-5/FH
Notes				
Note 1: the timing values for the ATSU and CSP are recommendations. Note 2: The 95% for Continuity is labelled in OPA Annexes as Probability$_{95\%}$ (P = 95%) Note 3: ATSU and CSP contract may specify a requirement. Note 4: Several allocations can be defined for each RCP specification. For example, "/A1" and "/A2" are designators for two uniquely defined allocations that satisfy RCP 400. Either allocation may be applied for when a specific technology and/or operation is used while continuing to maintain the overall end-to-end communication performance, i.e., RCP 400.				

Table 6: Medium Term - CPDLC Performance Figures

	RSP160		**RSP180**		**RSP400**	
Parameter	**OT**	**DT$_{95\%}$**	**OT**	**DT$_{95\%}$**	**OT**	**DT$_{95\%}$**

Transaction Time (Sec)	160	90	180	90	400	300
Continuity (C)	0.999	0.95	0.999	0.95	0.999	0.95
Availability (A)	0.989		0.989 (safety) 0.9899 (efficiency)		0.989	
Integrity (I)	1E-5/FH		1E-5/FH		1E-5/FH	
Defined Allocations for RSP160, RSP180 and RSP400						
	RSP160		**RSP180**		**RSP400**	
Parameter	**OT**	**$DT_{95\%}$**	**OT**	**$DT_{95\%}$**	**OT**	**$DT_{95\%}$**
Transaction Time (Sec)						
RSMP = RSTP	160	90	180	90	400	300
$RSTP_{ATSP}$	14	7	n/a	n/a	n/a	n/a
$RSTP_{ATSU}$	7 Note 1	3 Note 1	5	3	30	15
$RSTP_{CSP}$	12 Note 1	5 Note 1	170	84	340	270
$RSTP_{AIRCRAFT}$	159	86	5	3	30	15
Continuity (C)						
$C_{ATSU,\ CSP,\ and\ Aircraft}$ (See *Note 2*)	0.999	0.95	0.999	0.95	0.999	0.95
Availability (A)						
A_{ATSU}	0.9995		n/a		n/a	
A_{CSP}	0.9995		0.999 (safety) 0.9999 (efficiency)		0.999	
$A_{Aircraft}$	0.99		0.99		0.99	
Unplanned outage duration limit $_{ATSU\ \&\ CSP/SSP}$ (min)	6		10 (CSP only)		20	
Max number of service unplanned outages$_{ATSU}$ (per year)	40		n/a		n/a	
Max number of service unplanned outages$_{CSP/SSP}$ (per year)	40		48 (safety) 4 (efficiency)		24	
Maximum accumulated service unplanned outage time$_{ATSU}$ (min/year)	240		n/a		n/a	
Maximum accumulated service unplanned outage time$_{CSP/SSP}$ (min/year)	240		520 (safety) 52 (efficiency)		520	
Unplanned service outage notification delay$_{ATSU\ \&\ CSP/SSP}$ (min)	5		5		10	
Integrity (I)						
I_{ATSU}	1E-5/FH		1E-5/FH		1E-5/FH	

I_{CSP}	not specified (*Note 3*)		
$I_{AIRCRAFT}$	1E-5/FH	1E-5/FH	1E-5/FH
Navigation Figure of Merit (FOM)	See Note 4	See Note 4	See Note 4
Time at position accuracy	+/- 1 sec (UTC)	+/- 1 sec (UTC)	+/- 1 sec (UTC)
Notes			
Note 1: the timing values for the ATSU and CSP are recommendations. Note 2: The 95% for Continuity is labelled in OPA Annexes as $Probability_{95\%}$ (P = 95%) Note 3: ATSU and CSP contract may specify a requirement Note 4: The navigation figure of merit (FOM) is specified based on the navigation criteria associated with this spec. For example, if RNP 4 is prescribed, then for ADS-C surveillance service, the FOM level would need to be 4 or better. In all cases, when the navigation capability no longer meets the criteria specified for the operation, the flight crew is responsible for reporting the non-compliance to ATC in accordance with ICAO procedures Note 5: The RSP160 specification applies to ADS-C reports that includes route prediction data. This specification and the associated allocation have been derived with the main intent to address the use of ADS-C EPP data in APT, TMA and ENR-1 airspaces Note 6: The RSP180/400 specifications only apply to ADS-C reports that do not include any route prediction data. These specifications and the associated allocations have been derived with the main intent to address the use of ADS-C deviation events in ENR-2 airspace.			

Table 7: Medium Term - ADS-C Performance Figures

Long Term Performance (see also par 4.2.10.4 and PJ14.2.4-D5 [11]):

	RCP60		**RCP240**	
Parameter	**ET**	**$TT_{95\%}$**	**ET**	**$TT_{95\%}$**
Transaction Time (Sec)	60	30	240	110
Continuity (C)	0.999	0.95	0.999	0.95
Availability (A)	0.999		0.999	
Integrity (I)	1E-5/FH		1E-5/FH	
Defined Allocations for RCP60 and RCP240				
	RCP60		**RCP240**	
Parameter	**ET**	**$TT_{95\%}$**	**ET**	**$TT_{95\%}$**
Initiator	16	6	16	6
TRN	53	29	233	103
Responder	53	24	230	100
RCTP	11	7	11	7
$RCTP_{ATSP}$	8	4	8	4
$RCTP_{ATSU}$	5	2	5	2
$RCTP_{CSP}$	8	4	8	4

$RCTP_{AIRCRAFT}$	7	3	7	3
Continuity (C)				
C ATSU, CSP, and Aircraft (See *Note 2*)	0.999	0.95	0.999	0.95
Availability (A)				
A_{ATSU}	0.999995		0.999995	
A_{CSP}	0.999995		0.999995	
$A_{Aircraft}$	0.999		0.999	
Unplanned outage duration limit ATSU & CSP/SSP (min)	1		1	
Max number of service unplanned outages $_{ATSU}$ (per year)	2		2	
Max number of service unplanned outages $_{CSP/SSP}$ (per year)	2		2	
Maximum accumulated service unplanned outage time $_{ATSU}$ (min/year)	2.6		2.6	
Maximum accumulated service unplanned outage time $_{CSP/SSP}$ (min/year)	2.6		2.6	
Unplanned service outage notification delay $_{ATSU\ \&\ CSP/SSP}$ (min)	5		5	
Integrity (I)				
I_{ATSU}	1E-5/FH			
I_{CSP}	not specified (*Note 2*)			
$I_{AIRCRAFT}$	1E-5/FH			
Notes				
The timing values for the ATSU and CSP are recommendation. ATSP is the combined ATSU and CSP. ATSU and CSP contract may specify a requirement.				

Table 8: Long term Performance -RCP 240 performance figures

Note: RCTP values are two-way delays.

RSP60		
Parameter	OT	$DT_{95\%}$
Transaction Time (Sec)	60	25
Continuity (C)	0.999	0.95
Availability (A)	0.999	

Integrity (I)	1E-5/FH	
Defined Allocations for RSP60		
Parameter	OT	$DT_{95\%}$
Transaction time (sec)		
RSP=RSTP	60	27
$RSTP_{ATSP}$ [Note 2]	6	3
$RSTP_{ATSU}$ [*Note 1*]	3	1
$RSTP_{CSP/SSP}$ Note 1	5	2
$RSTP_{AIRCRAFT}$	58	25
Continuity (C)		
C_{ATSU}, $C_{CSP/SSP}$, and $C_{Aircraft}$ [*Note 2*]	0.999	0.95
Availability (A)		
A_{ATSU}	0.999995	
$A_{CSP/SSP}$	0.999995	
$A_{AIRCRAFT}$	0.999	
Unplanned s outage duration limit $_{ATSU\ \&\ CSP/SSP}$ (min)	1	
Max number service unplanned outages $_{ATSU}$ (per year)	2	
Max number service unplanned outages $_{CSP/SSP}$ (per year)	2	
Maximum accumulated service unplanned outage time $_{ATSU}$ (min/year)	2.6	
Maximum accumulated service unplanned outage time $_{CSP/SSP}$ (min/year)	2.6	
Unplanned service outage notification delay $_{ATSU\ \&\ CSP/SSP}$ (min)	5	
Integrity (I)		
I_{ATSU}	1E-5/FH	
$I_{CSP/SSP}$	not specified [*Note 3*]	
$I_{AIRCRAFT}$	1E-5/FH	
Notes		
1. The timing values for the ATSU and CSP are recommendation. 2. ATSP is the combined ATSU and CSP/SSP. 3. ATSU and CSP/SSP contract may specify a requirement.		

Table 9: Long term Performance - RSP 60 performance figures

Note: in this case, RSTP parameters are 1-way delays

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	The Performance Requirements are End to End and not apportioned to the different network segments. Therefore, they cannot be directly allocated to the identified Functional Blocks.
<ALLOCATED_TO>	<Function>	PERF
<ALLOCATED_TO>	<System>	The Performance Requirements are End to End and not apportioned to the different network segments. Therefore, they cannot be directly allocated to the identified systems.

[REQ]

Identifier	REQ.14.77-TS-PERF-0002
Title	FCI performance Requirements for ATS-B3 services
Requirement	FCI shall provide for the future ATS B3 services the E2E performance (QoS, CoS, latency,) reported in the tab Table 10 below.
Status	<validated>
Rationale	According to the SESAR 1 15.02.04 deliverable 04 study ([10]), which made speculative proposals for long-term services and performance levels and to SESAR2020 Wave 1 PJ14.02.04 ([9], [16]), which consolidated these requirements.
Category	<Performance>, <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	The Performance Requirements are End to End and not apportioned to the different network segments. Therefore, they cannot be directly allocated to the identified Functional Blocks.
<ALLOCATED_TO>	<Function>	PERF
<ALLOCATED_TO>	<System>	The Performance Requirements are End to End and not apportioned to the different network

		segments. Therefore, they cannot be directly allocated to the identified systems.

[REQ]

Identifier	REQ.14.77-TS-PERF-0003
Title	FCI performance Requirements for SWIM-PP services
Requirement	FCI shall provide to SWIM-Purple Profile the E2E performance (QoS, CoS, latency) reported in the Table 10 below.
Status	< validated>
Rationale	In the mission critical environment in which SWIM-TI is implied, it is fundamental to guarantee that mission critical functionalities provided by SWIM-TI are kept on by entering in a safe mode of operation for SWIM-TI. This requirement ensures that if functionality is deemed mission critical it is privileged when shortages of resources occur.
Category	<Performance>, <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	The Performance Requirements are End to End and not apportioned to the different network segments. Therefore, they cannot be directly allocated to the identified Functional Blocks.
<ALLOCATED_TO>	<Function>	PERF
<ALLOCATED_TO>	<System>	The Performance Requirements are End to End and not apportioned to the different network segments. Therefore, they cannot be directly allocated to the identified systems.

One-way e-t-e transit delay 95% (LONG TERM)	CoS Category	QoS PHB	ATN Priority	FCI Connectivity Type	Application	ATSC Classes
1.2 sec	Very High	EF	0	A/G; G/G	Digital Voice;	A

		EF	0	A/G	Also reserved for future streaming services	
2 sec	High	CS5	1	A/G	Future ATN B3	B (n.a. for ADS-C)
		CS5[18]	1	A/G	SWIM G/G Green Profile	
n.a.	High	AF41	2	G/G	Voice Signalling	C
5 sec	High	AF42	2	A/G	ATN B2	C (n.a. for ADS-C)
8 sec	High	CS4	3	A/G	ATN B1	C
n.a.	Medium	AF31	4	G/G	Voice Recording	D
10 sec	Medium	AF32	4	A/G	AIS/MET via SWIM PP - SAFE MODE (incl. FRDS)	D
15 sec	Medium	CS3	5	A/G	AIS/MET via SWIM PP - NORMAL MODE	E
n.a.	Medium	AF21	6	G/G	CM	F
n.a.	Low	CS2	7	G/G	ATSMHS	G
n.a.	Low	AF11	8	G/G	AIDC	G
TBD	Low	CS1	9	A/G	AOC – High Availability (*)	H
45 sec	Best Effort	CS0	9	A/G	AOC	H

Table 10: Map between ATSC Routing Class, E2E latency and applicable QoS on the network

Note#1: with respect to the ICAO Doc 9896, the following adjustments have been made:

[18] This CoS value CS5 for the Green Profile (Civil-Military GW) was inserted in the Wave 1 PJ14.02.04 TRL4 TS/IRS after a coordination with the Wave 1 Green Profile Project PJ.17.03 and continued in Wave 2 by PJ14-W2-101. This CoS requirement was identified in W1 to manage a safety scenario (Aircraft Hijacking) and in a coordination with Military and Civil Aircraft/Authority.

- *CM should have better priority than AMHS, as reported in the table;*
- *Introduced A/G and G/G voice PHB values;*
- *SWIM services follow the ATN priority defined for FIS and METAR;*
-

Note#2: the table aims also to map the performances defined in terms of one-way E2E latency @95%, as defined in this document, with ATSC Classes. Initially, the ATSC classes together with their E2E latency @95% was provided; now removed with the 9896 ATSC classes table definition. In any case, ICAO doc 9705 performance of ATSC Classes do not exactly match with the newly defined ones.

Note#3 – (*) derived from AOC classification of services as per document "ATN IPS communication performance user level requirement"

Note#4: please note that it is an initial proposal that aims to propose a traffic CoS/QoS rationalisation.

[REQ]

Identifier	REQ.14.77-TS-PERF-0004
Title	FCI performance Requirements for SWIM-PP safety critical services
Requirement	FCI shall provide to SWIM-Purple Profile safety critical services the performances reported in the Table 11 below.
Status	<validated>
Rationale	From SWIM-TI functional requirements (PJ17.01, [17]): "Due to the mission critical environment in which SWIM-TI is implied, it is necessary to restrict the types of activities that shall be carried out when certain adverse conditions are met, e.g. reduced communication bandwidth or limited computational resources. In such conditions it is fundamental to guarantee that mission critical functionalities provided by SWIM-TI are kept on by entering in a safe mode of operation for SWIM-TI. This requirement ensures that if functionality is deemed mission critical it is privileged when shortages of resources occur".
Category	<Performance>, <Safety>

	1-way 95% e-t-e delay	**1-way 95% delay** $_{CSP/SSP}$	**Integrity**	**A** $_{AIS/MET\ PROVIDER}$	**A** $_{CSP/SSP}$	**A** $_{AIRCRAFT}$
Immediate, Near-term AIS/MET	20 seconds	10 seconds	1E-5/FH	0.999995	0.999995	0.999

Table 11: SWIM PP safety critical services – performance figures

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	The Performance Requirements are End to End and not apportioned to the different network segments. Therefore, they cannot be directly allocated to the identified Functional Blocks.
<ALLOCATED_TO>	<Function>	PERF
<ALLOCATED_TO>	<System>	The Performance Requirements are End to End and not apportioned to the different network segments. Therefore, they cannot be directly allocated to the identified systems.

[REQ]

Identifier	REQ.14.77-TS-PERF-0005
Title	FCI performance Requirements for SWIM PP advisory services and AIS-MET services
Requirement	FCI shall provide to SWIM PP advisory and to AIS-MET services the E2E performance (QoS, CoS, latency) reported in the Table 12 below.
Status	<validated>
Rationale	For a detailed explanation of the rationale that brought these figures, please refer to SESAR1 P15.02.04 D04 deliverable ([10]). Assumption - as the AIS-MET service shall be a SWIM-based service, the above-mentioned performance figures for AIS-MET (the “Immediate Near-Term” row) can be extended to the “SWIM SWIM PP advisory services”” services.
Category	<Performance>, <Safety>

	1-way 95% e-t-e delay	**1-way 95% delay** $_{CSP/SSP}$	**Integrity**	**A** $_{AIS/MET\ PROVIDER}$	**A** $_{CSP/SSP}$	**A** $_{AIRCRAFT}$
Immediate, Near-term AIS/MET	30 seconds	15 seconds	1E-5/FH	0.999995	0.999995	0.999
Planning AIS/MET	90 seconds	30 seconds	1E-5/FH	0.99995	0.999995	0.999

Table 12: SWIM PP advisory services and AIS-MET - performance figures

[REQ Trace]

Relationship	Linked Element Type	Identifier

< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	The Performance Requirements are End to End and not apportioned to the different network segments. Therefore, they cannot be directly allocated to the identified Functional Blocks.
<ALLOCATED_TO>	<Function>	PERF
<ALLOCATED_TO>	<System>	The Performance Requirements are End to End and not apportioned to the different network segments. Therefore, they cannot be directly allocated to the identified systems.

[REQ]

Identifier	REQ.14.77-TS-PERF-0006
Title	FCI performance Requirements for AOC High Availability services
Requirement	FCI shall provide to AOC the E2E performance (QoS, CoS, latency) reported in the Table 13 below for New MET or AIS data “time critical” services.
Status	<validated>
Rationale	For a detailed explanation of the rationale that brought these figures, please refer to SESAR1 P15.02.04 D04 deliverable ([10]).
Category	<Performance>, <Safety>

	1-way 95% e-t-e delay	**1-way 95% delay** $_{CSP/SSP}$	**Integrity**	**A** $_{AIS/MET\ PROVIDER}$	**A** $_{CSP/SSP}$	**A** $_{AIRCRAFT}$
AOC-High Availability Services[19]	90s	45 seconds	1E-5/FH	0.999995	0.99	90s

Table 13: AOC performance figures

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	The Performance Requirements are End to End and not apportioned to the different network

[19] The AOC Service for maintenance will use a Best effort QoS as specified in tab.9.

		segments. Therefore, they cannot be directly allocated to the identified Functional Blocks.
<ALLOCATED_TO>	<Function>	PERF
<ALLOCATED_TO>	<System>	The Performance Requirements are End to End and not apportioned to the different network segments. Therefore, they cannot be directly allocated to the identified systems.

[REQ]

Identifier	REQ.14.77-TS-PERF-0007
Title	FCI performance Requirements for Scalability
Requirement	The Air/Ground Boundary Router (A/G-R) of an Access Network shall be able to support a minimum of 100 aircraft simultaneously connected and operating the IF9 interface (AGMI, [20])
Status	<validated>
Rationale	Scalability
Category	<Performance>, <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	A/G-R
<ALLOCATED_TO>	<Function>	PERF
<ALLOCATED_TO>	<System>	Ground ATN Network

4.2.9 FCI Safety Requirements

[REQ]

Identifier	REQ.14.77-TS-SAF-0001
Title	FCI Safety Requirements: Airborne Radio Redundancy
Requirement	The Aircraft Communications architecture should foresee the capability to install one single Airborne Radio for each Datalink.
Status	<validated>
Rationale	The need of implementing all FCI radio transponders will depend on Aircraft type.
Category	<Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	A/C-95
<ALLOCATED_TO>	<Functional block>	No specific FB, but rather on the overall aircraft architecture
<ALLOCATED_TO>	<Function>	n.a.
<ALLOCATED_TO>	<System>	Aircraft

[REQ]

Identifier	REQ.14.77-TS-SAF-0002
Title	FCI Safety Requirements: GB-LISP Domain
Requirement	The AC-R, A/G-R, G/G-R, MS/MR components shall be redundant.
Status	<validated>
Rationale	In order to avoid single point of failures. See also “FCI Transversal Studies” Deliverable [9]
Category	<Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	A-R, AC-R, G/G-R, A/G-R, MSE (MS/MR)
<ALLOCATED_TO>	<Function>	n.a.
<ALLOCATED_TO>	<System>	Ground ATN Network

[REQ]

Identifier	REQ.14.77-TS-SAF-0002a
Title	FCI Safety Requirements: GB-LISP Domain
Requirement	The AC-R, A/G-R, G/G-R, MS/MR shall provide a redundant connectivity towards the GB-LISP Domain.
Status	<validated>
Rationale	In order to avoid single point of failures. See also “FCI Transversal Studies” Deliverable [9]

Category	<Safety>

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	A-R, AC-R, G/G-R, A/G-R, MSE (MS/MR)
<ALLOCATED_TO>	<Function>	n.a.
<ALLOCATED_TO>	<System>	Ground ATN Network

4.2.10 FCI Performance Requirements details

The description and related considerations on the Performance Requirements provided in this chapter have been derived by studies done by Tony Whyman for Inmarsat and for the ICAO CP-DCIWG WG-I ATN/IPS mobility subgroup and documented in several Working Papers. The original purpose of these studies was to develop an allocation model for the Safety and Performance Requirements in a multilink environment. The original paper ([24]) identified the benefits of moving towards adding an “end-to-end” strategy for managing multilink communication in the ATN/IPS, in order to maximise the increase in availability and continuity, as well as having the potential to mitigate SC3 hazards using SC4 approved A/G Subnetworks. The solution proposed in PJ14-W2-77 “FCI Services” is a strategy that uses network events to manage multilink communication. This strategy is finally being kept for ATN/IPS, in the upcoming 3rd Edition of ATN/IPS Manual ([3]).

EUROCAE ED-228A ([14]) provides the Safety and Performance Requirements (SPR) for the ATN Baseline 2 services and defines RCP and RSP specifications for operations using the CPDLC and/or ADS-C application in different environments.

An RCP specification is a label (e.g. RCP130) that represents the values assigned to RCP parameters for transaction time, continuity, availability and integrity.

An RSP specification is a label (e.g. RSP180) that represents the values assigned to RSP parameters for surveillance data delivery time, continuity, availability and integrity.

The denomination of an RCP and RSP specification is provided by the expiration time (ET) and Overdue Delivery Time (OT), expressed in seconds, respectively.

The SPR gives guidance on which RCP/RSP set is appropriate for a given airspace. However, the final decision is made by the Safety Authority for the airspace.

4.2.10.1 RCP/RSP Parameters

The RCP/RSP parameters are:

- **RCP Transaction Time/RSP Data Delivery Time**:

  The RCP Transaction Time is for CPDLC and is expressed as two values:

  - The Expiration Time (ET) i.e. the time within which 99.9% of operational transactions must be completed.

  - The Nominal Time ($TT_{95\%}$) i.e. the time within which 95% of operational transactions are completed.

The RSP Data Delivery Time is for ADS-C and is expressed as two values:

- The Overdue Delivery Time (OT) i.e. the maximum time for the successful delivery of surveillance data.
- The Nominal Delivery Time ($DT_{95\%}$) i.e. the maximum nominal time within which 95% of surveillance data deliveries are required to be successfully delivered.

- **Continuity**: An RCP/RSP parameter that specifies the minimum proportion of relevant communications transactions to be completed within the specified time, given that the service was available at the start. The 99.9% Continuity is linked with the Expiration Time ($ET_{99.9\%}$) and Overdue Delivery Time (OT), while the 95% Continuity is associated with the Nominal Time ($TT_{95\%}$) and Nominal Data Delivery time ($DT_{95\%}$).

- **Availability**: An RCP/RSP parameter that specifies the required probability that an operational communication transaction can be initiated or that surveillance data can be provided.

  ED-228A ([14]) provides a simple definition of availability in terms of the Minimum Time Between Failures (MTBF) and the Minimum Time To Repair (MTTR), such that

  Availability = MTBF/(MTBF + ∑MTTR)

  Where ∑MTTR may be interpreted as the total outage time during a given measurement period.

- **Integrity**: An RCP/RSP parameter that specifies the required probability that an operational communication transaction is completed or the surveillance data delivered with no undetected errors.

4.2.10.2 Allocation of the RCP/RSP parameter values

The SPR ([14]) starts the initial determination of the RCP/RSP performance parameters by deriving each RCP/RSP parameter value for the end-to-end service as a whole, including the end users (e.g. pilot think time). This is as the result of an Operational Performance Assessment (OPA). The result is a set of parameter values for each RCP/RSP group.

The allocation of the end-to-end RCP/RSP parameter values then includes sub-allocation to the end-to-end technical communication (technical systems). This is the Required Communication Technical Performance (RCTP) for CPDLC and Required Surveillance Technical Performance (RSTP) for ATS-C.

Figure 45 taken from ED-228A ([14], FIGURE D-3) depicts the segmentation of the pilot-to-controller communication chain into different groups of system components.

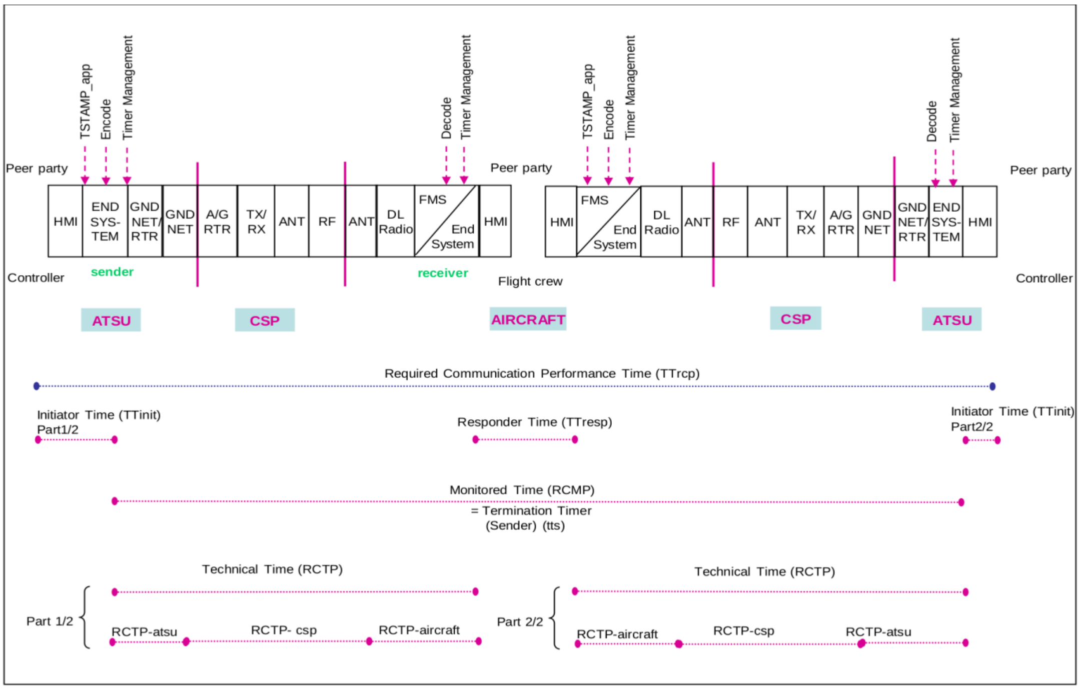

Figure 45: ED228A/DO-350A Figure D-3: Delineation of CNS/ATM system elements

A new update for FIGURE D-3, which has recently proposed by Honeywell in the EUROCAE/RTCA WG-78/SC-214 for inclusion in the next Edition of DO-350/ED-228 (see Paper [24]), is shown in Figure 46 for RCP and Figure 47 for RSP.

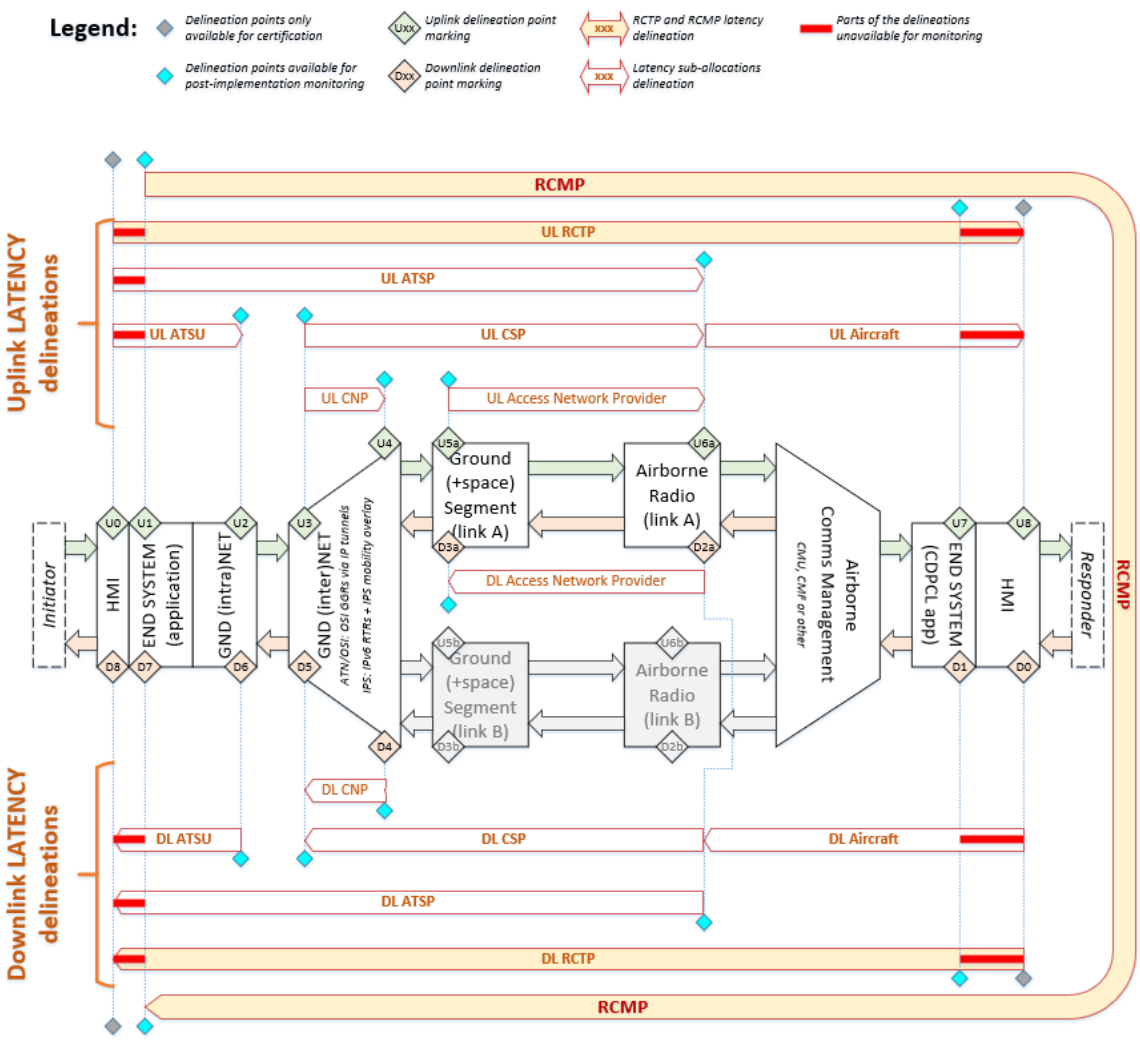

Figure 46: Delineation of CNS ATM SYTEM ELEMENTS for RCP time criteria

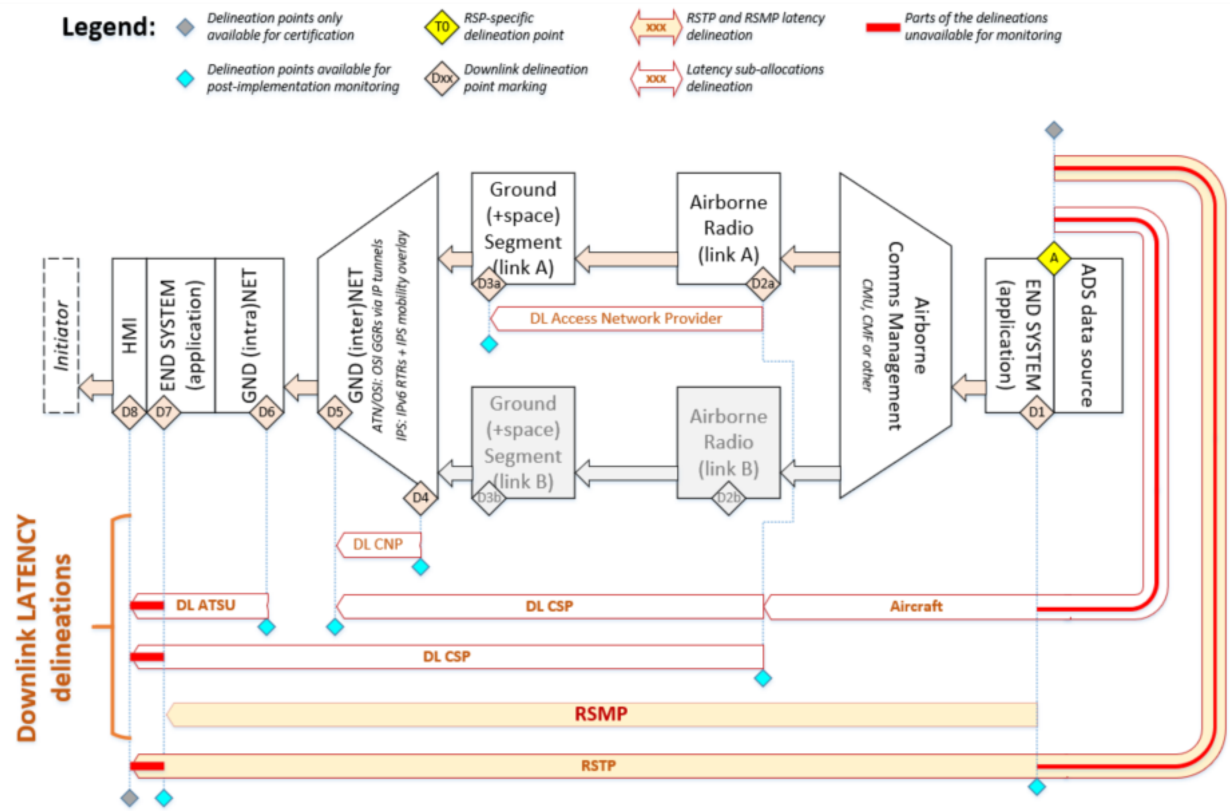

Figure 47: Delineation of CNS ATM SYTEM ELEMENTS for RSP time criteria

The RCTP and RSTP values are allocated to each of the System Components illustrated in Figure 45, Figure 46 and Figure 47 above. The major component groups are:

- ATSU (Air Traffic Services Unit): the Ground End System and network functions local to the ATSU
- CSP (Communication Service Provider): The A/G Subnetwork and ground ATN/IPS
- Aircraft: avionics systems up to the “tip of the antenna”.

4.2.10.2.1 Allocation of RCP Transaction Time and RSP Data Delivery Time

The SPR ([14]) uses two different approaches for the allocation of RCP transaction times and RSP data delivery times:

- Statistical distribution for RCP/RSP specifications, supporting the ATM Operations within ENR-1, TMA and APT airspace, i.e. for RCP130, RCP400/A2 (Departure Clearance), and for RSP160
- Arithmetic summation for RCP/RSP specifications supporting the ATM Operations within ENR-2 airspace, i.e. for RCP240, RCP400/A1 (ATC Comm and Separation Assurance in ENR-2), RSP180 and RSP400.

Statistical allocations result in larger individual allocations for each element (Initiator, ATSU, CSP, Aircraft, and Responder) than arithmetic allocations for the same overall end-to-end timing requirement. The statistical allocation approach relies on the assumption that element delays are independent, e.g., a long delay in one element is not likely to coincide with a long delay in the next element. The benefit of using statistical allocations is that larger allocated element delays will be more practical to achieve without impacting the overall transaction time requirement.

4.2.10.2.2 Allocation of Continuity

The SPR ([14]) assumes:

- (for CPDLC transactions) a per transaction Continuity (C) requirement of 99.9%, for the maximum acceptable transaction time, which is a trade off between usability and safety
- (for ADS-C transactions) a Continuity (C) requirement of 99.9% for the overdue delivery time, which is a trade off from usability and safety standpoint.

The SPR specifies:

- a nominal time for CPDLC transactions corresponding to a 95% continuity.
- a nominal Delivery Time (DT) for the ADS-C data deliveries, corresponding to a 95% continuity.

The 95% Continuity is a 'requirement' to be formally demonstrated for initial compliance demonstration for the certification of the Aircraft system and ground approval, while 99.9% Continuity is a target for continued compliance demonstration (i.e. post-implementation monitoring) to assess the variability and stability of continued operations, using the CPDLC and/or ADS-C application, and to perform corrective actions, as appropriate.

4.2.10.2.1 Allocation of Availability

Table **6** and Table 7 collect the RCTP performance requirements for ATS B2 services, subdivided for ATSU, CSP and Airborne apportionments.
Moreover, for the CSP segment – which the FCI belongs to – the following **Availability** performances are required:

CSP Unplanned outage duration limit (min)	6	6
CSP Maximum number of unplanned outages	40	40
CSP Maximum accumulated unplanned outage time(min/yr)	240	240
CSP Unplanned outage notification delay (min)	5	5

Table 14: CPDLC (RCP130) & ADS-C (RSP160) Availability performance

Note - ED228A ([14]) is the best available source of performance requirements. Nevertheless, some of the values are recommendations and therefore there is sufficient flexibility in the allocation between Aircraft, CSP and ATSU.

4.2.10.2.1 Allocation of Integrity

For all RCP/RSP, the Integrity requirement is stated as 1 x 10-5 per Flight Hour and it applies only to the Aircraft and the ATSU i.e. detection of loss of integrity and recovery is seen as an end-to-end function.

The allocated Integrity requirements are only evaluated over the data communication applications, implemented in the end-systems, i.e. the ATSU and Aircraft. Because integrity is expected to be addressed at application level (typically with an end-to-end application checksum), there is no credit taken into account for measures implemented by the CSP to mitigate the effects of errors introduced by the network. The Integrity allocated to the CSP is subject to local agreement between the ATSP/CSP and AO/CSP, and the CSP is expected to perform in accordance with these contract/service agreement terms. These may be allocated to the CSP in order to minimize the amount of corruption on transferred messages, and of the consequent end-to-end message retransmissions.

However, no guidance on the CSP network integrity requirement is given by the SPR other than the "ATSU and CSP contract may specify a requirement".

4.2.10.3 Short & Medium Term

According to ED-228A ([14]), ATN B2 supports and covers several ATC Services (4DTRAD, IM, SA, etc.…) that are performed by the joint use of CPDLC and ADS-C.

4.2.10.4 Long Term

4.2.10.4.1 CPDLC & ADS-C

In SESAR1 15.02.04 D04 Deliverable ([10]), the long-term CPDLC- and ADS-C performance requirements have been defined as initial proposals, not supported by any validations and are therefore speculative. Turning a regional proposal into a globally agreed set of requirements is a future EUROCAE/RTCA and ICAO standardisation activity.

Trajectory based operations comprise the up linking of complex 4D route clearances which, although auto-loaded in the aircraft system, require considerable cognitive workload from the flight crew and flight crew team coordination before a response can be provided. Same is true for the exchange of complex D-TAXI clearances.

At the airport side, flight crews may receive revised departure clearances due to e.g. changed weather conditions, containing the route to be flown. Such complex clearances require more cognitive workload and flight crew team coordination, including AO's control centre.

RCP60

Except for complex CPDLC clearances, the RCP60 specification has been established for the exchange of simple CPDLC clearances and ATC communication management within all airspaces, including TMA.

RCP240

The RCP240 specification supports any complex clearance (4D Route) in En-Route Continental- and Oceanic/Remote airspace and at the airport (D-Taxi, Departure) for which the largest contributor is the Responder.

RSP60

RSP60 specification is being proposed in support of the exchange of trajectories, using ADS-C. The trajectory-based operations are expected to include some parts of the oceanic/remote airspace. It is envisaged that aircraft flying in the NAT region will perform, negotiate and synchronise the trajectory negotiations and synchronisation such that it supports in meeting the multiple CTOs and RTAs.

The delivery of ADS-C is only used for IER service provision (e.g. trajectory monitoring, event-based reports) as it is expected that position reporting, using ADS-C will be no longer needed.

This is because it is expected that ADS-B space-based surveillance coverage will have become the normal means of surveillance in the NAT.

The tables below identify the CPDLC and ADS-C performance specifications in terms of Time, Continuity, Availability, and Integrity, including their allocations to the ATSP, ATSU, CSP/SSP, aircraft, and aircraft operator.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

4.2.10.4.2 ATS Baseline 3

ATS-B3 Application	Required Performance	1-way e-t-e delay RCP [s]	1-way 95% e-t-e delay RCP [s]	Integrity RCP	AvailabilityRCP
CPDLC	RCP 60	60	25	1E-5 per FH	0.999

This performance requirements for ATS B3 as proposed in W1-PJ 14.02.04 ([9]). Note that these values are an initial proposal and have not been standardized yet. It is expected that this level of performance will be applied to the rapid exchange of simple clearances, and also the exchange of complex 4D trajectory and D-TAXI clearances, which usually require considerable cognitive workload from the flight crew and coordination with the AU FOC before a response can be provided.

It can be assumed that yet-to-be defined future ATS alerting service and FIS make use of ATS B3 applications. Post-Departure Trajectory Information Sharing & Negotiation, and Air/Ground trajectory synchronisation are likely to have similar performance levels to ATS B3.

Two Required Communication Performance (RCP) levels are defined:

- RCP60 for the exchange of simple CPDLC clearances and ATC communication management within all airspaces, including TMA.
- RCP240 for any complex clearance (4D Route) in en-route Continental and Oceanic/Remote airspace and at the airport (D-Taxi, Departure) for which the largest contributor is the Responder.

ATS-B3 Application	Required Performance	2-way e-t-e delay RCP [s]	2-way 95% e-t-e delay RCP [s]	Integrity RCP	Availability RCP
CPDLC	RCP 60	60	30	1E-5 per FH	0.999
	RCP 240	240	110	1E-5 per FH	0.999

ATS-B3 Application	Required Performance	1-way e-t-e delay RCP [s]	1-way 95% e-t-e delay RCP [s]	Integrity RCP	Availability RCP
CPDLC	RSP 60	60	25	1E-5 per FH	0.999

Table 15- ATS B3 performance figures

4.2.10.5 FCI QoS and CoS

Deliverable PJ14.02.04-D5.1.020.2 –FCI Initial Transversal Studies ([9]) and PJ.14-W2-77 ConOps ([2]) has proposed QoS objectives and CoS framework for the data communications services, using the CPDLC, ADS-C, AIS/MET and AOC applications and operational concept as outlined in PJ14-W2-77 D01 (developed in task01) in support of the FCI design. It has taken the current Master Plan-Ed 2.0 and ICAO GANP as basis.

Given the stepwise integration of the various building blocks of SESAR, with trajectory-based operations as the new paradigm from data communications perspective, for the mid and long term SESAR projects, ED-228 was taken as the performance requirements baseline for deriving the long-term QoS and CoS to support the future CPDLC- and ADS-C operations. ED-228 is the baseline safety- and performance requirements (SPR) document for CPDLC and ADS-C air and ground implementations and deployment in the mid-term and to facilitate the work in the long-term, it was decided to use this as the basis for the PJ.14-W2-77 ConOps ([2]) delivery.

It has been assumed that the future ATS-B3/IP services planned for deployment in the long-term will to a large extent be based on ATS-B2 implementations (mid-term), but moved from i4D concept towards Full 4D concept, possibly with some new emerging services and with progressively increased performance requirements. It has also been assumed that AIS/MET and AOC services will be shared in a SWIM based architecture. For AOC a considerable expansion of the number of services is expected throughout the SESAR cycle with progressively increased performance requirements.

The proposed QoS for the future CPDLC, ADS-C, AIS/MET and AOC data communication services drive the FCI design from delay, integrity, and availability perspective. Given their message size and steady increase of AIS/MET and AOC services and users, these services will mainly drive the throughput requirements for the FCI-design.

The CM, CPDLC and ADS-C applications require a High CoS for which the use of multilink is an important function for the long-term. CPDLC- and ADS-C services require strong cockpit- and ATSU integration, using internationally agreed end-to-end and allocated safety- and performance requirements (SPR), which in turn drive the needs of the underlying FCI in such a manner that it can comply with the future SPR.

Data communications services, using AIS/MET and AOC applications, require much less cockpit integration (use of EFB or tablet). The requested information is in most cases obtained from AIS/MET providers, physically separated from the ACC/TMA/APT ATC service provision. The services require a more relaxed QoS from delay and availability (for AOC) perspective. It has been proposed to assign the Medium CoS to AIS/MET and Best-effort CoS to AOC. For the long-term, AIS/MET applications also require the use of the multilink function.

The multi-Link functionality foreseen by the FCI can be seen as a policy-driven routing procedure; the basic criterion that defines which policy has to be used and which way traffic shall be managed is the ATSC Routing Class.

Table 10 proposes a map between ATSC Routing Class, E2E latency (where available) and applicable QoS on the network; the table integrates what has been done in the ICAO doc. 9896, tables III-1-1 and III-1-2, plus the introduction of new services (SWIM and B3).

5 Recommendations for Implementation

The following recommendations are not exclusive, further improvements might be still possible. However, keep in mind that the current validated solution is already providing all the necessary features for a flight trial. A preliminary flight test was already successfully conducted using LDACS.

5.1 Airborne IPS Router

The following improvements has been identified for the implementors of the Airborne IPS Router:

- Update the AGMI stack to the latest approved AGMI protocol version as specified by the upcoming ICAO Doc 9896 Edition 3.
- Update the AGMI protocol specification to handle situations in which the AGMI Requests cannot be sent or delivered to the AGMI proxy. To mitigate issues caused by inability to signal general datalink status changes over other datalinks (as observed in TC-1-18 of the Validation Exercise 1, see TVALR, [25]) and to mitigate issues caused by stale preferences/routes installed in the ground infrastructure, namelypreferences for the last datalink, that remains installed when it becomes non-operational (no AGMI foreign report can be sent)
    - any preferences that are installed on ground when the Airborne IPS System is restarted (or turned off)Update to the latest version of the AEEC Common Radio Interface
- Take care about implementing the Multi-link and SR-HO MBB features as described in Section 6.1.3.
- Cover the need for generating Foreign Reports as described in Section 6.1.4 including resending unacknowledged Foreign Reports as soon as possible.
- Consider cross-layer signalling proposals for driving new path selections

The Airborne IPS Router is assumed to include the Air AGMI Endpoint functions integrated locally.

5.2 Radio Access Technology Systems

The following recommendations were identified during the validations:

- In the ICAO WG-I Mobility Subgroup to discuss further the topic of the Link DEGRADED status, its pros and cons and to evaluate the complexity of managing this additional information on both air and ground side
- In the ICAO WG-I Mobility Subgroup revise the default radio link retransmission timings for the multilink environment (i.e. tuning the timers to best exploit the multilink in terms of Continuity)
    - Radio link retransmission timing and signalling should be tuned with the multilink environment. For example, the retransmission timers at link layer could be more aggressive in presence of a multilink scenario, compared to the case where a single link only is available; a faster detection of a link loss would allow the Airborne IPS System to react more quickly than with a single link, re-routing the user traffic over an alternative radio link. The radio link should signal the Airborne IPS System the

need to try another radio link early enough to avoid long delays that can violate the Continuity requirements (e.g. the Link DEGRADED state could serve this purpose)

5.3 AGMI Ground Proxy

The AGMI Ground Proxy implementations should be updated to cover:

- Update to the latest approved AGMI Protocol version as specified by the upcoming ICAO Doc 9896 Edition 3.
- Use a higher performance API to instruct the COTS router on LISP transactions.
- Improve on the LISP event detection API with the COTS router.
- Consider moving from Python to C++ or Java for a better performance.
- Remove the SubMNP registration clean-up feature if the mobile network feature becomes available in the MS/MR.
- The prototype implementation of AGMI Ground Proxy used in the validation exercises require further performance improvements. There are identified steps to that, and implementation is already planned. It is recommended to test the performance again after those steps implemented. Production environments in the future should have these planned performance improvements.

The AGMI Ground Proxy was co-located physically in the AGBR COTS router in the validation exercises. However, the integration was using normal remote procedure call APIs over IPv6, so this kind of co-location is not mandatory.

This solution provides high availability through the multi-link architecture. It is left to the implementor how to create a local redundancy solution for the AGMI Ground Proxy itself.

5.4 AGBR

The AGBR implementors shall consider implementing the following improvements:

- Use LISP Priority=254 instead of 255 for the Foreign Report notifications into the LISP mobility backbone as specified by the upcoming ICAO Doc 9896 Edition 3.
- Check compliance with the final LISP standards
- Check compliance with finalized GB-LISP Profile as described by the upcoming EUROCAE ED-262A.
- Use a higher performance API to instruct the COTS router on LISP transactions.
- Change to expiration-based removal of Foreign Report notifications into an event-based action.
- Provide a selective LISP subscription feature.
- Implement a better LISP event notification API.
- Improve the amount of memory available for LISP Cache entries in smaller COTS routers.
- Some design guidance for vertical scaling resource allocations should be developed.

This solution provides high availability through the multi-link architecture. It is left to the implementor how to create a local redundancy solution for the AGBR itself.

5.5 Mapping System

The MS/MR implementors shall plan for the next features to be added for a production environment:

- Support the selective subscriptions in LISP
- Check compliance with finalized GB-LISP Profile as described by the upcoming EUROCAE ED-262A.
- Consider adding support for a mobile network flag for optimizing automated SubMNP removals inside the MS/MR
- Check compliance with the final LISP standards
- Some design guidance for vertical scaling resource allocations should be developed.

It is also recommended to establish capacity design guidelines.

5.6 GGBR

The GGBR implementation might check some additional improvements:

- Check compliance with the final LISP standards
- Check compliance with finalized GB-LISP Profile as described by the upcoming EUROCAE ED-262A.
- Provide an improved API for supporting local preference overrides in the local LISP cache
- Provide an improved API for checking the current LISP status
- Consider cross-layer signalling proposals for driving new path selections
- Some design guidance for vertical scaling resource allocations should be developed.

The LISP API already exists for some time but the performance has been currently improved by a new transport solution that needs to be tested and integrated in the future implementations.

5.7 LISP Standards

The new generation of IETF LISP standards move from the Experimental track into the Standards track. The publication of these standards is at the last stages, but not finished at the writing of this documents. A snapshot of the status is provided by the next pages:

Standard ID	Draft ID	Track	Title	Replaces	Recent status	Last check	Comments	Link
RFC 9299	draft-ietf-lisp-introduction	Informational	An Architectural Introduction to the Locator/ID Separation Protocol (LISP)		AUTH48-DONE	2022-09-21		https://datatracker.ietf.org/doc/draft-ietf-lisp-introduction/
RFC 9300	draft-ietf-lisp-rfc6830bis	Proposed Standard	The Locator/ID Separation Protocol (LISP)	RFC 6830	AUTH48-DONE	2022-09-21	Used by SESAR FCI	https://datatracker.ietf.org/doc/draft-ietf-lisp-rfc6830bis/
RFC 9301	draft-ietf-lisp-rfc6833bis	Proposed Standard	Locator/ID Separation Protocol (LISP) Control-Plane	RFC 6833	AUTH48	2022-09-21	Used by SESAR FCI	https://datatracker.ietf.org/doc/draft-ietf-lisp-rfc6833bis/
RFC 9302	draft-ietf-lisp-6834bis	Proposed Standard	Locator/ID Separation Protocol (LISP) Map-Versioning	RFC 6834	AUTH48-DONE	2022-09-21	Not used by SESAR FCI	https://datatracker.ietf.org/doc/draft-ietf-lisp-6834bis/
RFC 9303	draft-ietf-lisp-sec	Proposed Standard	LISP-Security (LISP-SEC)		AUTH48	2022-09-21	Used by SESAR FCI	https://datatracker.ietf.org/doc/draft-ietf-lisp-sec/

Standard ID	Draft ID	Track	Title	Replaces	Recent status	Last check	Comments	Link
RFC 9304	draft-ietf-lisp-rfc8113bis	Proposed Standard	Locator/ID Separation Protocol (LISP): Shared Extension Message & IANA Registry for Packet Type Allocations	RFC 8113	AUTH48	2022-09-21	Used by SESAR FCI	https://datatracker.ietf.org/doc/draft-ietf-lisp-rfc8113bis/
RFC 9305	draft-ietf-lisp-gpe	Proposed Standard	LISP Generic Protocol Extension		AUTH48	2022-09-21		https://datatracker.ietf.org/doc/draft-ietf-lisp-gpe/
RFC 9306	draft-ietf-lisp-vendor-lcaf	Experimental	Vendor Specific LISP Canonical Address Format (LCAF)		AUTH48	2022-09-21	Used by SESAR FCI, should target Proposed Standard	https://datatracker.ietf.org/doc/draft-ietf-lisp-vendor-lcaf/
<Second round>	draft-ietf-lisp-vpn	Experimental	LISP Virtual Private Networks (VPNs)		Active Internet-Draft	2022-09-21	Used by SESAR FCI, should target Proposed Standard	https://datatracker.ietf.org/doc/draft-ietf-lisp-vpn/
<Second round>	draft-ietf-lisp-yang	Experimental	LISP YANG Model		Active Internet-Draft	2022-09-21	Used by SESAR FCI, should target	https://datatracker.ietf.org/doc/draft-ietf-lisp-yang/

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Standard ID	Draft ID	Track	Title	Replaces	Recent status	Last check	Comments	Link
							Proposed Standard	
<Second round>	draft-ietf-lisp-pubsub	Experimental	Publish/Subscribe Functionality for LISP		Active Internet-Draft	2022-09-21	Used by SESAR FCI, should target Proposed Standard	https://datatracker.ietf.org/doc/draft-ietf-lisp-pubsub/
<Second round>	draft-ietf-lisp-map-server-reliable-transport	Experimental	LISP Map Server Reliable Transport		Active Internet-Draft	2022-09-21	Used by SESAR FCI, should target Proposed Standard / Cisco extensions shall be added	https://datatracker.ietf.org/doc/draft-ietf-lisp-map-server-reliable-transport/
<Second round>	draft-ietf-lisp-ecdsa-auth	Experimental	LISP Control-Plane ECDSA Authentication and Authorization		Active Internet-Draft	2022-09-21		https://datatracker.ietf.org/doc/draft-ietf-lisp-ecdsa-auth/
<Third round>	draft-ietf-lisp-eid-anonymity	Experimental	LISP EID Anonymity		Active Internet-Draft	2022-09-21		https://datatracker.ietf.org/doc/draft-ietf-lisp-eid-anonymity/

Standard ID	Draft ID	Track	Title	Replaces	Recent status	Last check	Comments	Link
RFC 6831	<published>	Experimental	The Locator/ID Separation Protocol (LISP) for Multicast Environments		Published, January 2013	2015-10-14	Used by SESAR FCI, should target Proposed Standard	https://datatracker.ietf.org/doc/rfc6831/
RFC 6832	<published>	Experimental	Interworking between Locator/ID Separation Protocol (LISP) and Non-LISP Sites		Published, January 2013	2015-10-14	Might be used by SESAR 3 IPS, should target Proposed Standard	https://datatracker.ietf.org/doc/rfc6832/
RFC 6835	<published>	Informational	The Locator/ID Separation Protocol Internet Groper (LIG)		Published, January 2013	2015-10-14	Accidentally might be used by SESAR FCI	https://datatracker.ietf.org/doc/rfc6835/
RFC 6836	<published>	Experimental	Locator/ID Separation Protocol Alternative Logical Topology (LISP+ALT)		Published, January 2013	2015-10-14		https://datatracker.ietf.org/doc/rfc6836/
RFC 7052	<published>	Experimental	Locator/ID Separation Protocol (LISP) MIB		Published, October 2013	2015-10-14		https://datatracker.ietf.org/doc/rfc7052/

Standard ID	Draft ID	Track	Title	Replaces	Recent status	Last check	Comments	Link
RFC 7215	<published>	Experimental	Locator/Identifier Separation Protocol (LISP) Network Element Deployment Considerations		Published, April 2014	2015-10-14		https://datatracker.ietf.org/doc/rfc7215/
RFC 7834	<published>	Informational	Locator/ID Separation Protocol (LISP) Impact		Published, April 2016	2016-04-29		https://datatracker.ietf.org/doc/rfc7834/
RFC 7835	<published>	Informational	Locator/ID Separation Protocol (LISP) Threat Analysis		Published, April 2016	2016-04-29		https://datatracker.ietf.org/doc/rfc7835/
RFC 7954	<published>	Experimental	Locator/ID Separation Protocol (LISP) Endpoint Identifier (EID) Block		Published, September 2016	2016-09-21		https://datatracker.ietf.org/doc/rfc7954/
RFC 7955	<published>	Informational	Management Guidelines for the Locator/ID Separation Protocol (LISP) Endpoint Identifier (EID) Block		Published, September 2016	2016-09-21		https://datatracker.ietf.org/doc/rfc7955/

Standard ID	Draft ID	Track	Title	Replaces	Recent status	Last check	Comments	Link
RFC 8060	<published>	Experimental	LISP Canonical Address Format (LCAF)		Published, February 2017	2017-02-02	Used by SESAR FCI	https://datatracker.ietf.org/doc/rfc8060/
RFC 8061	<published>	Experimental	Locator/ID Separation Protocol (LISP) Data-Plane Confidentiality		Published, February 2017	2017-02-02	SESAR FCI uses GETVPN	https://datatracker.ietf.org/doc/rfc8061/
RFC 8111	<published>	Experimental	Locator/ID Separation Protocol Delegated Database Tree (LISP-DDT)		Published, May 2017	2017-05-26		https://datatracker.ietf.org/doc/rfc8111/
RFC 8378	<published>	Experimental	Signal-Free Locator/ID Separation Protocol (LISP) Multicast		Published, May 2018	2018-05-02	Not implemented yet by Cisco, but it would be beneficial	https://datatracker.ietf.org/doc/rfc8378/
draft	draft-ietf-lisp-eid-mobility	Experimental	LISP L2/L3 EID Mobility Using a Unified Control Plane		Active Internet-Draft	2022-09-21		https://datatracker.ietf.org/doc/draft-ietf-lisp-eid-mobility/

Standard ID	Draft ID	Track	Title	Replaces	Recent status	Last check	Comments	Link
draft	draft-ietf-lisp-mn	Experimental	LISP Mobile Node		Active Internet-Draft	2022-09-21		https://datatracker.ietf.org/doc/draft-ietf-lisp-mn/
draft	draft-ietf-lisp-name-encoding	Experimental	LISP Distinguished Name Encoding		Active Internet-Draft	2022-09-21		https://datatracker.ietf.org/doc/draft-ietf-lisp-name-encoding/
draft	draft-ietf-lisp-nexagon	Informational	Network-Hexagons: Geolocation Mobility Edge Network Based On H3 and LISP		Active Internet-Draft	2022-09-21		https://datatracker.ietf.org/doc/draft-ietf-lisp-nexagon/
draft	draft-ietf-lisp-predictive-rlocs	Experimental	LISP Predictive RLOCs		Active Internet-Draft	2022-09-21		https://datatracker.ietf.org/doc/draft-ietf-lisp-predictive-rlocs/
draft	draft-ietf-lisp-te	Experimental	LISP Traffic Engineering Use-Cases		Active Internet-Draft	2022-09-21		https://datatracker.ietf.org/doc/draft-ietf-lisp-te/

Table 16: LISP standardization status

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Implementors should cross-check their compliance with the official IETF LISP standards based on the final published versions using the GB-LISP Profile for adaptations as described in EUROCAE ED-262A.

The current COTS routers used in validation exercises have some vendor specific extensions. However, this might be disabled by not allowing the usage of the reliable transport solution if necessary for interoperability or troubleshooting. These vendor specific extensions are beneficial for performance.

It is expected that the current vendor specific LISP extensions for the reliable transport will become an IETF standard in the future.

Additional recommendations are

- to discuss with the IETF LISP Workgroup adding a mapping system capability in the protocol, for automatic removal of all Sub-MNPs associated to one MNP, when the MNP itself is removed, instead of requiring one dedicated removal request for each Sub-MNP as it is now. This would be supported by a new flag marking a network prefix as mobile instead of the current interpretation as fixed network
- To push forward the remaining required standardization in the IETF LISP Workgroup. For example, the PubSub specification shall become a Proposed Standard in the near future

5.8 GB-LISP Profile

The GB-LISP Profile drafts were presented and discussed in the ICAO WG-I and its Mobility SG for many years [26]. The ICAO workpaper for this topic was used as basis for the validation exercises. An updated version will be included in the upcoming EUROCAE ED-262A.

Implementors shall cross-check their compliance with this final version of the GB-LISP Profile once it will be published. Major changes are not expected.

5.9 Upper Layers

The following recommendations on the Layers above the Network Layer have been identified during the Validation Exercises (see TVALR, [25]):

- Further work in the IPS Standardization WG-I is needed, to improve the rejection of duplicate ATNPKTs in the IPS Dialogue Service. Currently the ATNPKT protocol may fail to detect and reject duplicates in certain rare network conditions and, in consequence, incorrect or corrupted messages may be delivered to the application
- A recommendation for the IPS standardization is also that Dialogue Service Retransmission Timer is set to a compliant to than the RCP60 requirement, in order to account for at least 1 ATNPKT retransmission and still be able to meet the RCP60 required performance, if Dialogue Service is maintained for ATS-B3 applications
- Concerning SWIM PP user plane, whatever system is used on the aircraft to host the SWIM PP applications, in order for the SWIM user plane data to be downlinked by the Airborne Router, the packet size shall have to be limited to the maximum MTU allowed by the IPS Standard of 1280 bytes (see chapter 3.3.9 of EUROCAE ED-262

5.10 Digital Voice

We recommend for a future stage

- to split the requirement REQ.14.77-TS-GENR-0002a into two requirements, each for
    - Voice as Backup Contingency, where the Voice network must be diverse and separate from the Datalink network (e.g. fallback after cyber attack to FCI)
    - Generic Voice, which instead can be transported over the Datalink Network
- to define for each Digital Voice Types different specific Safety Performance Requirements (this is not covered currently by EUROCAE ED-228A, [14])
- to apportion these requirements down to each datalink Access Network

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6 Assumptions

The following are all the Assumptions taken in developing the requirements and validation plan.

6.1 Functional Assumptions

The user plane is defined as an IPv6 connectivity between the aircraft and the ground actors (ATS, AOC) following the EUROCAE/RTCA ATN/IPS profile definition. [4]

6.1.1 Reachability assumptions

Inside the mobile access and aggregation network the internal IP addressing is a private matter. Internal IP addresses are not seen by the user plane end systems.

For failure detection and status awareness information updates it is assumed that the data link layer can signal detected failures to the network layer. Status awareness information will be still exchanged in the network layer, but with overhead minimalization.

6.1.2 Break Before Make

Break-before-make (BMM) scenarios might happen if the need for a handover (HO) cannot be detected in time on a single link. In a multi-link environment, a quicker failover possible to an already active alternate link, however this might be still not perfectly smooth without small service gaps.

In an active multi-link scenario when one RAT link goes down, the Airborne IPS Router automatically changes traffic to another RAT link and informs the ground about the issue by using AGMI link status updates (or local link lost detection). The ground might also detect link availability problems locally.

If a link had active traffic when a link problem occurs, then some traffic might be lost. The upper layers have ARQ mechanism to correct such situations.

It is assumed that the chance for BBM scenarios, the duration, and the impact are reduced to an acceptable minimum by using a combination of:

- Local link status detection (e.g., using the AEEC Common Radio Interface on the aircraft) by the lower layers
- Optional cross-layer signalling from the upper layers (transport, application)
- Foreign Reports sent and received on alternate links

See the Section 6.1.4 for more details on implementing a Fast BBM solution.

If it is possible to forecast the need for a change in the usage of RAT links, then an MBB handover (HO) procedure shall be activated. However, if the BBM behaviour is fast enough in an active multi-link scenario, then an MBB solution might not be necessary. For some services and RAT links this could be the case in the production environment.

6.1.3 Make Before Break

Active multi-link is a kind of natural environment for vertical handover make-before-break (MBB) for unicast since an alternate path is already prepared. Analogy: MBB may happen inside a single RAT domain as horizontal handover. If the multi-link is degraded to a single link situation, then vertical handover multi-link MBB is not possible. This limitation is similar to a single-radio (SR) handover (HO) scheme.

If a second link comes back, it is automatically logged in and activated, without waiting for a traffic requiring its usage. This feature mitigates the problem of relatively slow authentication and authorization.

There is still a distinction between Fast BBM and Seamless MBB. Although Fast BBM requires some MBB preconditions such as a multi-radio connection already active, a truly lossless handover would be provided only by a Seamless MBB including HO or link down event predictions. Please, note that the overall continuity statistic of a Fast BBM might be good enough in production.

Two Seamless MBB scenarios are identified:

- Multi-link MBB, when the event of one RAT link predicted to go down for a longer duration automatically changes traffic to another RAT link by using AGMI preferences updates
- SR-HO MBB, when an alternate RAT link supports an MBB for SR-HO by changing preferences and redirecting traffic until the SR-HO process completed

It is assumed that an Airborne IPS Router implementation would support both approaches.

Please, note the SR-HO MBB is needed only if the SR-HO impacted RAT link has active traffic. If it is only in active standby carrying no traffic, then the SR-HO MBB mechanism does not need to be activated.

It is assumed that a RAT with multiple service providers (VDLm2, AeroMACS even NG, LDACS) on the aircraft is currently a Single Radio (SR) Handover (HO) scenario when changing service providers on a single RAT link. This might change in the future, but then we would have new RAT types that would require new analysis.

If the RAT link with a SR-HO need is standalone, then there will be a gap in service. This cannot be avoided. A decision has to be done based on the performance requirements if this service gap tolerable or not.

An active multi-link scenario can enable an SR-HO MBB process utilizing another RAT link. If the service gap of the SR-HO is not acceptable, then Airborne IPS router can send updated preferences to redirect traffic from the RAT that is due to make a service provider change.

Usually, a RAT SR-HO implementation should have a local trigger signal for detecting the need for an upcoming HO in advance. When this trigger signal is seen, then the aircraft could send out new preferences, if this RAT was already having critical traffic. Some traffic might stay, if the service gap is tolerable for them. Once the critical traffic is away from the RAT link planning an SR-HO, then the ATN/IPS System on the aircraft could actually start the SR-HO.

When the SR-HO is finished, the Airborne IPS Router might want to change back the preferences.

This SR-HO MBB mechanism is orthogonal to the problem of lost link down events and the needed foreign reports to ensure that lost links are not advertised into the mobility backbone. The SR-HO MBB might be also specific per application classes to avoid unnecessary congestions. The semantics of link status and preferences could be treated as orthogonal.

The SR-HO MBB implementation is local to the aircraft ATN/IPS System. It does not require changes in the AGMI protocol. It is recommended providing some guidance or examples for the future implementors.

If MBB is strongly required by general performance considerations, then multi-link is the only way to provide this with the existing SR RAT links. It is assumed that the Airborne IPS Router has this SR-HO MBB feature implemented for the production environment. The mechanism of changing preferences was thoroughly tested and validated in the exercises and covers the need for both MBB scenarios.

This SR-HO MBB solution is a strong argument why an active multi-link is required at the critical phases of the flight.

6.1.4 Black hole routing avoidance

6.1.4.1 Ground to air

Black holes in the air in the ground to air direction has to be handled by the Airborne IPS router has to handle it. Ground will still deliver to the airplane on whatever links are available.

Black holes on the ground in the ground to air direction might be detected from air to ground network layer status information updates, by the RAT data link layer, or by normal IP routing for ground sections where BFD or active probing might provide improved performance.

Link status updates and preferences provided by the airplane need to be distributed in the ground network. Solution 77 validation prototype would use GB-LISP for this purpose. [39]

It is assumed, that a status report about another RAT link is possible and supported. There are issues to be solved on trust and security.

If an upper layer detects the problem, it might request the selection of another RAT link for that application class.

It is assumed that the Airborne IPS router will send foreign reports for all links where an AGMI response was not orderly received or the local Common Radio Interface reported a link loss or severe degradation. This is even needed when a new link is coming up only later and there was no active alternate link at that time when the problematic link was lost or severely degraded. It is assumed that the Airborne IPS router maintains a list of foreign reports still due (up to an expiration time) and communicates them to the ground as soon as possible.

6.1.4.2 Air to ground

Black holes in the air in the air to ground direction has to be handled by the Airborne IPS router. It could decide on using another RAT link even different for each application class.

Black holes on the ground in the air to ground direction need to be managed by ground router when the ground network behind RAT link might not provide connectivity to destination. The ground might send link status update to aircraft, too – including back hole info that would enforce selecting another RAT link by the airborne IPS router. This would be typically implemented by a forced logoff in the lower layers on this RAT link if the air-ground link itself is still operational, just the supporting ground network sections are unavailable.

It is assumed that the Airborne IPS router can detect most RAT link availability and degradation problems in a timely manner through the AEEC specified Common Radio Interface.

6.2 Non-Functional Assumptions

6.2.1 Performance Assumptions

6.2.1.1 Load Balancing

The limited bandwidth of the safety certified RAT links might require some load balancing. It could be either per-packet or per-flow.

6.2.2 Security Assumptions

The following are the assumptions identified in the new PJ14-W2-77 Security Risk Assessment, presented in the D5.1.120 TRL6 Final TS/IRS Part IIIA (Low risk), Part IIIB (Medium risk) and Part IIIC (High risk).

ID	Assumption	Responsibility
AS#1	The A/G routers are operated by an ASP and every technology (AeroMACS, LDACS, SATCOM) is allocated with its own A/G router (depending on mutual agreements).	FCI (e.g. ISP provider)
AS#2	Connectivity for the FCI network services are administered by ISPs (e.g. telecom provider)	ISP
AS#3	Security mechanisms are implemented at upper layers (e.g. the ATN-IPS Dialogue Service secured by DTLS) and at subnetwork level for each of the technology (LDACS, SATCOM, AEROMACS).	ANSP
AS#4	A “federated” security infrastructure, able to enforce the “trust chain” between the various security infrastructures (e.g. AAA, PKI), is assumed.	ASP, CSP, ANSP
AS#5	Aircraft that is introduced into the network (e.g. LDACS, SAT) is authenticated. Datalink level / Radio system (e.g. SatCom) Air ground data link / Airborne IPS system Legacy another level above the radio link.	ASP (Access Service Provider)
AS#6	Traffic between aircraft and ground access network systems is integrity protected.	ASP, Airborne (Airspace Users)
AS#7	End to end traffic between aircraft end systems and ground end system is integrity protected.	Application, Airborne (Airspace Users), ANSP
AS#8	It is assumed that AOC data if needed are encrypted (end-to-end) on application layer. AOC data will be handled like any other data in FCI (not classified).	Airborne (Airspace Users), CSP

AS#9	It is assumed that for network segments outside the scope of FCI proper SecRA has been done and that the adequate level of security assurance is considered in the development, deployment, and maintenance. It is assumed that results of these individual assessments can be combined with the result from FCI SecRA.	CSP, ISP, ASP, ANSP, MIL
AS#10	TLS implementation for SWIM applications is assumed.	SWIM
AS#11	The security of the ATN infrastructure is assumed to be approved by aviation authorities assuring confidence in the level of security.	CSP, ISP, ASP, ANSP, MIL
AS#12	The Best Security Practice will be implemented by the operating authorities e.g. Minimum Set of Security Controls (MSSC), ISO/IEC27002, as example: physical protection, security management, hardening, input validation, network segregation/border protection functions/filtering, logging/auditing, access control/authentication/authorization, malicious code protection, patch management, vulnerability management, patch management, vulnerability management, intrusion prevention, user training and monitoring etc.(the list is not exhausting and shall not be used as the only source for security best practice controls!)	CSP, ISP, ASP, ANSP, MIL
AS#13	Only trained personnel have access to the system.	CSP, ISP, ASP, ANSP, MIL
AS#14	Every actor of the ATM communication shall have measures in place to monitor, detect and deal with malicious activities from the insiders.	CSP, ISP, ASP, ANSP, MIL
AS#15	Security Management support based on status information, logs and event monitoring is supported by the operating authorities e.g.: Security monitoring of the network elements (discover DoS) Traffic behaviour analysis including threat intelligence and incident correlation). Including response (removing attacked elements, redirect traffic)	CSP, ISP, ASP, ANSP, MIL
AS#16	The IPS network supports application or transport layer security using DTLS to ensure all data and control plane messages are received without modification. (DTLS mentioned in REG1)	CSP, ISP
AS#17	The radio access technology and all the underlay below the user plane are out of scope for the evaluation, the responsibility for security of these systems is with the radio technology providers.	ASP, CSP (when is also Access Network Provider)
AS#18	Hyper connected ATM networks are sufficiently secured and do not provide attack vector for FCI solution	Hyper connected CSP

AS#19	It is assumed that the connected OSI networks are sufficiently secured and do not provide attack vector for FCI solution.	CSP
AS#20	It is assumed that connected networks from military authorities are sufficiently secured and do not provide attack vector for FCI solution	MIL
AS#21	Secure channel between airborne radio system and ground radio access network is in place that verifies the authenticity of a communication partner and provides integrity protection. Assurance level is commensurate with the needs for risk mitigations.	ASP, CSP (when is also Access Network Provider)
AS#22	Data flow segregation. Segregation limits/confines threat propagation to prevent a disclosure, corruption, or loss of data during transit. In case of a shared network, it shall prevent communication among systems that is not allowed (e.g. through virtual links configuration). By using point-to-point A429 buses, segregation is intrinsically there. In case of a shared network, it shall prevent communications among systems that is not allowed (e.g. through virtual links configuration). By using point-to-point A429 buses, segregation is intrinsically there.	Airborne
AS#23	Address anti-spoofing protection is deployed all over the network (e.g. reverse path forwarding check in the routing system)	CSP. ISP
AS#24	Airborne Network Filtering. To limit the exposure of the airborne systems, the network traffic shall be filtered to restrict network communication to permitted data flows. To ensure effective filtering in front of exposed interfaces, it should be performed by the radio system as well as by the ATN/IPS router. It is assumed that such capabilities are already available in the existing router implementations.	Airborne (Airspace Users)
AS#25	Airborne access control (for maintenance interface). Airborne authentication and authorization for management interfaces. Any management interface exposed by an airborne radio system or system involved in datalink communication is subject to authentication and authorization.	Airborne (Airspace Users)
AS#26	T#01: Connection from AAA serve to the FCI nodes will be protected with tunnel security function (type of the implementation is to be defined)	CSP
AS#27	The ASPs, CSPs, ANSPs and Airspace Users shall bear responsibility to implement security in their domains and have in place security governance (e.g. management of PKI, SOC, processes for incident	ASPs, CSPs, ANSPs, AUs

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	management including IF externally administered domains.)	
AS#28	The Airborne IPS System implementation assumes that IPS ground systems provide some protection against flooding attacks, which could result in network performance degradation or denial-of-service conditions.	ASPs, CSPs, ANSPs
AS#29	Security assurance activities are a pre-requisite for the effectiveness of other security measures contributing to risk mitigation. Such confidence is gained by following a security assurance process during the whole life cycle of the deployed systems	ASPs, CSPs, ANSPs, AUs

Table 17 - PJ14-W2-77 Security Risk Assessment Assumptions

6.2.3 Safety Assumptions

6.2.3.1 Very high availability

Quick automated failover is always limited by failure detection. Limited bandwidth would slow down failure detection. Frequent active probing is not feasible for most of the proposed FCI RAT links since the overhead would be not acceptable. This might change in the future when higher bandwidth would become available.

Simulcast might be used for becoming independent on failure detection, but selectively, only for the most critical traffic. It is important to avoid unnecessary bandwidth consumption since some links are narrowband only and would limit the possibilities for simulcast. Simulcast might be used in both directions or only in one direction.

For traffic that cannot be simulcasted, fast convergence would be still necessary. From the Airborne IPS Router perspective, it is relatively easy: just pick up the next available link. From the ground perspective it has two major parts: EID vs. RLOC convergence. EID convergence is based on the EID by pub/sub mechanism. Based on recent testing in similar environment a feasible target is below 50 ms with all airplanes taken into account. It is important to note that because of this quick failover switching, the overall convergence is determined by the speed of failure detection.

Failure detection would be the main challenge for FCI. Active probing is only meaningful over 1 Mbps per aircraft and unfortunately most FCI interfaces are below this. Ideally, to declare failure for a datalink an in session QoS threshold crossing (if possible) could be used, E.g., packet loss, packet delay, etc. However, this is not always feasible depending on the details of the RAT capabilities.

It is assumed, that if air-ground L2 termination sees a link failure in the network further down the forwarding direction, then it needs to make an explicit down of the L3 interface, too (speed up failure detection) into the backward direction. It is also assumed that such events will be also communicated on alternate links. This is called as a “foreign report” expressing the fact from the RAT link owner perspective, that it would receive a link down report from a foreign agent.

It is also assumed, that if upper layers see connectivity failures, then it might be sent cross-layer for generating link status updates. This would be a slower, but useful as a safety net (last resort). However, it might not be available in some environments.

6.2.4 Scalability Assumptions

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Smaller COTS implementations for an AGBR or GGBR might be limited to a few thousand LISP cache entries. For later production environments, it is assumed that a selective subscription to certain LISP EID ranges or prefixes would be available. This could optimize the capacity sizing and selection of the proper COTS router for the AGBR and GGBR roles. Currently, the implementation of selective LISP subscribe feature is not completed in COTS. Further negotiations are planned to make it happen.

It is assumed that the workload for MS/MR instances can be distributed evenly. The used COTS routers have some examples for such scaling in other projects.

It is assumed that the workload of AGBR, GGBR and MS/MR can be distributed among multiple instances for a horizontal scaling and in the future.

7 References and Applicable Documents

7.1 Applicable Documents

Content Integration

[1] SESAR 2020 Requirements and Validation Guidelines Wave 2 Final_1 (2_0).docx

Content Development

[2] D5.1.610 - PJ14-W2-77 TRL6 Overall Concept of Operation_v01.00.00

[3] ICAO doc. 9896 ED II "Manual on the Aeronautical Telecommunication Network (ATN) using Internet Protocol Suite (IPS) Standards and Protocols"

[4] EUROCAE ED-262/RTCA DO-379 “Internet Protocol Suite Profiles”

[5] EUROCAE WG-108 / RTCA SC 223 MINIMUM AVIATION SYSTEM PERFORMANCE STANDARD FOR ATN/IPS, draft February 2021

[6] ICAO doc. 9880 ED II Manual on Detailed Technical Specifications for the Aeronautical Telecommunication Network (ATN) using ISO/OSI Standards and Protocols

System and Service Development

[7] https://ost.eurocontrol.int/sites/eatmac/Pages/EATMA-in-MEGA.aspx

[8] ISO/IEC/IEEE 42010:2011

Performance Management

[9] SESAR2020_PJ14_2_4_D5_1_020_2_FCI_Initial_Transversal_Studies_v00 01 01

[10]SESAR 1 15.02.04 deliverable D04

[11]SESAR2020_PJ14_2_4_D5_3_060_FCI_Transversal_Studies_v00_04_00.docx

Validation

[12]ICAO WG-I IPS SARPS VALIDATION REPORT – draft v1.1, 19th April 2021

[13]EUROCAE WG-108/RTCA SC-223 IPS MASPS Validation Report

System Engineering

Safety

[14]ANNEX E9 of EUROCAE ED228A “Safety and Performance Requirements Standard for Baseline 2 ATS Data Communications (Baseline 2 SPR Standard)”. Rationale: this standard provides performance figures that FCI has to meet in order to be able to provide support to ATS B2

Human Performance

Environment Assessment

Security

7.2 Reference Documents

[15]ED-78A GUIDELINES FOR APPROVAL OF THE PROVISION AND USE OF AIR TRAFFIC SERVICES SUPPORTED BY DATA COMMUNICATIONS.[20]

[16]SESAR2020_PJ14_02_04_D5_4_010_TS-IRS_v00_01_02.doc

[17]PJ.17.01 Advisory SWIM PP Final TRL6 TS

[18]PJ.14-W2-100-Safety critical PP FRD

[19]ATN-IPS Aircraft Protocol (AIAP) – Simple AIAP_v0.5_ext.pdf – 05-11-2020

[20]Air-Ground Mobility Interface – AGMI Protocol Specification rev 0.9 -26-04-2021

[21]PP858 -INTERNET PROTOCOL SUITE (IPS) FOR AERONAUTICAL SAFETY SERVICES Feb. 2021.

[22]FCI IF6 - ATN IPS AG-R to GB-LISP Interface Control Document, Ed 01.00.00

[23]D5.1.110 - PJ14-W2-77 TRL6 Initial TS-IRS FCI Services - Part I_01.00.03.docx

[24]SC-214/WG-78 Perf/safety subgroup and OPDLWG PBCS PT – WP0x RCP & RSP Allocations Definition, 23-May-2022, Meeting 7th-10th June 2022

[25]D5.1.400 - PJ.14-W2-77 TRL6 TVALR – FCI services – Part I, Edition 01.00.00

[26]ICAO Workpaper: "Ground Based LISP mobility solution for ATN/IPS". November 2021. https://portal.icao.int/CP-DCIWG/MobilitySG/Web%20Meeting%20No.%2016/GB-LISP%20solution%20report%2020211110.pdf

Mobility

[27]RFC6830: General Principles

[28]RFC6831: Multicast Environment

[29]RFC6832: Interworking with non-LISP sites

[30]RFC6833: Map-Server Interface

[31]RFC6833bis: Control Plane

[32]RFC6836: LISP ALT

[33]RFC8111: LISP-DDT

[34]draft-ietf-ipsecme-g-ikev2-02: Group Key Management using IKEv2 - https://tools.ietf.org/html/draft-ietf-ipsecme-g-ikev2-02

[35]draft-ietf-lisp-pubsub-06 (Rodriguez-Natal): LISP Publish-Subscribe - https://tools.ietf.org/html/draft-ietf-lisp-pubsub-06

[36]draft-ietf-lisp-sec-22: LISP-Security (LISP-SEC) - draft-ietf-lisp-sec-22 - LISP-Security (LISP-SEC)

20

[37]RFC5213: PMIPv6 - Proxy Mobile IPv6 –August 2008

[38]RFC 2463: ICMPv6

[39] ICAO WG-I report: GB-LISP Mobility solution for ATN/IPS-20.11.2020

Security

[40]RFC 6347: DTLS v1.2

[41]draft-ietf-tls-dtls13-42: DTLS v1.3 (draft)

Airborne Router

[42]ICAO Doc 9896 ed. 3, RTCA SC-223/EUROCAE WG108 profiles (in REQ-PJ14.02.04-TS-ABRT-0003);

Multicast

[43]RFC 3810 (MLDv2)

[44]RFC 4607 (SSM)

[45]P15.02.04 WA1.3 “Security Risk Assessment Report”, rel. 00.01.01 (D5 Deliverable)

Appendix A Service Description Document (SDD)

Not applicable to the solution.

Appendix B ConOps Requirements

In this paragraphs are reported the PJ14-W2-77 ConOps requirements and FCI Organisation Roles delivered in [2].

Requirement ID	Requirement description
REQ-14-W2-77-OP-001	The FCI shall support the communication of ATM applications between IPS hosts located in the ground infrastructure (G/G communications)
REQ-14-W2-77-OP-002	The FCI shall support the communication of ATM applications between IPS hosts located in the ground infrastructure and IPS equipped airborne systems located in aircraft mobile subnetworks (A/G communications) at all phases of flight while aircraft is located over the geographical coverage area
REQ-14-W2-77-OP-003	The FCI shall interface with the following IP stacks: - ATN/IPS as per ICAO Doc 9896 - SWIM Technical Infrastructure using Yellow, Blue, Purple-Advisory, Purple-Safety and Green Profile specifications - Native IP stack based on IETF RFC for ATM applications
REQ-14-W2-77-OP-004	The FCI shall support the following ATS services as per ICAO Annex 11: - Flight Information Service (FIS) - Alerting Service - Air Traffic Advisory Service - Air Traffic Control Service (ATS Baseline 2) applications as per EUROCAE ED-229
REQ-14-W2-77-OP-005	The FCI shall be capable of supporting evolution of ATS Baseline 2 for support of Trajectory Based Operations (TBO), including ATS Baseline 3
REQ-14-W2-77-OP-006	The FCI shall support the following AIS/MET services as per EUROCAE ED-151: - AIS: Aeronautical Update Service, Baseline Synchronization Service - MET: WPDS, WNDS, WIDS, Weather downlink
REQ-14-W2-77-OP-007	The FCI shall support Aeronautical Operational Control (AOC) services
REQ-14-W2-77-OP-008	The FCI shall support Digital Voice
REQ-14-W2-77-OP-009	The FCI shall support exchange of flight information for support of the FF-ICE concept for Trajectory Based Operations (TBO)
REQ-14-W2-77-OP-010	The FCI shall be scalable as to support TBD a number of simultaneously equipped aircraft as shown in Table 9 with and TBD peak data throughput as shown in Table 10
REQ-14-W2-77-OP-011	The FCI shall be capable to support ATM applications complying with the end to end performance levels indicated in Tables 9-12.
REQ-14-W2-77-OP-012	FCI shall provide mechanisms to mitigate detected loss of communications due to a failure of the aircraft IPS routing system, the radio system, or an FCI ground component, leading to a situation where safety-critical applications cannot be used anymore
REQ-14-W2-77-OP-013	Redundancy should be considered to FCI components on the aircraft (mobile subnetwork), access network and/or ground infrastructure between two connected IPS hosts). This requirement applicable to ground infrastructure is augmented by REQ-14-W2-77-OP-017 for security purposes

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Requirement ID	Requirement description
REQ-14-W2-77-OP-014	Aircraft (mobile subnetwork) FCI components shall be implemented at Design Assurance Level C
REQ-14-W2-77-OP-015	Software assurance levels for FCI components should be commensurate to, either: - Severity Class 3 - Severity Class 4, if proper mitigations are implemented
REQ-14-W2-77-OP-016	The FCI should implement, either: - Functional mechanism that timely and confidently monitors any undetected loss or misbehaviour of air/ground communications, implemented in DAL C - A mechanism ensuring that safety-critical communications cannot be disrupted in the event of an undetected loss or misbehaviour of air/ground communications (e.g. multiple transmission)
REQ-14-W2-77-OP-017	The FCI shall implement redundant communication infrastructure which does not rely on the same CSP network domain
REQ-14-W2-77-OP-018	Proper security control and security management practices shall be implemented on the FCI, including: - Configuration and operational audits - Secure monitoring and management - Attack monitoring and correction, and patch management - Self-protection and network security design practices
REQ-14-W2-77-OP-019	The FCI shall implement integrity and privacy protection of the control and data plane of the communications
REQ-14-W2-77-OP-020	The FCI shall support IPv6 unicast addressing
REQ-14-W2-77-OP-021	The FCI should support IPv6 multicast addressing for: - G/G communications - A/G communications in the ground-to-air direction if group sessions are required for ATM services (e.g. AIS/MET or Digital Voice)
REQ-14-W2-77-OP-022	Each IPS host in the FCI shall have at least one routable, globally unique IPv6 unicast address uniquely identifying a network interface
REQ-14-W2-77-OP-023	The globally routable IPv6 address of an operator-based aircraft shall be derived from the aircraft Mobile Network Prefix (MNP) and independent of an access network point of attachment.
REQ-14-W2-77-OP-024	Link Local Addresses (LLA) on the network-layer interfaces of the IPS Nodes facing air-ground datalink shall be configured with unique address derived from the MNP
REQ-14-W2-77-OP-025	The FCI shall provide the capability for an IPS host to query and receive the IPv6 address of a peer host using its generic host name (e.g. Ground Facility Designator, GUFI, or other)
REQ-14-W2-77-OP-026	The FCI shall provide mobile connectivity among IPS hosts served by a federation of multiple, independent CSPs
REQ-14-W2-77-OP-027	The FCI shall support monitoring of A/G data links in the access networks available for communication with A/C, including at a minimum UP/DOWN status
REQ-14-W2-77-OP-028	The FCI shall support signalling of link monitoring status from A/C to ground infrastructure
REQ-14-W2-77-OP-029	The FCI shall support link selection policy depending on the application type, including: - ATS dictated by ATSP - AOC dictated by the airspace user (A/C or FOC)

Requirement ID	Requirement description
REQ-14-W2-77-OP-030	The FCI shall support link selection for A/G communications among available access networks, which does not result in a loss of ATS services, based on: - Administrative policy and/or - Link performance based on link status monitoring
REQ-14-W2-77-OP-031	The FCI shall support link selection override by manual selection of data or voice communications in the case of a degraded link performance, or for testing and validation purposes
REQ-14-W2-77-OP-032	The mobile node (aircraft) IPS host shall provide situational awareness about connectivity services
REQ-14-W2-77-OP-033	The mobile node (aircraft) IPS host shall provide means to intervene on connectivity services when necessary
REQ-14-W2-77-OP-034	The CSP providing the MSP should operate a Network Operations Centre (NOC) with a 7/24 continuous human supervision
REQ-14-W2-77-OP-035	The ATM service providers should operate a Network Operations Centre (NOC) with a 7/24 continuous human supervision
REQ-14-W2-77-OP-036	FCI shall support traffic classification for packet forwarding and routing policy
REQ-14-W2-77-OP-037	The FCI shall support the following QoS functions: - Data rate guarantee for required applications (e.g. Digital Voice) - Packet differentiation, prioritization, and pre-emption in situations of congestion - Packet scheduling to support applications with different latency budgets
REQ-14-W2-77-OP-038	The FCI shall provide protection against intentional breach of integrity and mis-delivery for safety-critical applications.
REQ-14-W2-77-OP-039	The FCI shall provide security measures to protect and mitigate against Denial of Service attacks
REQ-14-W2-77-OP-040	The FCI shall provide protection against interception of confidential information for network control and system management data
REQ-14-W2-77-OP-041	The FCI shall provide ground accommodation of: - ATN/OSI equipped aircraft for ATS communication with IPS host - FANS1/A equipped aircraft for ATS communication with IPS host - IPS equipped aircraft for ATS communication with FANS or ATN/OSI endpoint
REQ-14-W2-77-OP-042	The FCI shall provide integration and interfacing to ensure effective and secure G/G data exchange between civil and military stakeholders
REQ-14-W2-77-OP-043	The FCI shall interface with other IP networks (e.g. U-Space, commercial networks) implementing the appropriate mechanisms for inter-domain routing and security

FCI Organisation Roles

FCI Actor	Associated Responsibilities
Air Traffic Service Provider (ATSP)	Provide ATS and Digital Voice services to A/C and other ATSPs Ensure end-to-end datalink service performance, security, and safety levels Manage service contract with CSPs providing connectivity to FCI Establish and manage ATS and Digital Voice applications
ATM Data Service Provider (ADSP)	Provide ATSP with integrated ATM data required to provide ATS Perform flight data processing functions (potential future evolution) Ensure end-to-end ATM data service performance, security, and safety levels Manage service contract with CSPs providing connectivity to FCI Establish and manage ATM data applications (weather/aeronautical information including AIS/MET, flight information for TBO)
Communications Service Provider (CSP)	Provide end-to-end connectivity, mobility and communications services to air and ground IPS hosts running ATM applications Provide access to ground network infrastructure (e.g. IP BB, NEW PENS…). Optionally, provide access to air/ground datalink infrastructure (if also an ASP) Manage service contract with ATSP, ADSP and airspace users (FOC and A/C). Ensure levels of security, safety, and performance as compliant with service level agreements in service contract Monitor network performance and events, and share with NM for system-wide monitoring Apply NM directives to improve network performance

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FCI Actor	Associated Responsibilities
Access Service Provider (ASP)	Provide accessibility to access network via air/ground datalink infrastructure Provide status of radio link with aircraft in the access network Manage service contract with CSP and airspace users (A/C). Ensure levels of security, safety, and performance as compliant with service level agreements in service contract Monitor access network performance and events, and share with NM for system-wide monitoring Apply NM directives to improve access network performance (e.g. radio resource allocation)
Network manager (NM)	Monitor system-wide performance of ground network and access radio networks in FCI. Publish appropriate performance statistics and reports Provide recommendations for corrective action on network-wide issues to appropriate stakeholders (CSP and ASP)
Aircraft (A/C)	Ensure the correct operation of on-board A/G datalink capability, and ATM applications (ATS, Digital Voice, AOC, AIS/MET) Monitor datalink avionics status and record logs for performance monitoring
Flight Operations Centre (FOC)	Provide AOC services to A/C operated by the airspace user Ensure end-to-end AOC service performance, security, and safety levels Manage service contract with CSPs providing connectivity to FCI Establish and manage ground AOC applications

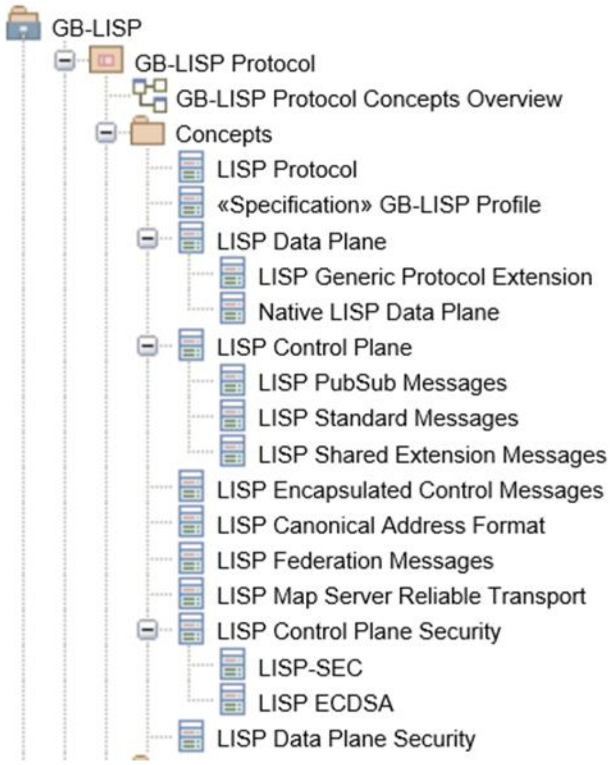
Appendix C IF6 Description and details

The document “FCI IF6 - ATN IPS AG-R to GB-LISP Interface Control Document” ([22]), which is an external appendix to this TS/IRS, specifies in detail the design of the Mobility & Multilink protocol exchanges (Message Sequence Charts, state Machines, etc.), covering the PJ14-W2-77 Validation ScopeThe GB-LISP solution is composed by a separated control plane (exchanging routing information) and data plane (executing forwarding intentions in the packet pipeline). The control plane generated lookup tables for packet pipeline. The specific packet pipeline architecture in a certain device may limit what actions are possible on a data plane packet.

LISP in general might support multiple data plane solutions, but GB-LISP is currently focusing on a single choice of the data plane architecture.

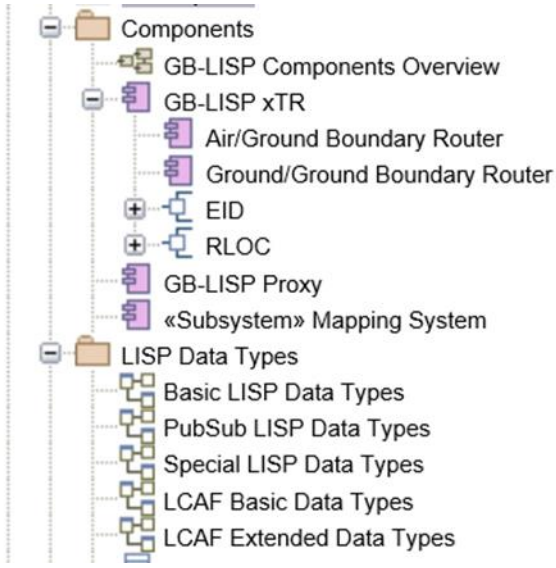
GB-LISP: Classes and protocols

The MEGA model of solution includes the protocol and standard definition associated to the «port definition» that are described in the Configuration Capability Diagrams (see Figure 18 and Figure 21). This description is already included in the standards GB-LISP protocol and protocol definition [22].



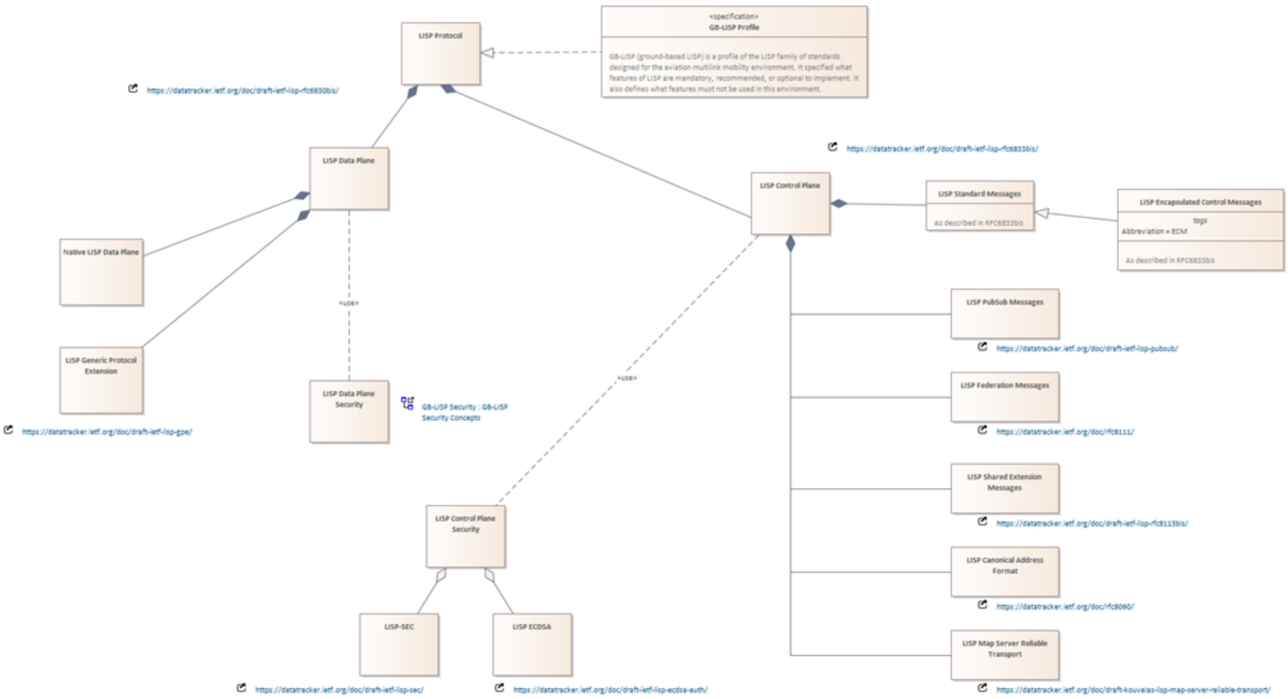
GB-LISP: Protocol and Functional Blocks

The GB-LISP xTR is part of IF6 interface on the Functional Blocks: AGBR and GGBR:



GB-LISP: Protocol Data model

The figure report the Communication Infrastructure Capabilities Architectures diagram with the IF6 GB-LISP interface description:



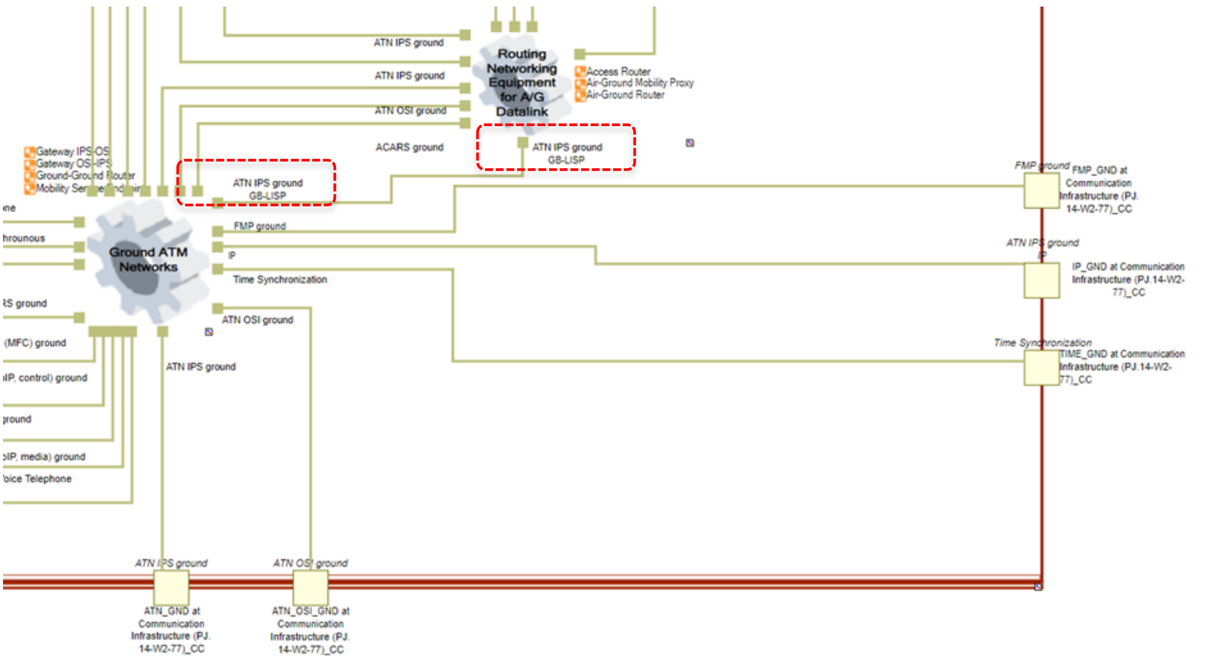


Figure 48: GB-LISP- Communication Infrastructure CC

Appendix D CONOPS AND TS-IRS REQUIREMENTS CROSS REFERENCE

Requirement ID	Requirement description	TS-IRS Requirement ID	Req. Title
REQ-14-W2-77-OP-001	The FCI shall support the communication of ATM applications between IPS hosts located in the ground infrastructure (G/G communications)	REQ.14.77-TS-GENR-0001	FCI Supported Services
REQ-14-W2-77-OP-002	The FCI shall support the communication of ATM applications between IPS hosts located in the ground infrastructure and IPS equipped airborne systems located in aircraft mobile subnetworks (A/G communications) at all phases of flight while aircraft is located over the geographical coverage area	REQ.14.77-TS-GENR-0001	FCI Supported Services
		REQ.14.77-TS-GENR-0002	Support for future services
		REQ.14.77-TS-GENR-0006	FCI compatibility towards OSI networks
		REQ.14.77-TS-PERF-0001	FCI performance Requirements for ATN-B2 services
		REQ.14.77-TS-PERF-0002	FCI performance Requirements for ATN-B3 services
		REQ.14.77-TS-PERF-0003	FCI performance Requirements for SWIM-PP services
		REQ.14.77-TS-PERF-0004	FCI performance Requirements for SWIM-PP Safe Mode services
		REQ.14.77-TS-PERF-0005	FCI performance Requirements for AIS-MET services
		REQ.14.77-TS-PERF-0006	FCI performance Requirements for AOC services

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Requirement ID	Requirement description	TS-IRS Requirement ID	Req. Title
REQ-14-W2-77-OP-003	The FCI shall interface with the following IP stacks: - ATN/IPS as per ICAO Doc 9896 - SWIM Technical Infrastructure using Yellow, Blue, Purple-Advisory, Purple-Safety and Green Profile specifications - Native IP stack based on IETF RFC for ATM applications	REQ.14.77-TS-GENR-0001	FCI Supported Services
		REQ.14.77-TS-GENR-0003	Interface with ATN Applications
REQ-14-W2-77-OP-004	The FCI shall support the following ATS services as per ICAO Annex 11: - Flight Information Service (FIS) - Alerting Service - Air Traffic Advisory Service - Air Traffic Control Service (ATS Baseline 2) applications as per EUROCAE ED-229	REQ.14.77-TS-GENR-0001	FCI Supported Services
REQ-14-W2-77-OP-005	The FCI shall be capable of supporting evolution of ATS Baseline 2 for support of Trajectory Based Operations (TBO), including ATS Baseline 3	REQ.14.77-TS-GENR-0002	Support for future services
REQ-14-W2-77-OP-006	The FCI shall support the following AIS/MET services as per EUROCAE ED-151: - AIS: Aeronautical Update Service, Baseline Synchronization Service	REQ.14.77-TS-GENR-0001	FCI Supported Services

Requirement ID	Requirement description	TS-IRS Requirement ID	Req. Title
	- MET: WPDS, WNDS, WIDS, Weather downlink		
REQ-14-W2-77-OP-007	The FCI shall support Aeronautical Operational Control (AOC) services	REQ.14.77-TS-ABRT-0002	Interface with AOC & SWIM applications
REQ-14-W2-77-OP-008	The FCI shall support Digital Voice (requirement to be refined)	REQ.14.77-TS-GENR-0002	Support for future services
REQ-14-W2-77-OP-009	The FCI shall support exchange of flight information for support of the FF-ICE concept for Trajectory Based Operations (TBO)	REQ.14.77-TS-GENR-0001	FCI Supported Services
REQ-14-W2-77-OP-010	The FCI shall be scalable as to support a number of simultaneously equipped aircraft as shown in Table 9 with peak data throughput as shown in Table 10	REQ.14.77-TS-PERF-0001	FCI performance Requirements for ATS-B2 services
		REQ.14.77-TS-PERF-0002	FCI performance Requirements for ATS-B3 services
		REQ.14.77-TS-PERF-0003	FCI performance Requirements for SWIM-PP services
		REQ.14.77-TS-PERF-0004	FCI performance Requirements for SWIM-PP Safe Mode services
		REQ.14.77-TS-PERF-0005	FCI performance Requirements for AIS-MET services
		REQ.14.77-TS-PERF-0006	FCI performance Requirements for AOC services
REQ-14-W2-77-OP-011	The FCI shall be capable to support ATM applications complying with the end to end performance levels indicated in Tables 9-12.	REQ.14.77-TS-PERF-0001	FCI performance Requirements
		REQ.14.77-TS-PERF-0002	FCI performance Requirements for ATN-B3 services

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Requirement ID	Requirement description	TS-IRS Requirement ID	Req. Title
		REQ.14.77-TS-PERF-0003	FCI performance Requirements for SWIM-PP services
		REQ.14.77-TS-PERF-0004	FCI performance Requirements for SWIM-PP Safe Mode services
		REQ.14.77-TS-PERF-0005	FCI performance Requirements for AIS-MET services
		REQ.14.77-TS-PERF-0006	FCI performance Requirements for AOC services
REQ-14-W2-77-OP-012	FCI shall provide mechanisms to mitigatedetected loss of communications due to a failure of the aircraft IPS routing system, the radio system, or an FCI ground component, leading to a situation where safety-critical applications cannot be used anymore	REQ.14.77-TS-SEC-0018	Air/Ground Link Switch in DoS Scenario
		REQ.14.77-TS-SEC-0020	No Network Single Point of Failure
		REQ.14.77-TS-SEC-0021	Diversity in Infrastructure
		REQ.14.77-TS-SEC-0022	DDoS Protection Service
		REQ.14.77-TS-SEC-0023	ISP Redundancy in Infrastructure Connections
		REQ.14.77-TS-SEC-0024	Geographically Separated MSEs
		REQ.14.77-TS-SEC-0025	Change of Global Mobility Service Provider
REQ-14-W2-77-OP-013	Redundancy should be applied to FCI components on the aircraft (mobile subnetwork), access network and/or ground infrastructure between two connected IPS hosts. This requirement applicable to ground	REQ.14.77-TS-SEC-0020	No Network Single Point of Failure
		REQ.14.77-TS-SEC-0021	Diversity in Infrastructure
		REQ.14.77-TS-SEC-0024	Geographically Separated MSEs

Requirement ID	Requirement description	TS-IRS Requirement ID	Req. Title
	infrastructure is augmented by REQ-14-W2-77-OP-017 for security purposes	REQ.14.77-TS-SEC-0025	Change of Global Mobility Service Provider
REQ-14-W2-77-OP-014	Aircraft (mobile subnetwork) FCI components shall be implemented at Design Assurance Level C		
REQ-14-W2-77-OP-015	Software assurance levels for FCI components should be commensurate to, either: - Severity Class 3 - Severity Class 4, if proper mitigations are implemented		
REQ-14-W2-77-OP-016	The FCI should implement, either: - Functional mechanism that timely and confidently monitors any undetected loss or misbehaviour of air/ground communications, implemented in DAL C - A mechanism ensuring that safety-critical communications cannot be disrupted in the event of an undetected loss or misbehaviour of air/ground communications (e.g. multiple transmission)	REQ.14.77-TS-MLNK-0018	Performance- based Multilink combined with Administrative Policy
		REQ.14.77-TS-MLNK-0019	Multilink QoS management
		REQ.14.77-TS-MLNK-0020	Multilink policy and preferences management (path selection)
		REQ.14.77-TS-MLNK-0023	Exchange A/G datalink status to the AGMI Proxy
		REQ.14.77-TS-MLNK-0027	Radio Link Quality and A-R Metric definition
		REQ.14.77-TS-MLNK-0028	Radio Data link congestion
		REQ.14.77-TS-MLNK-0030	Link Quality Metric Definition - AeroMACS
		REQ.14.77-TS-MLNK-0031	Link Quality metric definition - SATCOM

Requirement ID	Requirement description	TS-IRS Requirement ID	Req. Title
		REQ.14.77-TS-MLNK-0032	Link Quality Metric Definition - LDACS
		REQ.14.77-TS-MLNK-0033	Link Status
		REQ.14.77-TS-MLNK-0034	Link Quality metric definition – VDLM2
REQ-14-W2-77-OP-017	The FCI shall implement redundant communication infrastructure which does not rely on the same CSP network domain	REQ.14.77-TS-ABRT-0010	Multiple air-ground datalink usage
		REQ.14.77-TS-MLNK-0002	Multilink Administrative Policy criteria
REQ-14-W2-77-OP-018	Proper security control and security management practices shall be implemented on the FCI, including: - Configuration and operational audits - Secure monitoring and management - Attack monitoring and correction, and patch management - Self-protection and network security design practices	REQ.14.77-TS-SEC-0003	IPS security architecture
		REQ.14.77-TS-SEC-0008	General Security Principles: penetration attacks protection
		REQ.14.77-TS-SEC-0010	FCI Minimum Set of Security Controls
		REQ.14.77-TS-SEC-0011	Airborne Firewall functionality
		REQ.14.77-TS-SEC-0012	IF2 interface - security
		REQ.14.77-TS-SEC-0017	Security control and management
		REQ.14.77-TS-SEC-0018	Air/Ground Link Switch in DoS Scenario
		REQ.14.77-TS-SEC-0019	Packet Filtering Firewall
		REQ.14.77-TS-SEC-0020	No Network Single Point of Failure

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Requirement ID	Requirement description	TS-IRS Requirement ID	Req. Title
		REQ.14.77-TS-SEC-0021	Diversity in Infrastructure
		REQ.14.77-TS-SEC-0022	DDoS Protection Service
		REQ.14.77-TS-SEC-0023	ISP Redundancy in Infrastructure Connections
		REQ.14.77-TS-SEC-0024	Geographically Separated MSEs
		REQ.14.77-TS-SEC-0025	Change of Global Mobility Service Provider
		REQ.14.77-TS-SEC-0030	G/G Router ACL towards ISP network
		REQ.14.77-TS-SEC-0031	G/G Router protection towards ANSP network
		REQ.14.77-TS-SEC-0032	Automated DoS Alarm
		REQ.14.77-TS-SEC-0033	Intrusion Detection of physical access to network devices
		REQ.14.77-TS-SEC-0034	Automated Alarm for Network Management Access
		REQ.14.77-TS-SEC-0035	Traffic Shaping
		REQ.14.77-TS-SEC-0036	Traffic Policing
		REQ.14.77-TS-SEC-0037	Strict Priority Queuing
		REQ.14.77-TS-SEC-0038	Normal Configuration Operation only via Network Management System

Requirement ID	Requirement description	TS-IRS Requirement ID	Req. Title
		REQ.14.77-TS-SEC-0039	Policy Rules for Configuration of the MSE (MS/MR)
		REQ.14.77-TS-SEC-0040	Fallback to Analogue Voice Communications
		REQ.14.77-TS-SEC-0041	Alternative Transport Infrastructure
		REQ.14.77-TS-SEC-0046	Traffic Monitoring
		REQ.14.77-TS-SEC-0047	Physical Security of operational equipment
		REQ.14.77-TS-SEC-0048	Security Zone Separation of NOC and SOC
		REQ.14.77-TS-SEC-0050	Graceful degradation of air-ground communication on unavailable ATN/IPS communication
REQ-14-W2-77-OP-019	The FCI shall implement integrity and privacy protection of the control and data plane of the communications	REQ.14.77-TS--SEC-0001	A/G - G/G communication
		REQ.14.77-TS-SEC-0004	Airborne IPS System security services
		REQ.14.77-TS-SEC-0007	General Security Principles: MITM protection
		REQ-14.77-TS-SEC-0009	FCI Air Interface hardening - Authentication server
		REQ-14.77-TS-SEC-0013	IF3 interface - security

Requirement ID	Requirement description	TS-IRS Requirement ID	Req. Title
		REQ-14.77-TS-SEC-0014	IF9 message security
		REQ-14.77-TS-SEC-0015	IF_S_1 interface
		REQ-14.77-TS-SEC-0016	IF_S_2 interface
		REQ.14.77-TS-SEC-0026	Integrity Protection of GB-LISP Data Plane
		REQ.14.77-TS-SEC-0027	Integrity Protection of Network Management Traffic
		REQ.14.77-TS-SEC-0028	Integrity Protection of GB-LISP Control Plane
		REQ.14.77-TS-SEC-0029	Integrity Protection of AGMI Control Plane Protocol
REQ-14-W2-77-OP-020	The FCI shall support IPv6 unicast addressing	REQ.14.77-TS-ABRT-0002	Interface with AOC & SWIM applications
		REQ.14.77-TS-ABRT-0003	IPv6 protocol stack support
		REQ.14.77-TS-ABRT-0018	Addressing on the A-R datalink interfaces
		REQ.14.77-TS-GENR-0005	FCI Addressing
		REQ.14.77-TS-ESIF-0001	IF1 interface requirement for the FCI
		REQ.14.77-TS-ESIF-0002	IF5 interface requirements for the FCI
REQ-14-W2-77-OP-021	The FCI should support IPv6 multicast addressing for:	REQ.14.77-TS-GENR-0004	FCI Supported Services - Multicast

Requirement ID	Requirement description	TS-IRS Requirement ID	Req. Title
	- G/G communications - A/G communications in the ground-to-air direction if group sessions are required for ATM services (e.g. AIS/MET or Digital Voice)		
REQ-14-W2-77-OP-022	Each IPS host in the FCI shall have at least one routable, globally unique IPv6 unicast address uniquely identifying a network interface	REQ.14.77-TS-ESIF-0001	IF1 interface requirement for the FCI
		REQ.14.77-TS-ESIF-0002	IF5 interface requirements for the FCI
REQ-14-W2-77-OP-023	The globally routable IPv6 address of an operator-based aircraft shall be derived from the aircraft Mobile Network Prefix (MNP) and independent of an access network point of attachment.	REQ.14.77-TS-IPMB-0002	Ground Based LISP support to multi-homing
		REQ.14.77-TS-INT9-0023	IF9 interface - scope
		REQ.14.77-TS-ABRT-0018	Addressing on the A-R datalink interfaces
REQ-14-W2-77-OP-024	Link Local Addresses (LLA) on the network-layer interfaces of the IPS Nodes facing air-ground datalink shall be configured with unique address derived from the MNP	REQ.14.77-TS-ABRT-0018	Addressing on the A-R datalink interfaces
		REQ.14.77-TS-INT9-0041	IF9 Interface features - Addressing
REQ-14-W2-77-OP-025	The FCI shall provide the capability for an IPS host to query and receive the IPv6 address of a peer host using its generic host name (e.g. Ground Facility Designator, GUFI, or other)	REQ.14.77-TS-ABRT-0018	Addressing on the A-R datalink interfaces
		REQ.14.77-TS-GENR-0005	FCI Addressing
REQ-14-W2-77-OP-026	The FCI shall provide mobile connectivity among IPS hosts served by a federation of multiple, independent CSPs	REQ.14.77-TS-INT9-0023	IF9 interface - scope
		REQ.14.77-TS-IPMB-0007	GB-LISP Route Management - metric change notification
		REQ.14.77-TS-IPMB-0010	Route metric monitoring

EUROPEAN PARTNERSHIP

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Requirement ID	Requirement description	TS-IRS Requirement ID	Req. Title
REQ-14-W2-77-OP-027	The FCI shall support monitoring of A/G data links in the access networks available for communication with A/C, including at a minimum UP/DOWN status.	REQ.14.77-TS-MLNK-0033	Link Status
		REQ.14.77-TS-MLNK-0032	Link Quality Metric Definition - LDACS
		REQ.14.77-TS-MLNK-0031	Link Quality metric definition - SATCOM
		REQ.14.77-TS-MLNK-0030	Link Quality Metric Definition - AeroMACS
		REQ.14.77-TS-MLNK-0034	Link Quality metric definition – VDLM2
REQ-14-W2-77-OP-028	The FCI shall support signalling of link monitoring status from A/C to ground infrastructure.	REQ.14.77-TS-MLNK-0023	Exchange A/G datalink status to the AC-R
		REQ.14.77-TS-MLNK-0027	Radio Link Quality and AC-R Metric definition
		REQ.14.77-TS-ABRT-0004	A/G Datalink status monitoring
		REQ.14.77-TS-INT2-0011	IF2 interface - status message content
REQ-14-W2-77-OP-029	The FCI shall support link selection policy depending on the application type, including: - ATS dictated by ATSP - AOC dictated by the airspace user (A/C or FOC)	REQ.14.77-TS-MLNK-0001	Multilink Administrative Policy Selection
		REQ.14.77-TS-MLNK-0018	Performance- based Multilink combined with Administrative Policy
		REQ.14.77-TS-MLNK-0022	Multilink Policy and GB-LISP metrics
		REQ.14.77-TS-IPMB-0009	DL section Policy for Ground End User

Requirement ID	Requirement description	TS-IRS Requirement ID	Req. Title
REQ-14-W2-77-OP-030	The FCI shall support link selection for A/G communications among available access networks, which does not result in a loss of ATS services, based on: - Administrative policy and/or - Link performance based on link status monitoring	REQ.14.77-TS-MLNK-0001	Multilink Administrative Policy Selection
		REQ.14.77-TS-MLNK-0002	Multilink Administrative Policy criteria
		REQ.14.77-TS-MLNK-0003	Multilink Administrative Policy and End User Preference
		REQ.14.77-TS-MLNK-0004	Multilink Policy Configuration
		REQ.14.77-TS-MLNK-0005	Multilink AD Policy management
		REQ.14.77-TS-MLNK-0018	Performance- based Multilink combined with Administrative Policy
REQ-14-W2-77-OP-031	The FCI shall support link selection override by manual selection of data or voice communications in the case of a degraded link performance, or for testing and validation purposes	REQ.14.77-TS-SEC-0040	Fallback to Analogue Voice Communications
		REQ.14.77-TS-SEC-0044	Manual switch off of ATN/IPS communication
		REQ.14.77-TS-SEC-0050	Graceful degradation of air-ground communication on unavailable ATN/IPS communication
REQ-14-W2-77-OP-032	The mobile node (aircraft) IPS host shall provide situational awareness about connectivity services	REQ.14.77-TS-MLNK-0004	Multilink Policy Configuration
		REQ.14.77-TS-MLNK-0005	Multilink AD Policy management
		REQ.14.77-TS-MLNK-0018	Performance- based Multilink combined with Administrative Policy
REQ-14-W2-77-OP-033		REQ.14.77-TS-SEC-0044	Manual switch off of ATN/IPS communication

Requirement ID	Requirement description	TS-IRS Requirement ID	Req. Title
	The mobile node (aircraft) IPS host shall provide means to intervene on connectivity services when necessary	REQ.14.77-TS-SEC-0050	Graceful degradation of air-ground communication on unavailable ATN/IPS communication
		REQ.14.77-TS-SEC-0039	Policy Rules for Configuration of the MSE (MS/MR)
		REQ.14.77-TS-SEC-0041	Alternative Transport Infrastructure
		REQ.14.77-TS-SEC-0040a	DoS alarm and Analog voice backup contingency plan
		REQ.14.77-TS-SEC-0032	Automated DoS Alarm
REQ-14-W2-77-OP-034	The CSP providing the MSP should operate a Network Operations Centre (NOC) with a 7/24 continuous human supervision	REQ.14.77-TS-SEC-0048	Security Zone Separation of NOC and SOC
		REQ.14.77-TS-SEC-0046	Traffic Monitoring
		REQ.14.77-TS-SEC-0038	FCI Network Management System
		REQ.14.77-TS-SEC-0034a	Automated Alarm for Network Management Access
		REQ.14.77-TS-SEC-0033	Intrusion Detection of physical access to network devices
		REQ.14.77-TS-SEC-0032	Automated DoS Alarm
REQ-14-W2-77-OP-035	The ATM service providers should operate a Network Operations Centre (NOC) with a 7/24 continuous human supervision	REQ.14.77-TS-SEC-0048	Security Zone Separation of NOC and SOC

Requirement ID	Requirement description	TS-IRS Requirement ID	Req. Title
		REQ.14.77-TS-SEC-0038a	Normal Configuration Operation only via Network Management System
		REQ.14.77-TS-SEC-0034a	Automated Alarm for Network Management Access
		REQ.14.77-TS-SEC-0033	Intrusion Detection of physical access to network devices
		REQ.14.77-TS-SEC-0032	Automated DoS Alarm
REQ-14-W2-77-OP-036	FCI shall support traffic classification for packet forwarding and routing policy	REQ.14.77-TS-IPMB-0008	Link Quality Mapping on Route Metric
		REQ.14.77-TS-MLNK-0019	Multilink QoS management
		REQ.14.77-TS-MLNK-0020	Multilink policy and preferences management (path selection)
		REQ.14.77-TS-ABRT-0010	Multiple air-ground datalink usage
REQ-14-W2-77-OP-037	The FCI shall support the following QoS functions: - Data rate guarantee for required applications (e.g. Digital Voice) - Packet differentiation, prioritization, and pre-emption in situations of congestion - Packet scheduling to support applications with different latency budgets	REQ.14.77-TS-IPMB-0008	Link Quality Mapping on Route Metric
		REQ.14.77-TS-MLNK-0019	Multilink QoS management
		REQ.14.77-TS-MLNK-0020	Multilink policy and preferences management (path selection)
		REQ.14.77-TS-ABRT-0010	Multiple air-ground datalink usage
		REQ.14.77-TS-ABRT-0013	Class of Service recognition

Requirement ID	Requirement description	TS-IRS Requirement ID	Req. Title
		REQ.14.77-TS-ABRT-0014	Prioritization
REQ-14-W2-77-OP-038	The FCI shall provide protection against intentional breach of integrity and mis-delivery for safety-critical applications.	REQ.14.77-TS-SEC-0005	Airborne IPS System security - DoS protection
REQ-14-W2-77-OP-039	The FCI shall provide security measures to protect and mitigate against Denial of Service attacks	REQ.14.77-TS-SEC-0005	Airborne IPS System security - DoS protection
		REQ.14.77-TS-SEC-0007	General Security Principles: MITM protection.
		REQ.14.77-TS-SEC-0009	FCI Air Interface hardening - Authentication server
		REQ.14.77-TS-SEC-0014	IF9 message security
REQ-14-W2-77-OP-040	The FCI shall provide protection against interception of confidential information for network control and system management data	REQ.14.77-TS-GENR-0008	General Security Principles: penetration attacks protection
		REQ.14.77-TS-SEC-0014	IF9 message security
		REQ-PJ14.77-TS-SEC-0015	IF_S_1 interface
		REQ-PJ14.77-TS-SEC-0016	IF_S_2 interface
REQ-14-W2-77-OP-041	The FCI shall provide ground accommodation of: - ATN/OSI equipped aircraft for ATS communication with IPS host	REQ.14.77-TS-GTWs-0001	OSI-IPS DS Gateway: general
		REQ.14.77-TS-GTWs-0002	OSI-IPS DS Gateway: architecture

Requirement ID	Requirement description	TS-IRS Requirement ID	Req. Title
	- FANS1/A equipped aircraft for ATS communication with IPS host - IPS equipped aircraft for ATS communication with FANS or ATN/OSI endpoint	**REQ.14.77-TS-GTWs-0003**	**OSI-IPS DS GTW Scope**
		REQ.14.77-TS-GTWs-0005	**OSI-IPS DS GTW Transparency**
		REQ.14.77-TS-GTWs-0006	**OSI-IPS DS GTW IPS Standard**
		REQ.14.77-TS-GTWs-0007	**OSI-IPS DS GTW IPS: interface to OSI Domain (IF8)**
		REQ.14.77-TS-GTWs-0008	**OSI-IPS DS GTW IPS: interface to IPS Domain (IF5)**
REQ-14-W2-77-OP-042	**The FCI shall provide integration and interfacing to ensure effective and secure G/G data exchange between civil and military stakeholders**	REQ Not specified	**Note:** The ground-ground CIL-MIL GW is developed by Pj14-W2-101 GREEN SWIM Profile and the integration Requirement are specified by s by Pj14-W2-101 solution.
REQ-14-W2-77-OP-043	**The FCI shall interface with other IP networks (e.g. U-Space, commercial networks) implementing the appropriate mechanisms for inter-domain routing and security.**	REQ Not specified	**Note:** The Hyper Connected ATM Gateways will provide appropriate mechanism for inter domain routing capabilities but currently Functional REQ are not reported in the FCI TS-IRS.

Appendix E Requirements PJ14.02.04 (W1) discontinued and deleted in solution PJ14-W2-77 (W2)

General requirements deleted

[REQ]

Identifier	REQ-PJ14.02.04-TS-GENR-0010
Title	FCI Air Interface hardening - equipment
Requirement	Airborne Radio shall authenticate towards the Wireless Access Subnet Ground Infrastructure (and vice-versa) according to the procedures established for each subnet
Status	<deleted>
Rationale	*Please refer to the risk analysis performed in D5.1.020.2 "SESAR2020 FCI Transversal and Complementary Studies".* This Requirement is deleted, and its statement has merged in REQ.14.77-TS-SEC-0009.
Category	<Security>

[REQ]

Identifier	REQ-PJ14.02.04-TS-GENR-0017
Title	FCI Safety Requirements: A-R radio link management
Requirement	The ATN/IPS routing function shall be robust in maintaining communication despite misbehaviours of individual wireless access subnetwork (at subnetwork level)
Status	<deleted>
Rationale	*As an example, undetected corrupted transmission, undetected loss, or excessive delay.* This requirement was introduced together with the IF7 Safety-Net function, since the solution has now discontinued IF7 and replaces it with IF9 (AGMI), therefore this requirement is removed.
Category	<Safety>

[REQ]

Identifier	REQ-PJ14.02.04-TS-GENR-0024
Title	FCI Air Interface hardening - equipment
Requirement	A/G-R link with Wireless Access Subnet shall be protected by means of authentication.
Status	<deleted>
Rationale	This requirement is removed since it is duplicated by REQ.14.77-TS-SEC-0009. *Please refer to the risk analysis performed in D5.1.020.2 "SESAR2020 FCI Transversal and Complementary Studies"* *Mutual authentication over the "air interface" of each radio link does not cover the interface between ATN-IPS ground infrastructure*
Category	<Security>

IP Mobility requirements deleted

[REQ]

Identifier	REQ-PJ14.02.04-TS-IPMB-0005
Title	G-LISP Route Optimization: summarized route
Requirement	A "summarized route" (i.e. a /56 ICAO prefix) shall be sent from A-R to the A/G-R with a large metric on IF7, in order to avoid delayed registrations of airborne EID on A/G-R
Status	<deleted>
Rationale	This requirement was addressing an implementation issue of the Cisco routers, rather than a functional need of the GB-LISP protocol itself. This requirement has been removed. *LISP registration for a visiting Aircraft needs to be finished in the A/G-R before the A/G-R starts accepting downlink traffic from the Aircraft.* *The drawback of the summarized route is late rejection (=on the A/G-R instead of G/G-R) of uplink traffic towards an A/C which is currently not connected*
Category	<Functional>

Airborne requirements deleted

[REQ]

Identifier	REQ.14.77-TS-ABRT-0016
Title	Flow Control
Requirement	The Airborne Router should implement flow control mechanisms for its air-ground datalink interfaces
Status	<deleted>
Rationale	Discontinued since this is not considered and supported by the AIAP protocol. A-R internal mechanism to manage packet congestion on radio link interfaces.
Category	<Functional>

[REQ]

Identifier	REQ-PJ14.02.04-TS-ABRT-0017
Title	Air-ground L3 connectivity verification
Requirement	The Airborne Router should implement a method for verification of L3 connectivity to A/G-R of each available air-ground datalink.
Status	<deleted>
Rationale	The IF7 interface has been discontinued and the L3 mechanism isn't supported in the IF9 interface for performance reasons. *Indeed, this is implemented via IF7 HELLO packet exchange*
Category	<Functional>

[REQ]

Identifier	REQ.14.77-TS-MLNK-0012
Title	Multilink performance monitoring
Requirement	The A-R (Airborne Router) Functional Block shall include a dedicated function to monitoring datalink performance (W-DP), which will consider at a minimum these parameters: - Link Quality (LQ), - datalink data latency, - E2E delay.
Status	<in progress>
Rationale	In Wave 1, this requirement had been defined in scope of the old Interface IF7, now superseded by IF9 (AGMI), which is not designed to support this requirement.
Category	<Functional>, <Performance>

[REQ]

Identifier	REQ.14.77-TS-MLNK-0013
Title	Multilink performance monitoring and refresh rate
Requirement	The Multilink Management Function (MMF) should evaluate the DLs performance parameters (W-PL) dynamically and with a configurable refresh rate.
Status	<in progress>
Rationale	In Wave 1, this requirement had been defined in scope of the old Interface IF7, now superseded by IF9 (AGMI), which is not designed to support this requirement
Category	<Functional>, <Performance>

FCI multilink requirements deleted

In the table is described the mapping among the current TRL6 requirements described in this paragraphs and the W1 Multilink requirements after the input provided by the ConOps [2] document.

W1 MLNK requirements	Requirements status
REQ-PJ14.02.04-TS-MLNK-0006	deleted and merged in REQ.14.77-TS-MLNK-0019
REQ-PJ14.02.04-TS-MLNK-0007	deleted and merged in REQ.14.77-TS-MLNK-0002
REQ-PJ14.02.04-TS-MLNK-0009	deleted and merged in REQ.14.77-TS-MLNK-0001

REQ-PJ14.02.04-TS-MLNK-0010	deleted and merged in REQ.14.77-TS-MLNK-0002
REQ-PJ14.02.04-TS-MLNK-0011	deleted and merged in REQ.14.77-TS-MLNK-0019 and REQ.14.77-TS-MLNK-0020
REQ-PJ14.02.04-TS-MLNK-0014	deleted
REQ-PJ14.02.04-TS-MLNK-0015	deleted
REQ-PJ14.02.04-TS-MLNK-0016	deleted
REQ-PJ14.02.04-TS-MLNK-0017	deleted
REQ-PJ14.02.04-TS-MLNK-0021	deleted and merged in REQ.14.77-TS-MLNK-0002
REQ-PJ14.02.04-TS-MLNK-0024	deleted and merged in REQ.14.77-TS-MLNK-0002
REQ-PJ14.02.04-TS-MLNK-0025	deleted
REQ-PJ14.02.04-TS-MLNK-0026	deleted
REQ-PJ14.02.04-TS-MLNK-0029	deleted - Reason: "VDLm2 new standard is under evaluation in ARINC 613"
REQ-PJ14.02.04-TS-MLNK-0034	deleted and merged in REQ.14.77-TS-MLNK-0023
REQ-PJ14.02.04-TS-MLNK-0035	deleted and merged in REQ.14.77-TS-MLNK-0023

Interface requirements deleted

[REQ]

Identifier	REQ- PJ14.02.04-TS-ESIF-0003
Title	IF1 & IF5 security requirements
Requirement	In case IF1 is interfacing the ATC End System, no additional security measurements shall be required, as it is in the segregated domain. In case IF1 is interfacing an End System which is not within the segregated domain, security shall be implementation-dependent (Airborne manufacturer) IF5 security measurements (e.g. ACL and firewall) shall be implementation dependent (ANSP responsibility)
Status	<deleted>
Rationale	Discontinued since this requirement reports conditions that are related of A/C architecture and Airborne manufactures. *As a direct consequence of Airborne and ANSP End Systems architecture*
Category	<Interface>

[REQ]

Identifier	REQ- PJ14.02.04-TS-INT2-0006
Title	IF2 interface - Data Messages
Requirement	Data messages are those messages that are transmitted / received through the Air Interface. There shall be two messages types: a1) Messages flowing between the two End Systems, these are addressed with source and destination End System addresses; a2) Messages flowing between the A-R and the A/G-R.
Status	<deleted>
Rationale	This requirement is included in the REQ.14.77-TS-INT2-0005 *Airborne router needs to manage radio status information, routing information and route data.*
Category	<IER>, <Interface>

[REQ]

Identifier	REQ- PJ14.02.04-TS-INT2-0010
Title	IF2 interface - C-HELLO
Requirement	C-HELLO shall contain status and Link Quality information to be exchanged between the A-R and each Airborne Radio
Status	<deleted>
Rationale	Requirement is discontinued since the description has merged in REQ.14.77-TS-INT2-0011. *Please refer to AIAP interface document for more details.*
Category	<IER>, <Interface>

[REQ]

Identifier	REQ- PJ14.02.04-TS-INT2-0014
Title	IF2 interface - protocol layers
Requirement	L1 and L2 layers supporting the IF2 interface shall not be "a-priori" defined, as they depend on Airborne System architecture (e.g. Ethernet or Arinc 429)
Status	<deleted>
Rationale	Discontinued: with this rationale: "the REQ is dependent of Aircraft architecture". *FCI cannot impose any constraint on Airborne internal connectivity. However, prototypes shall implement Ethernet IEEE802.3 Layer*
Category	<Interface> , <IER>

Airborne requirements deleted

[REQ]

Identifier	REQ.14.77-TS-ABRT-0006
Title	CoS support by air-ground datalink awareness
Requirement	The Airborne Router shall be aware of Classes of Service supported by each of the air-ground datalinks.
Status	<in progress>
Rationale	Mandatory for Multilink operations
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
< ALLOCATED_TO >	<SESAR Solution>	PJ14-W2-77
< ALLOCATED_TO >	<Enable r>	CTE-C04
<ALLOCATED_TO>	<Functional block>	A-R
<ALLOCATED_TO>	<Function>	
<ALLOCATED_TO>	<System>	Aircraft

In this table is described the mapping of TRL4 IF requirements discontinued after the input provided by the new AGMI (IF9) protocol.

W1 INT requirement	Requirement status
REQ-PJ14.02.04-TS-INT7-0024	discontinued since a new IF9 (AGMI) interface is defined
REQ-PJ14.02.04-TS-INT7-0025	discontinued since a new IF9 AGMI interface is defined
REQ-PJ14.02.04-TS-INT7-0026	discontinued since a new IF9 AGMI interface is defined
REQ-PJ14.02.04-TS-INT7-0027	discontinued since a new IF9 AGMI interface is defined
REQ-PJ14.02.04-TS-INT7-0028	discontinued since a new IF9 AGMI interface is defined
REQ-PJ14.02.04-TS-INT4-0031	The GDOI protocol isn't supported in the new GB-LISP report [39]
REQ-PJ14.02.04-TS-INT4-0032	The [LISP-SEC] includes the usage of ephemeral one-time-keys (OTK) and shared key message authentication.
REQ-PJ14.02.04-TS-INT4-0035	The GDOI protocol isn't supported in the new GB-LISP report [39]
REQ-PJ14.02.04-TS-INT4-0036	"The GDOI protocol isn't supported in the new GB-LISP report[39]