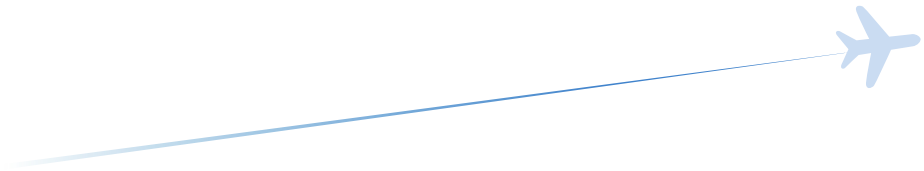

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Copyright Statement

PJ14 EECNS

[EECNS - ESSENTIAL AND EFFICIENT COMMUNICATION NAVIGATION AND SURVEILLANCE INTEGRATED SYSTEM]

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Abstract

This document represents the (Essential and Efficient Communication Navigation and Surveillance Integrated system). This document describes all the activities performed in PJ14 EECNS at European Level in order to avoid a fragmented approach and to ensure the interoperability as depicted in the ICAO Global Air Navigation Plan (GANP). For the aim to act as a single entity, and to pursue its defined objectives, in an unambiguous manner, PJ14 EECNS has provided itself with a transversal solution which provides CNS evolution roadmap and strategy and addresses the evolution of CNS applications with integrated view of the three domains, Communication, Navigation and Surveillance.

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Executive Summary

Communication, Navigation and Surveillance (CNS) systems provide the infrastructure and services that are essential for Air Traffic Management (ATM). CNS enables efficient navigation and safe separation in all phases of flight. Although current CNS systems are mature and globally providing a good service, SESAR is working towards the technological transition phases required to reach the objectives of the SESAR Concept of Operations in terms of safety and efficiency, whilst addressing quality of service, cost effectiveness and environmental impact. All the ATM elements will require an underlying supporting infrastructure including communication, navigation and surveillance capabilities that are adapted to support the concept elements in a cost and spectrum efficient way.

PJ14 EECNS - Essential and Efficient Communication Navigation and Surveillance integrated system – deals with these infrastructures.

iCNSS - Evolution, Strategy, roadmap and Spectrum

All the activities performed in PJ14 CNS have been developed at European Level in order to avoid a fragmented approach and to ensure the interoperability as depicted in the ICAO Global Air Navigation Plan (GANP).

With the aim to act as a single entity, to pursue its defined objectives in an unambiguous manner, PJ14 CNS includes a transversal solution PJ14-01-01. This solution provides the "CNS evolution strategy & roadmap" and addresses the evolution of CNS applications with an integrated view of the three domains, Communication, Navigation and Surveillance, whilst also considering spectrum efficiency aspects (i.e. iCNSS). In addition, it provides initial versions for the integrated performance approach and robustness analysis.

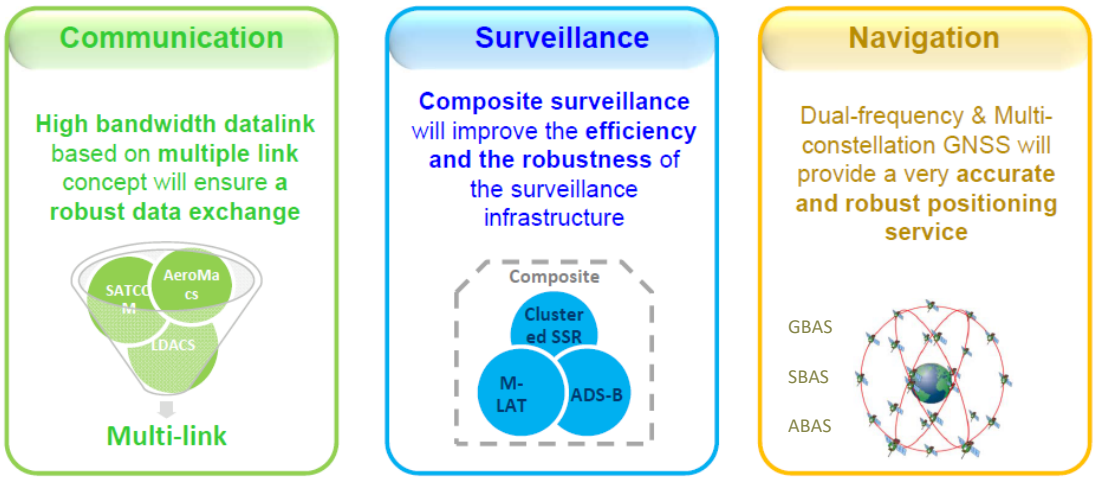


Figure 1 CNS & PJ14 solutions

Communication Domain

The Future Communication Infrastructure (FCI) concept envisions the use of multilink technologies enabling the digital transfer of flight critical data between aircraft and ground ATM services. The ultimate objective is to provide from ATM through to Airspace Users with the digital communications means required to cope with the forecast traffic growth.

In this optic, the communication transversal solution PJ14-02-04 achieved an overall Technical Readiness Level 4 (TRL4) maturity level, demonstrating support of symmetric communications addressing Terrestrial, Satellite and Airport datalinks within a multilink environment to a mobile end system. It integrates the prototyped and technically validated concepts of:

- The Terrestrial System L-band Digital Aeronautical Communication System (LDACS), as outcome of solution PJ14-02-01, which provides two different communication possibilities:
  - Air/Ground datalink using ATN/IPS reaching TRL4. Technical feasibility of this terrestrial system is demonstrated through technical validation of prototypes against the required performance levels.
  - Air/Air Functionality of the LDACS A/G radio reaching TRL2. Functional requirements have been defined for the system to support mid-air communication between different aircrafts.
- The long-term Satellite Communications System (SATCOM Class A), as outcome of solution PJ14-02-02 reaching TRL4. It provides an IPS based datalink technology ready to support both continental and oceanic regions.
- The Aeronautical Mobile Airport Communication System (AeroMACS), as outcome of solution PJ14-02-06 reaching TRL6 in a multilink context. Successful integration of AeroMACS with ATN/OSI and ATN/IPS networks in both stand-alone and multilink contexts, together with support to Digital Voice communications, conclude that AeroMACS is ready to be completely rolled-out by the European ATM stakeholders. It was noted that there was a risk of losing the spectrum allocated to AeroMACS in the coming years if not used.

As a complement for the communication domain, solution PJ14.02.05 has investigated suitable means to provide flight and traffic information to General Aviation pilots in order to increase safety in mixed traffic environment. The solution has reached V2 maturity level.

Navigation Domain

The vision of the Navigation domain solutions is to improve all phases of flight with suitable integrity, continuity and availability to support the evolution of Air Traffic. Satellite navigation based robust positioning has been developed for all phases of flight, taking advantage of signals from dual frequency and multiple constellations such as Global Positioning System (GPS) and GALILEO with different types of augmentations. The emphasis has been on the provision of 3D Approach guidance targeting the lowest approach minima.

The navigation solutions contribute as follow:

- PJ14-03-01 has investigated GPS Single Frequency Ground-Based Augmentation System (GBAS) and Dual Frequency GPS and GALILEO GBAS. The objective behind the solution PJ14.03.01 was to advance the GBAS Approach Service Type D (GAST-D) concept, currently TRL6, to address “Extended Scope”, namely Complex Airports and Extended to High/Mid Latitudes reaching TRL4 and “Extended Service Volume (ESV)” reaching TRL6 ongoing at the end of Wave 1. The target maturity of GBAS GAST F at the end of Wave 1 has been TRL4 on-going through the Consolidation of the GAST-F Concept and related specifications
- PJ14-03-02 solution has investigated Dual Frequency Multi Constellation augmented by Aircraft-Based Augmentation System (ABAS) and Satellite-Based Augmentation System (SBAS). In parallel, evolution of terrestrial navigation systems has been explored, to ensure that resilient

performance based navigation services are available to mitigate the vulnerabilities of satellite navigation. The solution has achieved the TRL4 maturity contributing to a significant number of SESAR Operational Improvements.

- PJ14-03-04 solution investigated short, medium and long term Alternate Positioning Navigation and Timing (A-PNT) services finalized to provide efficient navigation during Global Navigation Satellite System (GNSS) outages. It achieved the objective to mature at different levels the following areas:
  - A short-term A-PNT solution relying on the assumption that most of current aircraft DME/DME navigation can support RNP 1 reversion without any modification in the avionics, if the ground infrastructure provides a required level of integrity, and if the flight crew is appropriately trained. The DME/DME solution achieved TRL6.
  - A mid-term A-PNT solution that has explored the capability to fit multi-DME positioning in the existing FMS with RAIM algorithm to fully comply with RNP requirements involving On-Board Performance Monitoring Alerts (OBPMA) features, for the continuation of RNP1 operations in case of GNSS loss, without any operational impact from flight crew or ATC perspective, and using existing DME ground infrastructure. The multi DME positioning solution achieved TRL4.
  - The long-term A-PNT solution builds on new technologies currently not available on board the avionics (LDACS as a navigation system, eDME and eLORAN) to define the functional requirements of the future A-PNT system. This future A-PNT achieved TRL2.

Surveillance Domain

The Surveillance domain envisions enhancing, harmonizing and integrating cooperative and emerging non-cooperative sensors, advanced multi-sensors data fusion capabilities, security related functionality together with enhanced Surveillance Performance Monitoring (SPM) tools.

- Solution PJ14-04-01 addressed the adaptation of SPM methods and tools to take into account the evolution of the emerging standards for the development of a quasi-real time functionality to monitor the surveillance performance at:.
  - Sensor level, for both cooperative and non-cooperative surveillance. The successful integration of the system requirements into four different SPM prototypes has been demonstrated achieving TRL4 maturity.
  - End-to-End level (covering the whole surveillance chain): functional requirements have been defined and validated, allowing achievement of TRL2 maturity.
- Solution PJ14-04-03 addresses the evolution of non-cooperative surveillance systems, like Multi-Static Primary Surveillance Radar (MSPSR) and Video Trackers, and cooperative surveillance systems such as Automatic Dependent Surveillance-Broadcast (ADS-B), Airport and Wide Area Multilateration systems in multiple fronts: composed surveillance systems (i.e. cooperative surveillance + ADS-B and non-cooperative surveillance + ADS-B); multi-sensor data fusion; a new surveillance system for multi remote tower operations; enhanced security functionalities to ensure safe ATM operations; and the phase modulation for ADS-B and Mode S. An overall maturity of TRL4 has been achieved for all these features.

Next steps

- The main objectives from Wave 1 have been achieved with the component elements of C, N and S all reaching TRL4 or above and prepared for development to TRL6 at the end of the next phase. This will facilitate strategic decision-making, based on multiple technological capabilities being available in all CNS fields at the same time, moving towards an Infrastructure Service Based Approach in line with the Airspace Architecture Study (AAS) and 2020 European ATM Master Plan.

- The integrated CNS and Spectrum roadmap will be further updated, to deal with the requirements coming from new operational concepts and supporting technologies, such as Single Pilot Operations. The transition towards a performance and service-based iCNSS will be consolidated in the next phase.

- The Communications solutions will in the next stages aim to bring the multilink concept to TRL6, thus preparing the technological developments to ATN/IPS. Aspects such as backwards compatibility with ATN/OSI, security features and support to operational use cases will be key. The usage of commercial technologies (such as 4G) in the ATM environment will be also investigated along with digital voice.

- GNSS as primary means of Navigation supported by a Minimum Operational Network (MON) of legacy technologies. GAST D extended scope will target TRL6 while GAST F will aim to achieve TRL4, through completion of the conceptual aspects and system functionalities. A number of A-PNT solutions are also in the pipeline to ensure full contingency in case of GNSS outage.

- The Surveillance developments will build on the results achieved in Wave 1 to target for TRL6 maturity for evolution of different types of surveillance systems, as well as the performance monitoring tools.

1 Project Overview

Within SESAR2020, project (PJ)14 – EECNS-(Essential and efficient communication navigation and surveillance integrated system) is researching the next generation of CNS (Communication Navigation and Surveillance) technologies in a manner focused on the needs of the Single European Sky (SES), whilst taking account of the global nature of the aviation industry.
Communication, Navigation and Surveillance systems provide the invisible and often unappreciated infrastructure which is essential for Air Traffic Management, ATM Network Services, Airport Services and Aeronautical Info Services, enabling efficient navigation and safe separation in all phases of flight.

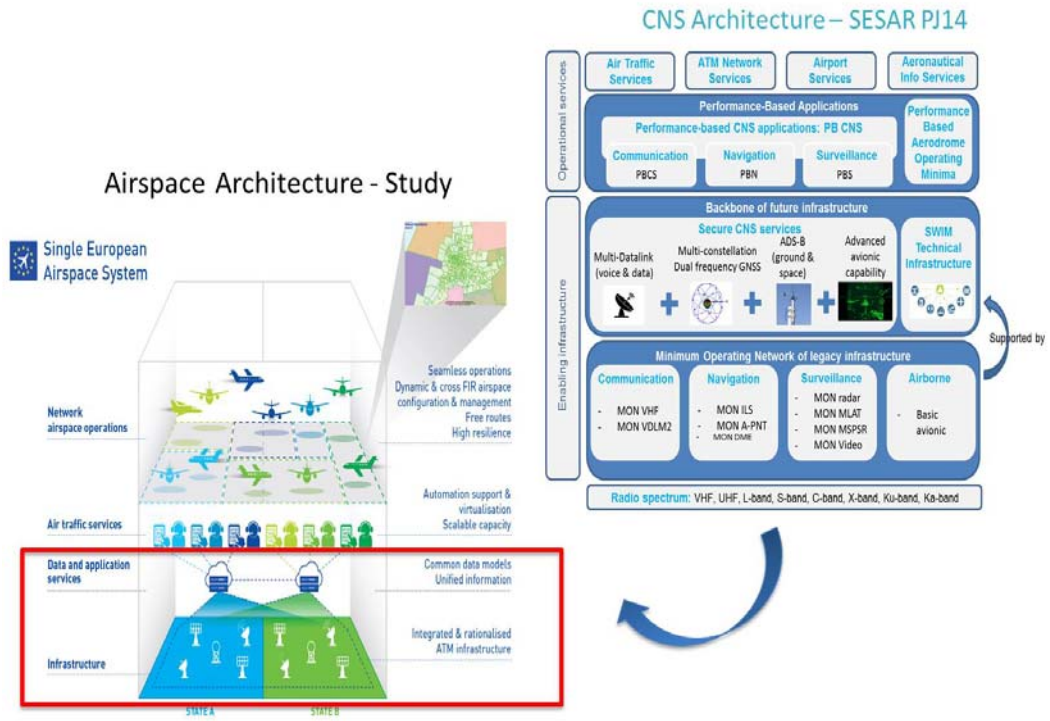


Figure 2

The key ambition of the PJ14 EECNS can be summarized in the intention to act as unique entity, to intervene exactly where CNS needs to evolve, by driving this evolution.
The scope is to improve the quality of service to the travelling public, whilst reducing cost and environmental impact. Although current CNS systems are mature and generally providing a good service, they have not yet fully transitioned from analogue to digital technologies. Such a shift is needed to meet the challenges of the coming years, to accommodate higher levels of traffic and improve operational efficiency.
Many CNS technologies have been developed in a modular fashion. As a result a transition to network thinking is needed to overcome the inefficiencies of fragmented services whilst supporting local needs. Building on the experience of SESAR1, the EECNS has developed and integrated suite of CNS technological solutions to meet the requirements of the ATM systems in

the short, medium and long term, with technologies that are consistent with the European ATM Master Plan[1] and ICAO Global Air Navigation Plan[4][6].

Project concept

The future CNS infrastructure can be seen as part of an integrated, holistic system of systems, one of which includes air and ground CNS solutions, converging on a common infrastructure and a unified concept of operations, where possible.

One of the cornerstone for this vision has been represented by the role of the PJ14-01-01 solution as integrated CNS, which has provided CNS evolution roadmap and strategy. PJ14-01-01 has given the global view of the future Communications, Navigation and Surveillance services, with the associated paths for systems integration.

In the Integrated EECNS solution, all CNS developments have been benchmarked and aligned to ensure the solutions are consistent in terms of robustness, spectrum use, interoperability and operational service quality for all airspace users, including military.

SESAR developments are based on four Key Features, as described in the European ATM Master Plan [1]:

- Optimised ATM Network services
- Advanced air traffic services
- High-Performing airport operations
- Enabling aviation infrastructure

PJ14 EECNS, as one of the enabling aviation infrastructure projects, aims at providing advanced, integrated and rationalised aviation infrastructure for Communication, Navigation and Surveillance (CNS), supporting the first three Key Features, and providing the underlying technical capabilities to meet the operational improvements.

More in detail, the overview of the aims for each single CNS domain, as for the available technological features, is summarized below.

Communication domain

This project started the development of multi-link technologies which will underpin the future communications infrastructure (FCI) concept. FCI facilitates the digital transfer of flight-critical data and voice **Communications** between aircraft and ground ATM services in a resilient, secure and timely manner; it also provides interoperability and coordination with military flights. This, in turn, will facilitate ATM automation, reducing both pilot and air traffic controller workloads so that they can focus more on value-added tasks.

The Future Communications Infrastructure (FCI) envisions an integrated air/ground and ground/ground network architecture for high-performance, secure datalink applications supporting modern ATM services for air safety and efficiency.

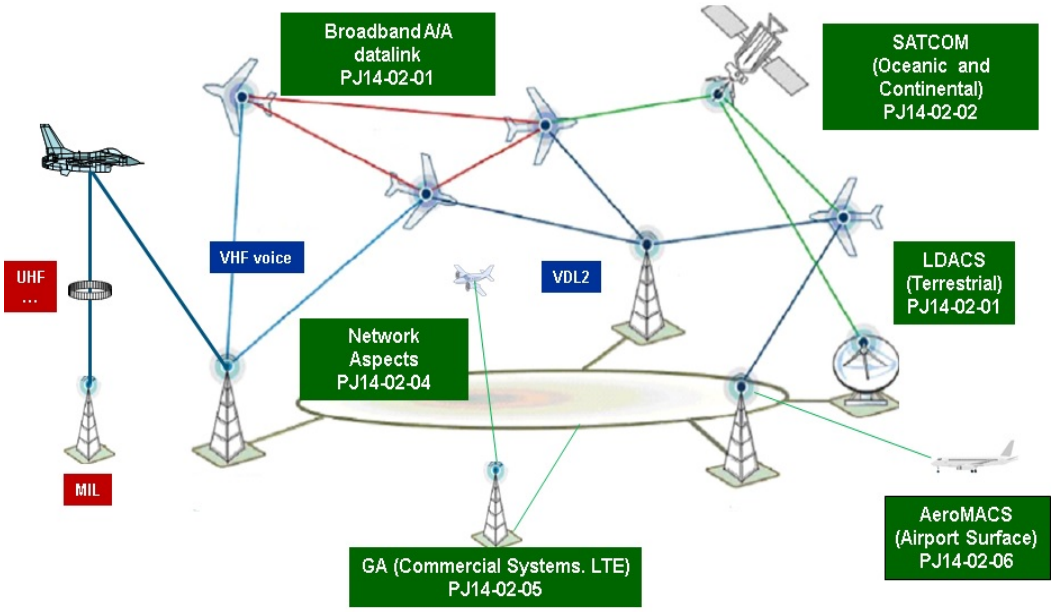


Figure 3 Communication domain

Navigation domain

In **Navigation**, satellite navigation-based robust positioning are developed for all phases of flight, taking advantage of signals from multiple constellations, including Galileo. Strong emphasis is addressed to provide final approach guidance for low approach minima. The development of terrestrial navigation systems is explored to ensure that resilient performance-based navigation services are available from spectrum-efficient systems in order to mitigate the vulnerabilities of satellite navigation.

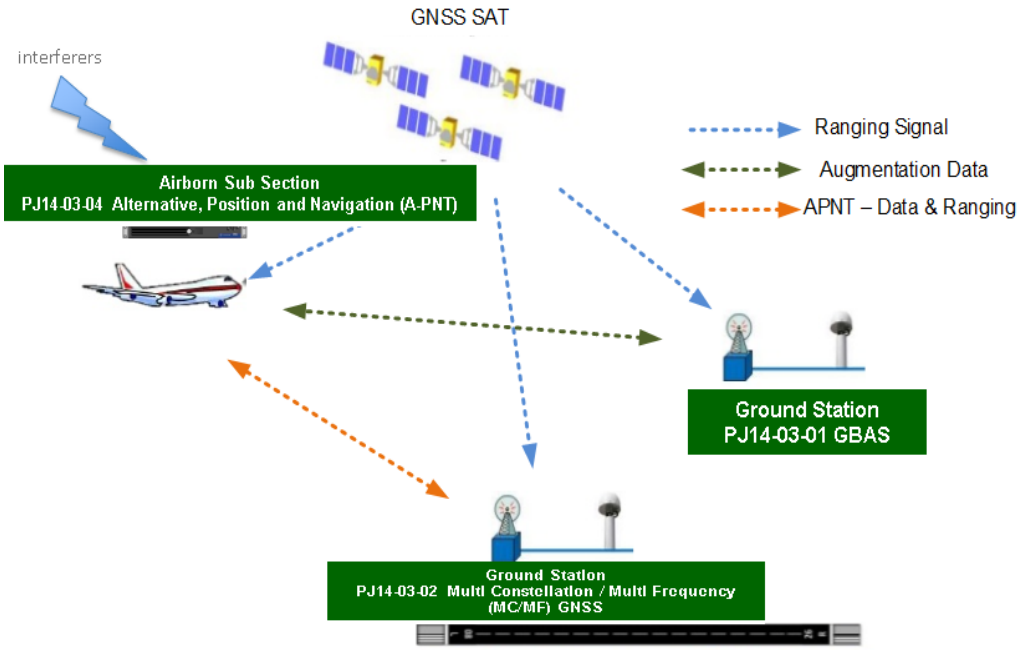


Figure 4 Navigation domain

Surveillance domain

In **Surveillance**, solutions are developed to enhance, harmonise and integrate cooperative and emerging non-cooperative sensors, advanced multi-sensor data fusion capabilities, security-related functionalities together with the methods and tools for surveillance performance monitoring. This is in line with a performance-based surveillance (PBS) approach.

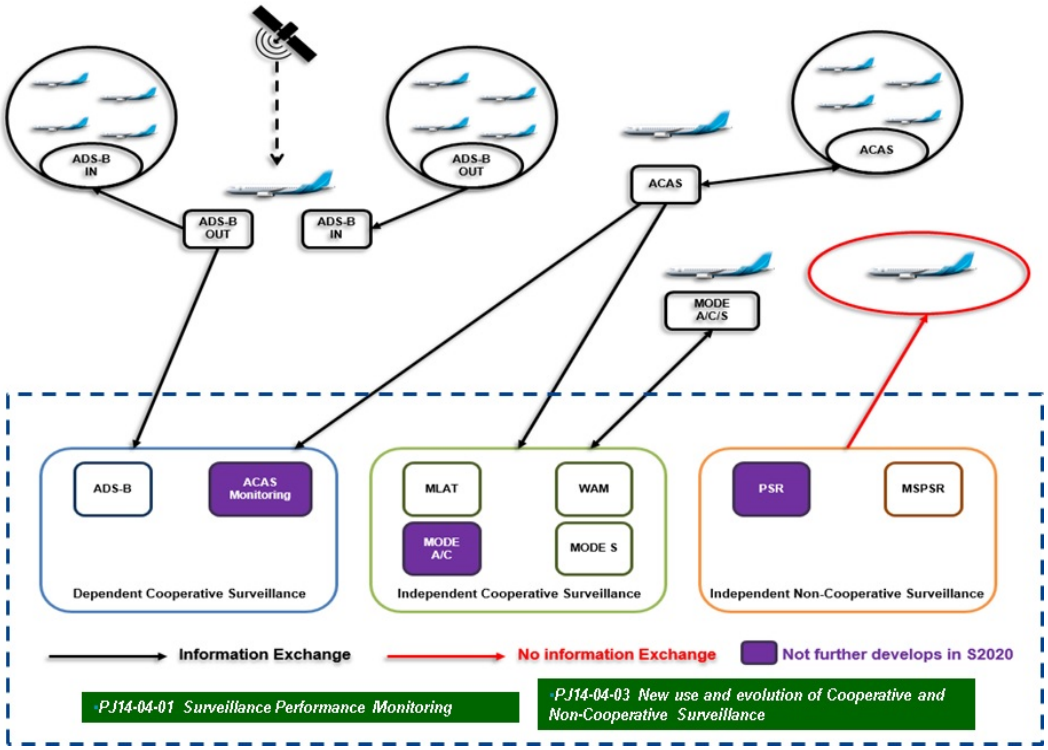


Figure 5 Surveillance domain

1.1 Operational/Technical Context

PJ14 aims to develop and improve solutions able to support the future ATM global system and, according to the timeframe addressed by the ATM Master Plan, mainly in:

- surface data sharing to allow for exchanging huge amount of data exchange for effective and efficient airport operations and awareness;
- new data communications infrastructure to reduce the air traffic controllers (ATCOs) workload avoiding misunderstandings and improve efficiency;
- collaborative air traffic management to support the ATCOs, pilots, airport operators to improve situation awareness;
- optimisation of capacity, flexible use of airspace and turn-around operations to avoid congestion in ATM domain.

All the activities performed in the project are developed at European level in order to avoid a fragmented approach and to ensure the interoperability as depicted in the ICAO Global Air Navigation Plan (GANP). The CNS technologies support the GANP in terms of airport operations,

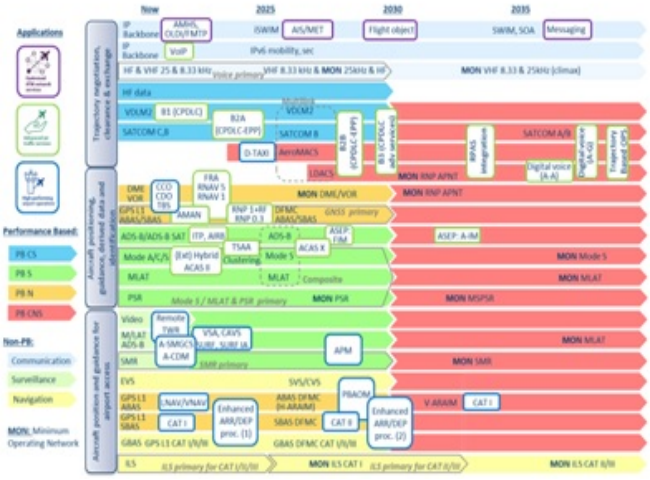
globally interoperable system data, optimum capacity and flexible flights. The main stakeholders are fully involved to ensure that all the operational needs are duly considered.

Technological and performance requirements for CNS systems are becoming increasingly complex and demanding.
Referring to the three domains of development of the project, the picture below presents the complete set of solutions.

1.2 Project Scope and Objectives

PJ14-01-01 CNS Environment Evolution

The SESAR Solution PJ14-01-01 was introduced as transversal solution with the aim to harmonize, where beneficial, C, N, S concepts in order to ensure a more optimized CNS service provision. The integrated CNS concept has been addressed through four main axes:

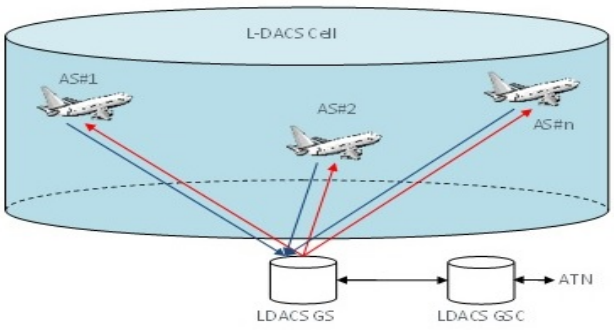


- CNS evolution roadmap and strategy: any large CNS evolution needs to be coordinated amongst all stakeholder in a stepped approach
- Performance Based integrated CNS to pave the way for a future integration of the individual C, N, and S performance-based concept being currently developed
- CNS robustness to identify s the robustness concept of an integrated CNS domain
- Civil-Military CNS information exchange requirements: civil military is a key element of any large CNS/ATM evolution.

1.2.1 Communication Domain

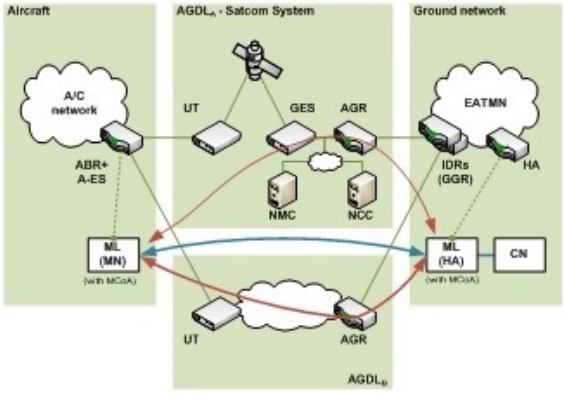
PJ14-02-01 Future Communication Infrastructure (FCI) Terrestrial Data Link

Solution PJ14.02.01: FCI Future Terrestrial Data Link has the objective to develop and standardize the candidate future terrestrial data link system, called LDACS. The goal of this solution is to make progress in developing and standardizing the LDACS technology. To achieve these goals, the solution will develop and verify LDACS prototypes. The



prototypes will be made available to Solution PJ14-02-04 for integration into an FCI validation platform. Solution PJ14-02-01 will also address transversal topics and concepts, including the seamless transition from existing data link technologies to LDACS and the inclusion of a ranging functionality. PJ14-02-01 aims to reach TRL4 maturity level for the LDACS A/G data link and TRL2 for the LDACS A/A functionality of new A/G radio, during W1 activities. The LDACS data link, available at the end of W1, shall also support the communication between ATS B2 applications over an L-band air/ground data link communication technology (i.e., LDACS) using the ATN/IPS protocol.

PJ14-02-02 Future Satellite Communications data link



PJ14.02.02 Future Satellite Communications datalink is focused on the definition and validation of near and long term satellite datalink technologies for both continental and oceanic regions.

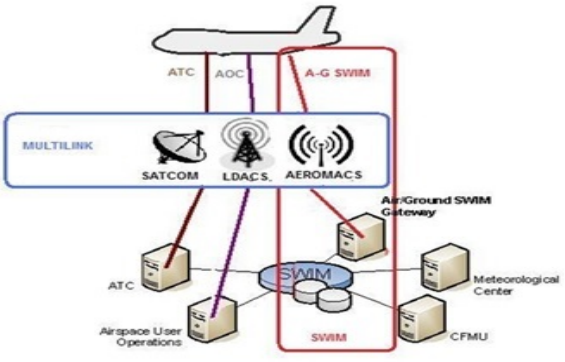
The solution aims to improve and complement the work of SESAR 1 P15.02.06 “Future mobile satellite communications” based on outcomes of SESAR 1 P15.02.05 “i4D via SATCOM”.
The future SATCOM to support the ATM will have to enable the new FCI technologies (i.e. particularly IPS and multilink) and meet any new performance requirements apportioned to SATCOM in the FCI. At the same time the SATCOM will have to retain the backwards compatibility and keep supporting the oceanic data and voice services as well as the ATN/OSI technology. Another specific area of SATCOM is the use of SATCOM voice in oceanic airspace as an alternative to HF.

The main objectives of PJ14-02-02 solution are:

- Definition of Technical Specifications for Long Term SATCOM for ATM (Class A SATCOM) integrated in the FCI (TS-IRS, OSED, SPR, INTEROP);
- Definition of the technical validation procedures and execution of two main validation exercises, aiming to:
  - Validation of Long Term SATCOM (Class A) integrated in the FCI at TRL4;
  - Validation of SATCOM Class B in dual-link mode at TRL6;
- Coordination with ESA Iris Programme.
- Contribution to standardization at the global level (ICAO PT-S and EUROCAE WG-82);

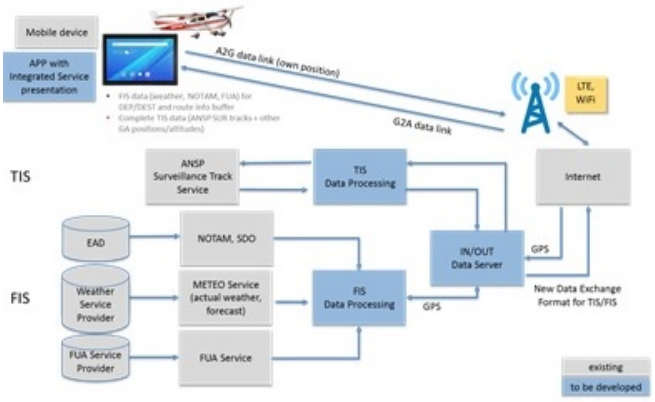
PJ14-02-04 FCI Network Technologies

The objective of PJ14-02-04 project 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 IP-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 SATCOM, LDACS, and AeroMACS.
The FCI and the data links should also be able to support new voice functionality (e.g. sector-less voice communication) as well as civil-military coordination through the ground/ground communication segment.
The exchange of AOC data between the flight crew and the Airline's Operational Control Centre and data exchange with ANSPs for flight regularity and efficiency purposes also plays an important role during the execution of the flight for which the SWIM mechanism will be used.
The need for higher data link communication capacity and better performance has therefore arisen and for this to happen, a new IP-based Future Communication-Infrastructure (FCI) and new broadband A/G data links are required. Long-term SATCOM, LDACS, and AEROMACS are the new future data links, envisioned by ICAO, SESAR and NextGen (USA). The flexible, resilient, efficient use of these multiple links requires the definition and specification of the mobility and multilink functions.

PJ14-02-05 Development of new services similar to FIS-B to support ADS-B solutions for General Aviation.



SESAR2020 solution PJ14-02-05 aims to provide additional information to General Aviation (GA) pilots during flight. Based on their pre-flight preparation, they will receive updated information on-board of their GA aircraft like weather data, NOTAM, FUA information and traffic information. This real-time information during flight will be displayed on mobile devices like tablets, which GA pilots carry with them on their aircraft and where a new integrated App will be installed. In this way, the avionics of the GA aircraft will not need to be modified or re-certificated, but the service will provide a low-cost solution for GA pilots.
The main technological means to enable GA pilots to receive updated FIS/TIS information during flight and to get them displayed on the screen of their mobile devices is a new data link for altitudes between 1,000 ft. AGL up to 10,000 ft. MSL (or up to 13,000 ft. MSL in mountain areas). This Air/Ground data link will be based on the existing mobile/cellular LTE network, but will use new, up-tilted antennas in order to cover GA altitudes. Easy access and connection of the mobile device to the selected mobile frequency of this adapted LTE network will be enabled, once the necessary ground infrastructure has been installed and operated by telecom providers.
Operation of the new App is planned for en-route and approach phases and in all airspace types, where GA aircraft are flying. The defined sub-operating environments are "En-route" and "Terminal airspace". In the long-term, the extended LTE based data link should cover the whole of Europe laterally.
The scope is only to provide a supplementary information means to increase safety, while better understanding the situation around own aircraft so that pilots will be able to adapt easier and faster to new circumstances.

PJ14-02-06 Completion of AeroMACS Development

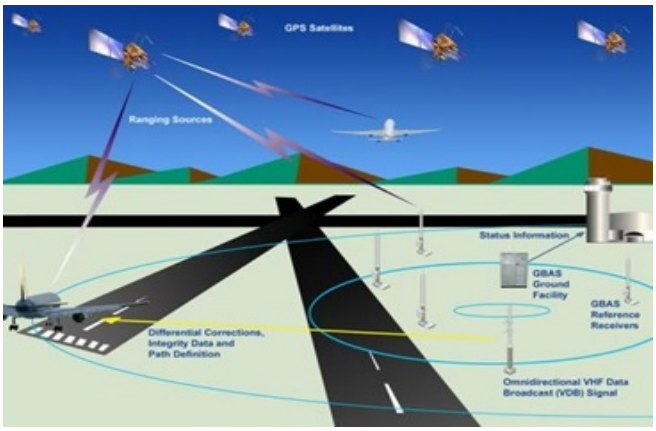
The AeroMACS Solution PJ14-02-06 builds upon the SESAR1 Solution #102, published in the SESAR 1 catalogue (specifically projects P15.02.07 and P9.16, in addition to PJ12.03.04, that investigated the use of D-TAXI with AeroMACS). AeroMACS Solution #102 reached TRL6 Maturity Level as Data Link in SESAR1, however at that time no specific Validation was executed concerning the integration of AeroMACS Access Network with ATN/OSI and ATN/IPS Networks, neither in Multilink environment, and neither with Digital Voice Systems. To achieve also these goals, scope of PJ14.2.6 Solutions is to technically validate, with specific Exercises, the following Implementation Options:

- Integration of AeroMACS and ATN/OSI Systems
- Multilink in ATN/OSI environment
- Integration of AeroMACS and ATN/IPS Systems
- Integration of AeroMACS and Digital Voice Systems

In addition, PJ14-02-06 Solution has the objective to provide PJ14-02-04 Solution with AeroMACS System, as part of the FCI Network to technically validate the concept of Multilink in ATN/IPS environment, under the scope of PJ14-02-04 Solution.
It is expected that all of these technical validations will bring the AeroMACS System, fully integrated with ATN and Multilink Systems in all of their variants, to TRL6 maturity level.

1.2.2 Navigation Domain

PJ14-03-01 GBAS

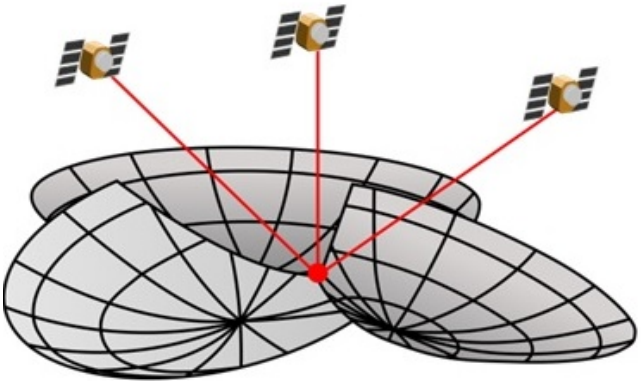


The ICAO ANC promotes the use of GNSS throughout all phases of flight. GBAS technology implements this concept for the approach, landing, rollout and departure. Also, within the scope of SESAR2020 is the use of GBAS prior to the final approach, in order to enhance the performance during this phase. The idea behind the solution is to advance the GBAS concept to a stage where it is ready for implementation through a series of activities listed in the MAWP. The activities focus on practical development work, validation and performance assessment.
GBAS GAST D extended scope: Whereas the maturity for basic scope of GAST D at the end of SESAR1 is TRL6, the target maturity for the extended scope in Wave 1 is TRL4. The focus is on:

- Ionospheric monitoring and analysis
- Large airports with complex environments
- Performance assessment in new threat scenarios (RFI and multipath)
- VDB measurement tools
- ATC & Maintenance interface
- Preparing GBAS Approval in Europe

GBAS GAST F focused mainly on basic research and early proof-of-concept implementation in SESAR1. The target of the identified activities is to continue research and move the results into standardisation and regulation, and to advance to prototype level for the ground segment.
Civil/Military interoperability: A paper study to identify potential cross use of technologies.

PJ14-03-02 Multi Constellation / Multi Frequency (MC/MF) GNSS



SESAR solution PJ14-03-02 Dual Frequency Multi Constellation (DFMC) GNSS aims to define up to maturity level TRL4 the technical solution based on the use of DFMC technology to provide airspace users navigation positioning with better availability, improved robustness and higher integrity. The solution is expected to also provide improved velocity information for applications such as ADS-B.

- In accordance with ICAO DFMC GNSS CONOPS objectives, the solution has investigated how DFMC technology can provide substantial operational improvements in following areas: PBN Navigation
- 3D approach GNSS approaches
- Business continuity

The scope of the solution has considered Aircraft technical functions, and the solution has mainly investigated the internal changes inside this function.
The only situation where modifications could be foreseen in the architecture relates to the new capability expected from the DFMC technology to provide alerting and sometimes backup Navigation in case of abnormal GNSS interference environment, in order to enable maximum improvement for business continuity. Indeed, maximum benefits from the reporting of abnormal GNSS interference events by the aircraft, and from the capability of an aircraft to maintain navigation upon such GNSS interference supposes an ATM system optimizing globally the traffic taking into account the areas where the interference is detected, and the distinctive capability of aircrafts for resilient navigation.

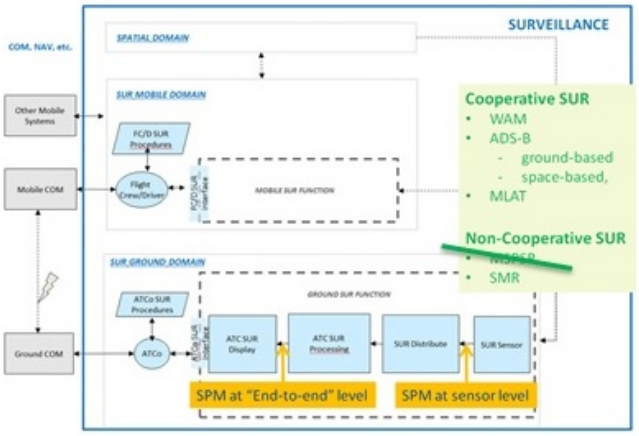
PJ14-03-04 Alternative Position, Navigation and Timing (A-PNT)

Alternative-Position, Navigation and Timing (A-PNT) is the technological enabler related with the need to introduce ground and airborne systems that can support currently defined and standardized PBN and other CNS-based operations and provide a backup with the required level of performance in case of degradation and absence/loss of GNSS.

This subject is particularly important in the context of European PCP-IR planning RNP1 SIDS or STARS for major TMA within 2024. Indeed, according to the existing regulations, RNP1 navigation requiring integrity requires the use of GNSS positioning. Therefore, the GNSS loss may become a critical issue for the design of TMA airspace complying with PBN-IR.

1.2.3 Surveillance Domain

PJ14-04-01 Surveillance Performance Monitoring



The SESAR solution PJ14-04-01 “Surveillance Performance Monitoring” (SPM) is a technological solution that, in line with the performance-based Surveillance (PBS) approach, aims at enabling an improved performance monitoring of surveillance systems e.g. “quasi real-time” functionality and ensuring the correct functioning of the ATM surveillance function (for example spotting degradation trends early in the process). This solution supports the Operational Improvement POI-0005-CNS "Performance Based Surveillance Monitoring”. The scope of the solution is the development of the requirements for the SPM Tools and the development of the prototypes.

It is to be noted that the solution objectives do not cover the evaluation of the performance of the real traffic datasets or the sensor performance used within the context of the solution, but rather to address the verification of the requirements for the Surveillance Performance Monitoring Tools.

This solution focuses on SPM Tools specifications and applies both at the individual “sensor” level and at ATC “end-to-end” level (input to the controller working position). This solution provides a means to harmonise Industry tools specifications for SPM, aligned with existing or developing Surveillance Standards (e.g. EUROCAE ED129 and ED142) and Specifications (e.g. EUROCONTROL Specification for ATM Surveillance System Performance - ESASSP).

The solution has been focused on the Sensor level part targeting TRL 4 while the “end-to-end” part was targeting TRL2. The solution is addressing 4 different technical validation objectives related to the 4 enablers included in the scope of the solution. These enablers are covering different operational environments (ER/TMA and surfaces) at both sensor level and “end-to-end” level.

PJ14-04-03 New use and evolution of Cooperative and Non-Cooperative Surveillance

PJ14-04-03 will introduce new capabilities into existing technologies (multi-sensor trackers, ADS-B systems, WAM/MLAT systems, video trackers) as well as introducing new surveillance technology (INCS – mainly MSPSR). A revised approach to ADS-B is also to be addressed.

The use in combination of sensor data, both on tracker as well as at the sensor level increases operational robustness and is an input for security functions. Non-cybersecurity aspects focussing on RF signals and RF content and the resulting alarming methods and performance are one of the key subjects of this solution.

The expected maturity level achieved at the end of Wave 1 will be TRL4.

1.3 Work Performed

PJ14-01-01 CNS Environment Evolution

This SESAR solution is a transversal solution and thus, does not follow the validation process defined for an industrial solution. However, this solution has been matured through a series of expert analysis, data analysis and simulation:

- The CNS roadmap has been matured through a wide consultation within the CNS community:
  - Recurrent draft of the roadmap has been reviewed by CNS expert through the EUROCONTROL working groups: Navigation, Communication and Surveillance Steering Groups, CNS Team and the Agency Advisory Board.
  - The final concept of the roadmap has been agreed during the CNS symposium, an event organized by EUROCONTROL and bringing together 350 participants from the CNS community (Industry, ANSPs, Airlines, Institutions, Research institutes….)
  - The CNS roadmap has been used as input for the development of the 2019 edition of the European ATM Master Plan. As such, the concept of the roadmap went through the EATM MP review process
- The performance-based CNS concept has been introduced in the CNS roadmap and went through the same consultation and review. This concept has been detailed in the Performance-Based CNS deliverable that has been reviewed by the solution's members.
- The CNS robustness concept, based on a two layers approach (the backbone of recent and global CNS technologies supported and backed-up by Minimum Operational Network or the legacy infrastructure), has been introduced in the CNS roadmap and went through the same consultation review. The CNS robustness deliverable details this concept and has been reviewed by the solution's members.

- Civil-Military CNS information exchange requirements has been reviewed by the solution's members and by the EUROCONTROL civil-military coordination groups and arrangements.

1.3.1 Communication Domain

PJ14-02-01 Future Communication Infrastructure (FCI) Terrestrial Data Link

The solution started to revise the existing LDACS A/G Specification and produced several iterations of this report documenting the achievements made in the LDACS design. The final edition of this document is Deliverable D3.3.030 – Final LDACS A/G Specification. The LDACS A/G Specification served as input when working on the development of the ICAO Standards and Recommended Practices (SARPs) for LDACS. The requirements, captured in the SARPs, were introduced in the LDACS Technical Specification and Interface Requirement Specification document (Deliverable D3.2(.030)TS-IRS).

LDACS offers an additional functionality, which can serve as ranging sensor for an A-PNT system. The integration of this capability has been analysed and documented in Deliverable D3.3.020 - A-PNT Contribution to LDACS A/G Specification.

PJ14-02-01 also addressed transversal topics and concepts like for instance the seamless transition from existing data link technologies to LDACS and these concepts and recommendations have been documented in Deliverable D3.4.020 - Final LDACS Deployment Options and Recommendations.

The solution carried out four Validation Exercise described in D3.1.010-Initial TVALP validated the following area:

- Exercise #1/2: Conformance testing of L1 aspects involving Frequentis' respectively Leonardo's LDACS prototypes was successfully executed.
- Exercise #3: Interoperability Testing involving Frequentis and Leonardo LDACS prototypes was successfully executed in Florence in Leonardo premises.
- Exercise #4a-b: Hand-over testing involving one LDACS airborne station and two LDACS ground stations was executed in the lab in Vienna and End-to-End Data transfer in ATN-IPS Infrastructure.

The results of the four validation exercises have been documented in Deliverable D3.1.030 TVALR.

Concluding the work, the validation plan for the next phase (Deliverable D3.1.040-Updated TVALP defining the validation roadmap for phase TRL6) has been drafted.

As LDACS not only supports A/G communication, but also A/A communication, further deliverables were added to the scope of PJ14 WP3, namely D3.7 - FRD for LDACS A/A Mode and D3.8 - TVALP for LDACS A/A Mode defining the validation roadmap for TRL4.

Coordination between PT-T (LDACS) and Navigation System Panel (NSP) Spectrum Working Group (SWG) is ongoing. The outcome of these activities is documented in Deliverable D3.6.020 - Final LDACS Standardization and Global Harmonization Report.

PJ14-02-02 Future Satellite Communications data link

PJ14.02.02 Future Satellite Communications datalink is focused on the near and long term satellite datalink technologies for both continental and oceanic regions.

The main performed activities are the following:

- Definition of Technical Specifications for Long Term SATCOM for ATM (Class A SATCOM) integrated in the FCI (TS-IRS, OSED, SPR, INTEROP);
- Definition of the technical validation procedures and execution of two main validation exercises, with the following objectives:

- **EXE-01**: The scope of this Validation Exercise is to confirm the achievement of TRL 4 of the SATCOM Class A solution for inclusion in the IPS-based Future Communications Infrastructure (FCI). The EXE-01 has been performed in coordination with PJ14.2.4.
- **EXE-02:** The scope of this Validation Exercise is to confirm the achievement of TRL 6 of SATCOM Class B solution based on Iris Initial Operation Capability (IOC) SATCOM in a multilink environment. This validation exercise aims at checking behaviour of the global ATN transmission chain from the Aircraft to the ATC centre in a multilink context. More precisely, purpose of this task is to check uplink and downlink routing operations in a multilink environment.

The EXE-01 and EXE-02 scopes have been achieved and the target TRLs are confirmed.
Results and recommendations are consolidated in the final Technical Validation Reports (D4.1.090 - SATCOM Class A - TVALR and D4.2.100 - SATCOM Class B – TVALR) as well as in the update of the technical requirements stated in the TS/IRS (D4.1.040 - SATCOM Class A - TS-IRS (TRL4))

- Definition of a Cost Benefit Analysis (CBA);
- Execution of periodic coordination workshops with ESA Iris Programme.
- Support and contribution to global and international standardisation, through the participation to the ICAO PT-S and EUROCAE WG-82.

PJ14-02-04 FCI Network Technologies

The solution PJ14-02-04 further developed the Technical Requirements within the deliverable D5.4.010 and based on this developed a prototype at two test bed locations.
Starting from the work done on SESAR1 P15.02.04, the Technical Validation Plan consists of checking that:

- The solution is able to announce a mobile network prefix with the required prefix length on the ground through multiple radio technologies
- Several radio technologies can be used to send and receive traffic from the air and the ground
- Multiple radio technologies can be used to send application data at the same time depending on a predefined policy
- Information about the link quality is communicated from the radio subsystem to the airborne router
- Information about the link quality is considered by the airborne router for its routing preference
- Routing preference of the airborne router is translated to OSPF route metric and is then communicated from the airborne router to the A/G router
- Routing decisions are made automatically in accordance to the quality of the available radio links
- Loss of any network element on the ground is automatically mitigated
- Times of connection loss are measured in case of an error of a radio link or a mobility component.

PJ14-02-05 Development of new services similar to FIS-B to support ADS-B solutions for general Aviation.

The system architecture has been completed by developing an App prototype and a GDPU prototype. These prototypes have been validated in a laboratory environment in order to achieve V2 maturity. For this purpose, a GDPU HW testbed (V&V platform prototype) was prepared at the premises of one of the solution partners with all necessary interfaces. During the V2 validation exercises, the existing terrestrial LTE mobile cellular network was used. The App and GDPU software prototypes were tested against the functional and performance requirements as laid down in the TS/IRS (D6.4.010, Edition 00.01.00 of 23 September 2019) and the SPR-INTEROP/OSED Part I (D6.3.010, Edition 01.01.00 of 24 September 2019). Dedicated test scenarios with real and simulated data were developed and the respective exercises conducted for stationary validation and for moving mobile devices (tablets) with the installed App prototype on the ground in cars on motorways. GA pilots representing future end users of the new service were involved in the execution of the V2 validation exercises. The V2 Validation Objective of this solution (OBJ-14.02.05-V2-VALP-003) is defined as:

“To validate the improvement in safety by providing in-flight information (FIS, TIS) for GA pilots under laboratory conditions”.

The two validation exercises in the V2 Phase have validated the improvement in safety by providing in-flight information (FIS, TIS) for GA pilots under laboratory conditions:

- EXE-14.02.05-V2-VALP-005: Validation of the new service and its system components (App and GDPU prototypes) under laboratory conditions at a stationary place
- EXE-14.02.05-V2-VALP-006: Validation of the new service and its system components (App and GDPU prototypes) in moving cars

The validation results have been summarized in the V2 Validation Report of the Solution (D6.3.021, Edition 00.01.02 of 20 September 2019).
Regarding the future extended data link based on mobile cellular networks, the candidate technologies 3G, 4G (LTE) and 5G have been analysed. As a result, 4G/LTE has been identified as the preferred technology for this purpose. Data link throughputs as well as capacity and spectrum issues were investigated. Necessary LTE coverages for the required altitudes were simulated. The data link results have also been summarized in the SPR-INTEROP/OSED Part I (D6.3.010, Edition 01.01.00 of 24 September 2019).

PJ14-02-06 Completion of AeroMACS Development

The solution work started with the definition of the technical requirements to be developed in order to implement the integration of AeroMACS System with the ATN, Multilink and Digital Voice Systems, identified in the Scope. A specific Task was created for each of the Technical Validations expected. In addition, one Task was created to support international Standardization. All Technical Requirements were traced in SE-DMF environment and inserted in the Initial TS/IRS (D7.1.010).
AeroMACS devices, VoIP devices, ATN Routers and End Systems were used in the validation exercises (documented in TVALP D7.1.020 and Availability Note D7.2.010):

- EXE-PJ14.2.6-TRL6-TVALP-001: EXE#01: Technically validate the integration of AeroMACS with ATN/OSI.
- EXE-PJ14.2.6-TRL6-TVALP-002: EXE#02: Technically validate the integration of AeroMACS with ATN/IPS.
- EXE-PJ14.2.6-TRL6-TVALP-003: EXE#03: Technically validate the capability to support digital voice by the AeroMACS Data Link.
- EXE-PJ14.2.6-TRL6-TVALP-004: EXE#04: Technically validate the integration of AeroMACS with Multilink in ATN/OSI environment.

In addition to the previously mentioned Exercises, protocols defined within PJ14-02-04 for Multilink in ATN/IPS environment were implemented on AeroMACS devices, and these devices were provided to PJ14-02-06 for their technical validations.

The results of the four PJ14-02-06 technical validation exercises have been documented in Deliverable D7.1.030 TVALR. Finally, after technical validations executed within the Solution timeframe, the Technical Requirements were consolidated in the Final TS/IRS D7.3.010.

1.3.2 Navigation Domain

PJ14-03-01 GBAS

Building upon SESAR 1 work, the objective of PJ14-03-01 GBAS was to extend the GAST D solution to operate in new, challenging environments and to further develop the GAST F concept. The challenging GAST D operating environments cover, among other, regions with adverse ionospheric conditions and airport environments impacted by RFI, jamming, and multipath threats. Since June 2018, a GBAS data logger, installed at Tenerife Norte Airport, is providing ionosphere and scintillation data logs for on-going analysis work. A number of low cost RFI event loggers, deployed in various locations in Europe during the spring 2018, are providing input data to the on-going characterization and analysis of threat scenarios. GAST D activities include development of VDB measurement tool and Runway coverage simulation tool, providing means of verifying fulfilment of regulatory and operational requirements, Multipath prediction tool for GBAS GS siting purposes, and GBAS GS ATC and maintenance interface for providing Ground Station status to external users. The GAST D TRL4 verification activities were finalized in 2Q2019 and the associated deliverables are approved. A Security Risk Assessment has been carried out, concluding that PJ14-03-01 GAST D Extended Scope is covered by SESAR 1 16.06.02 OFA 01.01.01 GBAS Security Risk Assessment.

The objective of GAST D Expanded Service Volume task was to validate, from a technical perspective, the ICAO concept for Expanded Service Volume and use of GBAS at greater distances by increasing the Dmax parameter:

- Expanded service volume – use of GBAS at distances beyond 23NM while maintaining integrity, continuity, and availability
- Pilot monitoring guidance at further distances (outside the published service volume) for better situational awareness prior to entering the approach service volume.

The GAST F activity, has been focused on:

- the generation of the corrections for the differential positioning, with the new processing modes (Single Frequency (SF) and Iono Free (IFree)).
- on the integrity aspects, related to the ionospheric mitigation capabilities of IFree and SF with DF iono monitoring.
- on the detailed definition of the concept framework for DF/MC GBAS, as a coordination document between the different standardisation bodies and stakeholders, such as ICAO/NSP, RTCA or EUROCAE.

The verification activities, successfully completed, were focused on performance analysis, taking advantage of the improvement on the Galileo coverage. This analysis used Barcelona airport data (collected from the GAST F mock-up with choke-ring antenna) and Tenerife Norte data (collected from the GBAS data logger with MLA Antenna and using DFMC receiver).

As a complement, some GAST F activities have been addressed also to study an airborne segment activity relative to the enabler A/C-56b to derive a non-MMR architecture design for non-mainline aircraft targeting CATII/III operations supported by XLS guidance including GAST D and GAST F. The

maturation of the enabler A/C-56b (TRL non addressed in SESAR1) also consider the requirements coming from the others XLS guidance modes which are supported by

- the ILS, which is the APNT precision approach backup mode in case of GNSS loss;
- SBAS providing the LPV modes,

A FRD has been produced reflecting the maturation of A/C56b up to TRL2 level, in the case a non MMR avionics is considered to support the different precision approach capabilities on board the aircraft. The TRL2 Safety and Security Assessment and the Roadmap TVALP for TRL4 have been also produced.

A technical report on the potential use of MC/MF GBAS solutions, to be considered in a Military precision approach and landing system transition strategy, was produced.

PJ14-03-02 Multi Constellation / Multi Frequency (MC/MF) GNSS

PJ14-03-02 represents continuation and extension of the activities done in SESAR1 project WP9.27 up to the TRL4 taking benefit from the achieved evolution of the DFMC MOPS and advance in the deployment of the core constellation systems.

At the beginning of the validation process a set of the performance, functional, safety, security requirements was derived and allocated to the different technical components of the EATMA model allowing the implementation of the use cases, particularly with regards to the details of aircraft technical function. The requirements suitable for the validation were chosen based on several criteria including maturity and type of requirements where the priority was given to the performance requirements targeting the DFMC GNSS receivers concerning also the possible added value for the further development of the standards. This involved mainly algorithms for processing of dual-frequency signals, range-measurement performance, positioning performance and resilience against intentional interference and spoofing as well as service-volume simulations assessing availability of DFMC positioning with ABAS provided integrity for different navigation operations.

The validation activities were divided in three main exercises covering a number of objectives, each one in turn covering one or more requirements. The validation approach was based on simulations using the service-volume simulators and laboratory tests conducted using the solution members' prototypes with signals generated by a GNSS simulator as well as live signals received through an antenna.

The validation activities were concluded with the validation report, which provides a detailed description of each scenario and test procedure used to validate every one of the specified objectives as well as the associated limitations and recommendations for the identified issues.

PJ14-03-04 Alternative Position, Navigation and Timing (A-PNT)

Three technical threads have been investigated by the SESAR PJ14-03-04 (PJ14 WP10) solution aiming at the maturation of A-PNT:

- **Long Term: A-PNT based on LDACS NAV and eLORAN**

  The long-term APNT solution considers new technology currently not existing on board the avionics The long-term solution will provide a reversionary solution in case of GNSS outages based on new technologies (LDACS, eLORAN) and will have a major impact in the ground and airborne systems. The targeted performance is RNP0.3 for en route and TMA.

  The solution has defined the high level architecture of the long term A-PNT solution in order to derive the functional requirements that will be targeted by the system. Although no standardization activities were foreseen due to the low level of maturity of the solution, the technical progresses were presented at ICAO NSP, at conferences of the Institute of Navigation and at the European Navigation Conferences. Since the Long-Term solution was

suggested to support RNP0.1 Navigation and LDACS is primarily a communication system, the addition of navigation functionality to LDACS was decided after the design of the system.

- **Mid Term: A-PNT based on Multi DME Positioning**.
  The mid-term APNT solution has explored the capability to fit multi-DME positioning in the existing FMS with RAIM algorithm to fully comply with RNP requirements involving OBPMA features, for the continuation of RNP1 operations in case of GNSS loss, without any operational impact from flight crew or ATC perspective, and using existing DME ground infrastructure. RTS and FTS validation exercises have been defined and successfully performed to assess the technical maturity to on-going TRL4, with initial objective to validate first the core of the MT APNT solution (the new MultiDME positioning with RAIM and the reversion aspects), before going into a full prototype implementation taking into also account the modifications of database required to support the optimal tuning for MultiDME positioning along the trajectory. The purpose of the FTS validation was double:
    - The demonstration that the proposed MT APNT solution could be supported with no impact of the existing ground MDE infrastructure in Europe.
    - The demonstration that the proposed MT APNT solution is able to fully support RNP1 navigation specification defined by the PBN manual, through the statistical assessment of the performance of the new MultiDME positioning algorithm with its RAIM, in fault free and faulted conditions regarding the DME ranging measurements

  The purpose of the RTS was the validation of the performance of the new Multi DME positioning algorithm with RAIM implemented as an add-on of existing DME/DME/IRS localisation algorithm inside the FMS, with regards to the operational requirements defined in the TS/IRS for reversion, DME tuning and alerting aspects. The operational aspects and the technical feasibility has been demonstrated with the FMS prototype integrated in a complete avionics bench allowing the performance of simulated flight of an aircraft operating a SID or STAR with RNP1 constraints, in AFCS coupled navigation mode, with corresponding navigation and alerting displays. The MultiDME position protected by RAIM along the trajectory was computed by the FMS prototype from DME ranging measurements output by a simulated legacy aircraft 5 channels DME equipment, tuned by the FMS and emulating the replies from the interrogated ground transponders.
  TRL4 Completed Maturity level for the mid-term APNT solution supporting RNP1 Navigation in the TMA was achieved at the end of wave 1, and maturation to TRL6 with respect to additional optimisation is planned to be done during wave 2.
- **Short Term: A-PNT based on DME-DME solution.**
  A short-term solution relying on the assumption that most of current aircraft DME/DME navigation can support RNP 1 reversion without any modification in the avionics, if the ground infrastructure provides a required level of integrity, and if appropriate flight crew is appropriately trained. The activities related to the Short-Term A-PNT solution in WP10 are mainly related to the support of the EUROCAE WG-107 which has as objectives:
    - The update of ED-57 (MOPS for DME Ground Equipment) to bring the standard in line with current equipment capabilities.
    - Develop MASPS for “RNP Reversion using DME/DME Positioning”. The MASPS would describe an acceptable means of compliance to permit prolonged support to PBN operations requiring an RNP navigation specification in case of a GNSS outage, while taking credit for the updated capabilities in ED-57.

Considering the fact that DME systems complying with the updated ED-57 are already deployed and have been in operation for many years, the scope of the short-term A-PNT activities does not include validation exercises.

1.3.3 Surveillance Domain

PJ14-04-01 Surveillance Performance Monitoring

The work performed in the Solution PJ14-04-01 Surveillance Performance Monitoring Tools is divided in three different Task addressing different technologies. The ***SPM Tools for Cooperative Sensors*** and ***SPM Tools for Non-Cooperative Sensors*** have reached TRL4 during the current phase with the development of the SPM prototypes and the refinement of the requirements paving the road for TRL6 during the next phase. The ***SPM Tools for the Surveillance Chain ("end-to-end" level)*** has reached the TRL2 with the performance of a Proof of Concept and the development of a Functional Requirement Document paving the road for TRL4 during the next phase.

SPM Tools for Cooperative Sensors

The initial requirements of the Cooperative sensors SPM Tools (ER/TMA and Surface) have been developed in the initial TS/IRS. It was refined at the end of the project with the results obtained during the exercises and with the updates of the developing Surveillance Standards and Specifications. These requirements have been developed in close coordination with the standardisation bodies responsible of the relevant Surveillance Standards and Specifications (e.g. ED-129C, ED- 142A and ESASSP Ed.2 – Still developing at the time of edition of this final report). The TVALP has been developed for the validation of functional requirements describing the planned exercises and the coverage of the test performed by each of the three developed prototypes (Thales, Indra and ECTL). Three different exercises were executed to validated each prototype:

- MAGS Explorer – Thales Electronic Systems (ER/TMA)
- AccPoDTool – Indra (ER/TMA and Surface)
- SASS-C/VERIF – EUROCONTROL (ER/TMA)

The three prototypes have been tested with real traffic data from Naviair and Nav Portugal and additionally the EUROCONTROL prototype has been tested with real traffic data from ENAIRE. The content of the TVALR is confidential as the performance results of surveillance systems of ANSPs are sensitive information, and the results are reported as part of the Verification Report (TVALR). It is therefore requested that these are not disseminated outside the PJ14-04-01 Solution members participating to exercises related to Task 01. It is also requested that PJ14-04-01 Solution members may not further disseminate those reports, either partly or as a whole, without the prior written consent of all representatives of beneficiaries involved in the PJ14-04-01 solution".

An Initial TVALP with a Roadmap for the TRL 6 during the next phase has been developed.

SPM Tools for Non-Cooperative Sensors

The initial requirements of the Non-Cooperative sensors SPM Tools (ER/TMA and Surface), describing the functional requirements for the inclusion of the emerging metrics, the adaptation of the calculation methods and the graphical representation, have been developed in the initial TS/IRS. It was refined at the end of the project with the results obtained during the exercises and with the updates of the developing Surveillance Standards and Specifications. The TVALP has been developed for the validation of functional requirements developed in the initial TS/IRS describing the planned exercise and the coverage of the test performed by the INDRA prototype. It consists in a single exercise for the checking of the various metrics coverage.

The prototype has been tested with real traffic data from Nav Portugal. The core part of the TVALR is public, however, the performance results of surveillance systems of ANSPs are sensitive information and the Annex A containing the results obtained by the prototype are stored in a confidential repository of Stellar. The access rights to this folder is restricted to the contributors of the PJ04-04-01 Task 1 and the SJU reviewers of the document.

SPM Tools for the Surveillance Chain ("end-to-end" level)

The Task 3 has reached TRL2 during the Wave 1. The FRD document describing the functional requirements has been developed following the approach used for the Tasks 1 and 2 TS/IRS. The Standards and Specifications (ESASSP Ed.2 and GEN-SUR/ SPR) didn´t reach a high maturity level during the Wave 1 and the functional requirements will be refined during the next phase with the updates of the Standards.

A TVALP has been developed with a single theoretical exercise. This exercise is a proof of concept, which aims at checking the inclusion of all the metrics and methods and their validation following the experience gained during the execution of the Tasks 1 and 2 exercises. This proof of concept is described in the TVALR.

In the last period of the project, the TS/IRS has been refined with the results obtained during the exercises and with the updates of the developing Surveillance Standards and Specifications. An Initial TVALP with a Roadmap for the TRL 4 during the next phase has been developed.

PJ14-04-03 New use and evolution of Cooperative and Non-Cooperative Surveillance

The solution PJ14-04-03 New use and evolution of cooperative and non-cooperative systems is composed of five technical areas:

- Composite Cooperative and Non-Cooperative Surveillance
- Improved Multi-sensor Data Fusion
- Multi Remote Tower Control Surveillance
- Secured Surveillance Systems
- Future ADS-B communication link

The work performed for each tasks have been based on an incremental process based on the development of technical and testing specifications (TS/IRS, TVALP), several prototypes and the performance of several exercises for which the results have been collected in TVALR artefacts.

For the Composite Surveillance Systems, the purposes of the validation were to check that the requirements given in the TS/IRS are implemented.

Regarding the Mode-S/ADS-B cooperative configuration the purpose of the system validation can be summarized as follows:

- Check the validation of the ADS-B data (output data flow ASTERIX Cat 21) on the basis of Mode-S data (output data flow ASTERIX Cat 48).
- Check the Mode-S/ADS-B integrated solution of using ADS-B data output reinjected in radar extractor in order to optimize the targets acquisition phase minimizing the number of DF11 replies (minimizing the electromagnetic pollution at 1090 MHz) and the subsequent Enhanced ROLL-CALL scheduling interrogation.

For the WAM+ADSB composite surveillance system, the purpose of the validation was to update the system with the new requirements developed by EUROCAE WG51SG4 and TS/IRS of this solution. The use of these methods will be directly of use for Secured Surveillance Systems.

The purpose of the MSPSR-ADS-B validation was to verify and validate the integration of the MSPSR into the T-TK multi-sensor tracker running on Thales Paris In-house surveillance system.

For the Improved Multi-sensor Data Fusion, the purposes of the validation were to check the multi-sensor data fusion integrating MSPSR. It has supported the development of prototype ARTAS

software to verify that the capability of the draft ASTERIX CAT 015 format that will be deployed to transfer the Non-Cooperative Sensor data was appropriate. For The Thales TopSky-Tracking, in complement of the MSPSR integration, some testing has been conducted on the Multi-sensor data fusion improvement based on an advanced monitoring of the tracker coherence. On the COOPANS platform in Copenhagen (Naviair), the testing of the multi-sensor data fusion integrating Space-Based ADS-B has been achieved by integrating ASTERIX CAT 021 Ed 2.4 data into ARTAS V8B4-U2 software.
For the Multi Remote Tower Control Surveillance, the validation activities of the Multi Remote Tower Control Surveillance system were conducted at the international airport of Erfurt (EDDE) for ADS-B and Mini-MLAT providing range and range difference data among a WGS-84 position solution. Video plot measurements in combination with ADS-B plots were conducted under laboratory conditions in Vienna.
For the Secured Surveillance Systems, in the frame of the Thales and Indra exercises performed ion separate platforms, it has been possible to validate the main high-level objectives of obtaining performance values for Continuity of security function, Integrity of security function, Time to alarm and Accuracy of security function.
For the Future ADS-B communication link, the objective was the validation of the interoperability and the performances between transponder transmitter and the ADS-B receiver using the new waveform.

1.4 Key Project Results

PJ14.01.01 CNS Environment Evolution

The main achievement of the solution is the development of a CNS roadmap, defining the short, medium and long-term evolution of the CNS infrastructure and application. This roadmap also identified the concept of a future Performance-Based integrated CNS approach and defined the high-level CNS robustness concept through a two layer approach:

- A backbone of global and recent CNS technologies in the form of secure CNS services, supported and backed-up by:
- Minimum Operational Network of the legacy infrastructure.
- A wide consultation amongst the CNS community ensured a buy-in from all stakeholder. As a result, the overall concept of the CNS roadmap will be detailed in the 2019 edition of the European Master Plan.

In addition to this main achievement, the solution achieved:

- the development of a methodology to monitor the GNSS core constellations
- the development of an ionosphere threat model in support of the GBAS deployment
- the identification of the civil-military CNS information exchange requirements
- an analysis of the CNS Robustness concept defined in the CNS roadmap
- the identification of recommendation to move forward an integrated performance-based CNS framework.

1.4.1 Communication Domain

PJ14-02-01 Future Communication Infrastructure (FCI) Terrestrial Data Link

LDACS provides, amongst others, two different communication possibilities, which are covered by Enabler CTE-C02e (New A/G datalink using ATN/IPS over L-band) and CTE-C02g (Air to Air functionality of New A/G radio). These two enablers have achieved different TRLs:

- Air to Ground (A/G) datalink using ATN/IPS over L-band (TRL4)
- Air to Air (A/A) functionality of new A/G radio (TRL2)

Main focus of the work carried out in Solution PJ14-02.01 was on the A/G datalink and to achieve TRL4 maturity. The work in TRL4 has consisted of the development of LDACS A/G prototypes based on the specifications defined in the early stages of this (TRL4) phase and the execution of four validation exercises described in the technical validation plan to support the exploration of the proposed concepts, technical feasibility and support of operational use cases. The LDACS A/G prototypes, developed within Solution PJ14-02-01, were handed-over to Solution PJ14-02-04 and integrated into the FCI test environment, as well.

The work for the A/A aimed at achieving TRL2. For that, no explicit technical validation exercises were carried-out in Solution PJ14-02-01. Taking simulations results from already carried-out in previous research activities into consideration, a Functional Requirements Document (FRD) was produced and the proposed technical validations, which shall be carried in the subsequent phase (TRL4), were documented in the Technical Validation Plan (TVALP) for the next phase.

PJ14-02-02 Future Satellite Communications data link

PJ14.2.2 has successfully provided:

- Technical Specifications for Class A SATCOM Data Link;
- Technical validation of satellite air-ground datalink for:
- Long Term SATCOM (Class A) integrated in the FCI at TRL4;
- SATCOM Class B in dual-link mode, to complement Solution #109 from SESAR1, at TRL6;
- Contribution to standardization at the global level (ICAO PT-S and EUROCAE WG-82)
- Coordination with ESA/Iris Programme.

The main findings from the overall validation exercises can be summarised as follows:

- **Class A**:
  - Class A validation exercises aimed to
    - Technically validate that Iris FOC datalink is able to meet the (more stringent) long term RCP requirements.
    - Technically validate that Iris FOC datalink is able to support the multilink functionality expected from ATN/IPS subnetworks.
  - Based on the work and results achieved in the solution PJ14.02.02, the deliverable TVALP Roadmap for the Next Phase describes the validation approach and activities proposed for Wave 2 PJ14 Solution#107 (WP6) “Future SATCOM Data Link”. The target SATCOM Class A TRL for Wave 2 is TRL5 with initial steps towards TRL6.
- **Class B:**
  - Class B related validation exercises focused on testing the ATN/OSI routing (for downlink and uplink messages) in a multilink SATCOM + VDL2 environment. Many test scenarios, covering all ATN/OSI routing aspects, were successfully achieved and confirmed that:
    - ATN/OSI protocols can support multilink equipped Aircraft;
    - The ground ATN/OSI infrastructure is able to support multilink Aircraft.
  - An important finding is that VDL2 is slow to report loss of connectivity with an Aircraft. Consequently, if VDL2 is configured to be the preferred link and VDL2 connectivity is lost, uplink messages may not be timely rerouted via SATCOM. It is therefore recommended to privilege the selection of SATCOM over for multilink equipped aircraft. This is considered particularly suitable in the initial phases of the

Iris deployment, when due to the relatively small and slowly increasing proportion of Iris-equipped aircraft, there should be a strong motivation to maximise getting experience on the use of SATCOM for continental datalink communications, and to make the best out of the SATCOM equipage by off-loading ATN traffic from the congested VDL/2 network

PJ14-02-04 FCI Network Technologies

The solution validation demonstrates that multiple mobile prefixes residing inside an aircraft can be announced over multiple radio paths. Traffic routing is done according to a predefined policy residing inside the airborne router. Through the newly introduced IF2, link status and quality information can be communicated from the radio to the airborne router. This information can then be used as a parameter for routing decisions made by the airborne router.

Multiple aircraft can communicate with multiple sites on the ground by utilizing ATN and IPS traffic.

Backwards compatibility towards currently deployed airborne and ground OSI end systems has been demonstrated with the OSI-IPS Gateway that has been successfully integrated within the FCI.

During validation technical exercises the solution tested QoS handling transferred the DCSP marking information end to end and it was shown (under the conditions of the test in the lab) that low priority traffic would not be able to starve high priority traffic in the situation when the air-ground data links are congested.

The robustness of GB-LISP on the ground was also tested. GB-LISP can run on standard routers easing the introduction and deployment. The tests included redundant MS/MR configuration and redundant G/G routers running in an HSRP redundancy mode. Multiple MS/MR are recommended since they are critical for the operation of the network. The implementation of these mobility elements is straightforward. No synchronisation is done between MS/MR. Each xTR is set to use and registers at multiple MS/MR. Redundancy of G/G routers works as expected.

PJ14-02-05 Development of new services similar to FIS-B to support ADS-B solutions for general Aviation.

The new App prototype developed by this solution integrates all these information types and provides graphical overlays on displayed charts. Furthermore, a dedicated Ground Data Processing Unit (GDPU) prototype has been developed in order to process all necessary FIS and TIS data, which originate from a number of different external data sources. The processed data are prepared for transmission via this extended LTE based data link to the installed App at the pilot's mobile device on-board of the GA aircraft. The main conclusion of the App and GDPU prototypes' validation is that the provision of the surrounding traffic displayed on-board the aircraft as well as the actual updated meteorological information have the potential to increase the safety of General Aviation operations. Depending on the interface by which the information is displayed and filtered, FIS data such as NOTAM and FUA may also increase the safety of operations. The data transfer between the mobile device and the GDPU to run the App could be performed during the V2 tests with the requested capacities and throughput by the mobile network. This leads to the conclusion that mobile networks based on the LTE standard and deployed on the standard design criteria regarding cell sizes und working mechanisms with respect to the use case requirements are applicable and appropriate for the proposed service.

Following potential benefits of the proposed service have been identified:

- Increase of safety for GA pilots;

- Cost-efficient solution for General Aviation compared to ADS-B, assumed that the App purchase price and the regular data link fee will not be higher in reality than estimated (and accepted by GA pilots) in the CBA V2.

PJ14-02-06 Completion of AeroMACS Development

As already stated, a specific Task was created for each of the Technical Validations planned. The work in TRL6 has consisted in the integration of AeroMACS Access Service Network with ATN, Multilink and Digital Voice Systems. This led to the implementation of a realistic and complete end-to-end System in Leonardo Laboratories, and to the execution of four validation exercises described in the technical validation plan to support the defined operational use cases. Below a report of the main results obtained in each Task:

- **T01- International Standardisation and Harmonisation**
  Major part of the Standards related to AeroMACS had already been published in SESAR1. In SESAR2020 PJ14-02-06 has actively taken part in the activities of WMF and ETSI Groups: WMF has refined the certification procedures for Radio and Protocol Conformance Tests, besides arranging Interoperability Events among AeroMACS Manufacturers, to which Leonardo took part. ETSI TGAERO group has started work for the development of a Harmonised Standard for AeroMACS, for the CE Mark. In addition it is developing a Community Specification for AeroMACS following European Mandate 524 for compliance with the Essential Requirements of EASA Regulation 1139.
- **T02- Integration of AeroMACS within ATN**
  - **ATN/OSI**
    An end-to-end system composed by a real AeroMACS Access Network (provided by Leonardo) and an ATN/OSI Network composed of real AGR, together with ATN B2 Test Tools for both the airborne and ground side (provided by Airtel) was built in Leonardo Laboratories. The ATN Test Tool was including Air/Ground End System Applications, Airborne Router and GGRs. More scenarios were reproduced, also taking into account roaming between different Service Providers. The whole set of ATN B2 messages was made available by the Airtel simulators. Both CM/CPDLC and ADS-C sessions were established in all the technical validations. Concerning ADS-C, periodic contract sessions were established, requesting transmission of 1 EPP message per second containing up to 120 waypoints. This in order to stimulate a high data rate on the air interface. In addition, the same AeroMACS GS was used to decode and reproduce live video surveillance streaming data from a remote video camera. This to emphasize the broadband capability of AeroMACS. Measured Transaction Times were orders of magnitude lower than the Transaction Times required by ED-228A Standard.
  - **ATN/IPS**
    The Architecture reproduced in Leonardo Lab was identical to the one used for the ATN/OSI scenario, with the obvious difference that in this case ATN Routers did not implement any part of the OSI stack like CLNP, IDRP or TP4. Again the Validation Methodology was to verify the end-to-end exchange of CM/CPDLC messages and verify compliance with B2 Transaction Times specified in EUROCAE ED-228A
- **T03- Digital Voice Communications over AeroMACS**
  AeroMACS system can easily support voice communications, besides a wide variety of other IP data/video information exchanges among mobile and fixed users at the airport surface. Of course, legacy voice links between pilots and Air Traffic Controllers are not intended to be

replaced, at least for the time being. However voice over AeroMACS can constitute an important service enhancement.
A possible application of AeroMACS with VoIP was reproduced in Florence Laboratories (Leonardo), with a VoIP Radio Controller reaching remote users via VOIP over AeroMACS. The Methodology to validate this scenario was to establish a SIP session between the VoIP Radio Controller and the remote VoIP AM Radio over the AeroMACS Link, send speech and audio tones via PTT from the VRC, and, at the VoIP AM Radio, measure SIP/RTP Packet Loss and jitter. It was verified that they easily comply with performance requirements given by EUROCAE ED138.

- **T04- Integration of AeroMACS A/G DL within Multilink (ATN/OSI)**
  In this Exercise, the Technology Handover between AeroMACS and VDL2 was technically validated, in a possible operational scenario (Aircraft at ground before take-off -> AeroMACS; aircraft in flight -> VDL2; aircraft at ground after landing -> AeroMACS). The Airborne Router shall be able to manage Link preferences (i.e. select the Data Link) according to predefined policies.

1.4.2 Navigation Domain

PJ14-03-01 GBAS

The GAST D Extended Scope for new challenging environments passed a TRL4 maturity gate at end of wave 1.
A GAST D Expanded Service Volume (ESV) activity validated, from a technical perspective, the ICAO concept for Expanded Service Volume and use of GBAS at greater distances by increasing the Dmax parameter. A conclusion from GBAS ESV Maturity Gate was that the solution has a maturity close to TRL6.
The GAST F activity defined and validated (mainly accuracy and ionospheric mitigation capabilities) two candidate processing methods: 1) IFree (ionospheric free method) and 2) Single frequency (SF) L1/E1-band with dual frequency (DF) ionospheric monitoring. In both cases, the accuracy was inside the limits, but better for SF due to the increment of noise coming from both L1 and L5 bands for IFree solution. The candidates were investigated with regard to ionospheric mitigation. The IFree showed a better performance, demonstrating a high mitigation capability. The SF with DF iono monitoring validation exercises are moved to wave 2, due to problems in the calibration of the monitors. Based on the above GAST F results, the definition of the concept framework for DFMC GBAS was derived and presented to the standardization working groups of ICAO NSP and RTCA.
The GAST F including an airborne segment activity related to the technical enabler A/C-56b to derive a non-MMR architecture design for non-mainline aircraft targeting CATII/III operations supported by xLS guidance including GAST D and GAST F bring the maturity of A/C-56b to TRL2 at end of wave 1.

PJ14-03-02 Multi Constellation / Multi Frequency (MC/MF) GNSS

The technical specifications were elaborated to investigate and present a number of use cases providing operational improvements expected from DFMC technology. The performance, functional, safety, security requirements were derived and allocated to the different technical components of the EATMA model, allowing the implementation of the use cases, particularly with regards to the details of aircraft technical function.
The impact derived from the different safety requirements has been also taken in to account.
It has proposed a logical decomposition of the architecture based on a number of individual components, supporting the necessary redundancy and HW and SW constraints.

The impact of the different options considered at ICAO level regarding the acceptance of GNSS elements by States was highlighted. The requirements allocated to the MC/MF (DFMC) receiver were developed, to provide the basis for the validation of the DFMC receiver component.
Cost Benefit Analysis was carried out in order to provide an overview of the costs and benefits related to SESAR Solution 14-03-02, DFMC GNSS, from different stakeholders' point of view. In accordance with ICAO DF/MC CONOPS objectives, the solution shall allow airspace users to get operational benefits in the following areas: Improved business continuity, Improved 3D Approaches, Innovation and Airborne Equipment rationalization.
However, according to the feedback received in the frame of the ICAO DF/MC CONOPS benefits assessment, the most promising benefits for different aviation segments are so far:

- Extension of SBAS APV I and LPV 200 service areas, particularly in equatorial regions
- SBAS approaches with minima less than 200' and enabling CAT I Autoland
- Enabling further rationalization of conventional NAVAIDs depending on the equipage of the fleet with DFMC GNSS receivers

The CBA document summarizes the
As main achievements and conclusions of the solution the following can be stated:

- DFMC has been brought to TRL4, which is the highest maturity it could have achieved in the current environment.
- PJ14-03-02 has significantly contributed to the baseline of the CONOPS and provided some key inputs to SARPS and MOPS.
- However, to further develop DFMC, a mature standardization baseline is required, particularly a higher maturity of the SARPS and the MOPS.
- In order to use a DFMC receiver inside a complete navigation architecture, a better understanding of the user-expectations is also needed.

Solution PJ14-03-02 has proposed the possible modification options that could be foreseen from an airborne perspective. The identification of the complete impact on the baseline architecture of such an optimisation needs to be considered from an overall ATM perspective, and should be analysed further by an ATM SESAR solution related to overall CNS consolidation such as solution PJ14-01-01. Possible impact might be further addressed in Wave 2, whenever EATMA would consider the navigation hazards coming from abnormal GNSS interference.

PJ14-03-04 Alternative Position, Navigation and Timing (A-PNT)

Long Term: A-PNT based on LDACS Datalink

Relevant contribution to ICAO NSP are provided in form of information papers, where a performance assessment based on simulation, lab and flight tests is presented. Different scenarios have been considered and different ground network configurations have been investigated during the simulation evaluations. These preliminary studies have generated the functional requirements, reflected in the FRD document, that will bring to significant operational benefit by achieving RNP0.3 for en route and TMA
The considered performance parameters are:

- Horizontal dilution of precision,
- Pseudo range accuracy and error over bounding,
- Position accuracy and integrity limits
- Level of continuity of service,
- Availability of accuracy, integrity and continuity of the navigation service.

Mid Term: A-PNT based on Multi DME Positioning

The tests results show that multi DME positioning supporting navigation with RNP1 constraints has achieved on going TRL4 level of maturity with the following technical performance objectives:.

- The multi DME algorithm with RAIM has the required performance to fully support RNP1 navigation requirements in the major European TMA with current existing DME infrastructure, additionally showing that the solution might support lower than RN1 performance.
- The RNP navigation is not discontinued for performance of RNP operations in case of GNSS loss. Reversion from GNSS positioning to DME positioning is fully transparent from flight crew perspective. RNP Navigation alert from OPBMA indicating the loss of capacity have same signification whether the source of position if GNSS or multiDME, providing optimal operational safety.

It assesses that the multi DME seems to be a suitable technical solution to fully support RNP navigation in case of GNSS loss, with no expectable operational impact for the flight crew, for the ATC, and not requiring modification on existing DME infrastructure.

Short Term: A-PNT based on DME-DME solution

Relevant contribution has been provided to EUROCAE WG 107 both for the update of ED-57 and for the definition of the MASPS for RNP reversion based on DME/DME. The preliminary conclusions of SESAR 1 regarding the achieved performance of the DME transponders that are currently in production have been confirmed, while the updated performance requirements are reflected in the TS/IRS document.. The update of the ground DME system MOPS is focused on:

- Minimum Integrity level specification
- Range accuracy requirements
- Service continuity requirements

In addition, a methodology for the integrity demonstration is being defined, such that the integrity levels achieved by different OEMs can be compared and validated.

1.4.3 Surveillance Domain

PJ14-04-01 Surveillance Performance Monitoring

The solution PJ14-04-01 is divided in three different areas targeting TRL 4 for SPM Tools for Cooperative Sensors and SPM Tools for Non-Cooperative Sensors, and TRL 2 for SPM Tools for the Surveillance Chain (“end-to-end” level). During the Wave 1 the main outcomes of the solution have been on the one hand the deliverables indicated in Chapter 1.5 and on the other hand the development of the SPM prototypes.

The key results of the activities described in the previous section are:

- Functional requirements: At sensor level (SPM Tools for Cooperative Sensors and SPM Tools for Non-Cooperative Sensors) a set of functional requirements that have been validated during the exercises using prototypes and real traffic datasets. At “end-to-end” level (SPM Tools for the Surveillance Chain (“end-to-end” level)) a set of requirements that have been validated through the proposed exercise using the experience gained during the SPM Tools for Cooperative Sensors and SPM Tools for Non-Cooperative Sensors exercises.
- Initial TVALP with Roadmap for next phase: At sensor level a roadmap for the next phase targeting TRL 6 has been provided. At “end-to-end” level a roadmap for the next phase targeting TRL 4 has been provided.

- The TVALR demonstrating the validation of the functional requirements developed in the TS/IRS (SPM Tools for Cooperative Sensors and SPM Tools for Non-Cooperative Sensors) and FRD (SPM Tools for the Surveillance Chain ("end-to-end" level)).
- Continuous feedback between the prototypes development and the Standardisation bodies taking advantage from the practical point of view from the software development during the development of the Surveillance Standards and Specifications.

For the SPM Tools for Cooperative Sensors and SPM Tools for Non-Cooperative Sensors the Solution has reached the maturity level TRL 4 and for SPM Tools for the Surveillance Chain ("end-to-end" level) it has reached the maturity level TRL 2.

PJ14-04-03 New use and evolution of Cooperative and Non-Cooperative Surveillance

The Cooperative part of the solution PJ14-04-03 (Composite Cooperative and Non-Cooperative Surveillance), aiming at developing a Cooperative surveillance + ADS-B composite system, is demonstrated to be mature enough for TRL4 phase supporting the enabler CTE-S06a. This maturity level is linked to the current state of the Standards and Specification that are still developing, therefore aiming at TRL6 in the future, once fully completed and available.

The Non-Cooperative part of the solution PJ14-04-03 (Composite Cooperative and Non-Cooperative Surveillance), aiming at developing a Non Cooperative surveillance + ADS-B composite system using MSPRS DVB-T/ADS-B sensor configuration , is demonstrated to be mature enough for TRL4 phase supporting the enabler CTE-S06b.

Relevant benefits have been identified on Safety, Environment and Cost Efficiency although potential benefits could be achieved in the future.

On the Human Performance point of view the Composite ICS & ADS-B and NCS & ADS-B systems may contribute to an enhanced situational awareness inside/outside a sector (ex.: early detection of emergency transponder codes or potential gross navigation errors) allowing a controller to intervene sooner and reducing risk of incidents and the possible loss of separation. For the Improved Multi-sensor Data Fusion, several key results have been found. For the Industry the steps taken in the initial development and exercises will help towards:

- an industrialised version of the multi-sensor tracker systems capable of integrating data from emerging sensor technologies when such sensors are operationally deployed.
- a performance-based data fusion based on an advanced monitoring of the tracker coherence. The main benefit for the ANSPs is the knowledge that the tracker is "fit for purpose", i.e. able to handle Space-Based ADS-B and INCS/MSPSR data served respectively in ASTERIX CAT 021 and CAT015, which would be a step further to a possible operational use of these data.

The MRT-SUR will add value through increased ATCOs situation awareness. With its tailored performance, which is cost effective, the MRT-SUR is an option for Multi Remote Tower Control of small and medium sized airports, where the enhanced situation awareness enables new possibilities e.g. the automatic generation of MRTC events or an enhanced control of the pan tilt zoom (PTZ) camera what is expected to increases the efficiency of the MRT ATCO.

The results clearly indicate that it is possible to use a sensor in the intended operating mode: the provision of a basic surveillance for small and medium sized airports.

For from ANSP's point, Secured Surveillance Systems has shown that the development of Security functionalities for ADS-B and WAM systems are in line with the last Standards and Specifications, increasing the confidence level of the ADS-B surveillance data.

In addition to this, potential benefits have been identified:

- Increase of the security level in the ADS-B surveillance data provision.

- Security functionalities in line with Standards and Specifications.
- Early detection of security threats and activation of appropriate alarms and procedures in order to mark the potential threats.

The Future ADS-B communication link Key Results permit to demonstrate the capability of the solution to be interoperable and to reach performances required, mainly on the capability to decode correctly data transmitted. It has been demonstrated that it is possible to increase bit rate transmission by four, which permits to reduce drastically RF pollution which is a main issue for air traffic today.

This solution contributes to improve the Security of the studied systems. Prior to the operational introduction of the developments conducted within this solution a full range of safety and security assessments are to be conducted.

1.5 Technical Deliverables

The following tables report the list of relevant deliverables developed for domain by each solution during the whole life of the project.
The first table is devoted to highlight a summary of the deliverables prepared by the transversal solution PJ14-01-01 being part of the formal Data Pack. In this case the Data Pack includes a set of deliverables relevant for the future evolution of the CNS solutions.

Reference	Title	Delivery Date[1]	Dissemination Level[2]
	Description		
D2.1.030	CNS evolution roadmap and strategy	02/09/2019	PU
This deliverable summarizes the development of a CNS roadmap, taking into account and ensuring consistencies with all relevant documents (ICAO GANP, European ATM Master Plan, Flight Path 2050)			
D2.1.040	CNS Robustness study	19/09/2019	PU
This document provides a description of the SESAR 1 and SESAR 2020 ATM architecture and lists the systems and enablers allocation in EATMA. The document also provides a security assessment for certain CNS domains.			
D2.1.090	Civil-Military CNS information exchange requirements	17/09/2019	PU
The parts I & II of the deliverable lists the exchange requirements for aeronautical information, airspace and flow management, flight planning and flight data, surveillance data and air ground communications.			
D2.2.020	_Performance based integrated CNS	13/09/2019	PU
The version 1 of the document collects the CNS requirements from the existing performance-based Communication, Navigation and Surveillance and groups together in order to pave the way for a future integrated performance based CNS concept. The version 2 is summarises the current performance monitoring requirements defined in the performance-based Communication, Navigation and Surveillance concept. This deliverable has also assessed the current aircraft fleet navigation performances.			
D2.1.070	_Ionosphere Threat Mitigation	27/09/2019	PU
Space weather refers to natural perturbations coming from the sun or from space that can influence the performance and reliability of space-borne, ground-based or airborne systems and can endanger			

[1] Delivery data of latest edition

[2] Public or Confidential

human life or health. This deliverable characterises some selected abnormal ionosphere event, and summarize how a threat model has been developed.			
D2.1.080	_GNSS core constellation monitoring	05/09/2019	PU
This document proposes a methodology to monitor the GNSS performances, summarizing the current performance monitoring requirements defined in the performance-based Communication, Navigation and Surveillance concept. In addition, this deliverable has also assessed the current aircraft fleet navigation performances.			

Table 1 PJ14-01-01 transversal solution, Data Pack deliverables

1.5.1 Communication domain

The following tables are devoted to highlight a summary of the deliverables prepared by each COM solution being part of the formal Data Pack together to additional relevant deliverables, where available.

Reference	Title	Delivery Date[3]	Dissemination Level[4]
	Description		
PJ.14-02-01a	Data Pack for FCI Terrestrial Data Link – A/G TRL4 Gate	03/10/2019	PU
The Data Pack includes the mandatory deliverables for TRL4 Gate (TS/IRS, TVALR)			
D3.2.030	_Final TS/IRS for LDACS	02/09/2019	PU
This deliverable developed in WP3 of PJ14 EECNS, provides the final version of the TS/IRS for the future terrestrial datalink LDACS, which is currently developed in the SESAR2020 Programme. This document constitutes the final (fourth) revision of the LDACS Technical Specification, which was continuously revised throughout the execution of Solution PJ14-02-01 with the aim to reach TRL4 maturity at the end of wave 1.			
D3.1.030	_Technical Validation Report (TVALR)	03/10/2019	PU
This document represents the Technical Validation Report for the SESAR Solution PJ14-02-01 (FCI Terrestrial Datalink – LDACS. This document describes the results of the technical validation exercises executed during the SESAR Solution PJ14-02-01 aiming to reach TRL4. It describes the validation approach, objectives, the assumptions and the results of the TRL4 validation exercises. The TRL4 Validation of this solution shall enable the solution to reach maturity level TRL 4.			

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D3.1.040	Updated TVALP defining the validation roadmap for phase TRL6	03/10/2019	PU

This Technical Validation Plan is a relevant document, not part of the Data Pack, describing how the Technological Solution PJ14-02-01 expects to reach the planned TRL6 maturity level for enabler CTE-C02e "New A/G datalink using ATN/IPS over L-band" through the execution of several technical validation exercises. Therefore, this document contains an overview of the context of the technical validation at Technological Solution PJ14-02-01 level in terms of R&D needs, technical validation targets, stakeholders' expectations, objectives and specific details related to each planned technical validation activities. This document integrates individual technical validation plans for the following exercises by detailing how each of them contributes to the achievement of the Target Maturity Level (TRL6) for the LDACS A/G datalink (enabler CTE-C02e "New A/G datalink using ATN/IPS over L band.

D3.4.020	LDACS Deployment Options and Recommendations	02/09/2019	PU

This document is a relevant document, not part of the Data Pack. The LDACS new Air-Ground Link standard will be part of the Future Communications Infrastructure together with SATCOM and AeroMACS with ATN-IPS as a common layer 3 protocol. However, it is understood that there are several topics that have to be addressed before putting into operation LDACS integrated within the FCI. This document tries to give a "way ahead" to answer to these questions.

PJ.14-02-01b	Data Pack for FCI terrestrial Data Link A/A TRL2 Gate	03/10/2019	PU

The Data Pack includes the mandatory deliverables for TRL4 Gate (FRD)

D3.7	FRD for LDACS A/A mode	06/09/2019	PU

This report provides the FRD for the air-to-air mode of the future terrestrial datalink LDACS, which is currently developed in the SESAR2020 Programme. This document constitutes the first version of the LDACS A/A FRD (for TRL2) and shall enable the development to TRL4.

D3.8	TVALP for LDACS A/A Mode	20/09/2019	PU

This Technical Validation Plan, not part of the Data Pack but relevant for the solution, describes how the Technological Solution PJ14-02-01 expects to reach TRL4 maturity level for enabler CTE-C02g - "Air to Air functionality of New A/G radios" through the execution of validation exercises.

D3.3.030	Updated LDACS A/G Specification	06/09/2019	PU

This document is a relevant document not part of the Data Pack. It represents deliverable D3.3.010 developed in WP3 of PJ14 EECNS, providing an update of the already existing LDACS specification produced in SESAR1 P15.02.04 with modified wording and additional clarifications in some areas. The updated specification shall serve as a solid and stable baseline for further LDACS testing and technical verification activities. Current maturity level of LDACS A/G data communication (i.e., enabler CTE-C02e — New A/G datalink using ATN/IPS over L-band) is TRL4.

Table 2 PJ14-02-01 COM solution: PJ14-02-01a & PJ14-02-01b Data Packs and relevant deliverables

Reference	Title	Delivery Date[5]	Dissemination Level[6]
Description			
PJ.14-02-02	Data Pack for SATCOM Class A TRL4	20/11/2019	PU
The Data Pack includes the mandatory deliverables for TRL4 (OSED, TS/IRS, TVALR, INTEROPS, CBA)			
D4.1.010	SATCOM OSED	09/10/2019	PU
The scope of the present document SATCOM OSED to define the operational services and environment definition of SATCOM Class A , on the basis of the work performed in PJ 15.2.4, 15.2.5 and 15.2.6, in parallel with PJ14.2.4 that defines FCI and also taking into account the updates from Iris Program progresses.			
D4.1.030	SATCOM Class A TS/IRS	11/10/2019	PU
Purpose of the document is to define a technical specification for the SATCOM service, with main focus on SATCOM service Class A and starting from what already defined in Class B context. Specifications are provided independently from the technical solution defined in other context, i.e. ESA Iris Program, and avoiding overlapping with ESA Iris Program that defines the System Specifications at a lower level.			
D4.1.090	SATCOM Class A TVALR	11/10/2019	PU
This document is a Technical Validation Report (TVALR) produced in the scope of SESAR Solution 14.02.02 (Deliverable ID D4.1.090). The scope of this report is to detail results of the tests achieved following PJ14-02-02 TVALP (Deliverable ID D4.1.060) and to give a status regarding Validations Objectives and Validation Exercises that were defined in that TVALP.			
D4.1.130	SATCOM Class A - INTEROPS	21/10/2019	PU
This document is developed under PJ14 EECNS - Essential and Efficient Communication Navigation and Surveillance integrated system – for the solution PJ 14.2.2 - Future Satellite Communications datalink, that addresses the new SATCOM communication with main focus on SATCOM Class A. The deliverable provides the interoperability requirements for the new SATCOM communication link (SATCOM Class A) providing general and fnctional requirements, m This document provides the Interoperability requirements for the new SATCOM communication link (SATCOM Class A), providing requirements of the following categories, multi-link requirements, interface and standardization requirements..			
D4.1.150	SATCOM Class A CBA	04/10/2019	PU
This document provides the first version of the Cost Benefit Analysis (CBA) related to SESAR Solution			

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[6] Public or Confidential

PJ 14-02-02 Future Satellite Communications Datalink which addresses development of future long-term satellite datalink technologies (Class A SATCOM), starting from incremental Class B SATCOM enhancements, for both the continental and remote/oceanic airspace volumes. It is in principle a qualitative description of the anticipated benefits associated with the known features of future Class A SATCOM service			
D4.2.100	SATCOM CLASS B TVALR	11/10/2019	PU
This document is a Technical Validation Report (TVALR) produced in the scope of SESAR Solution 14.02.02 (Deliverable ID D4.1.080). For SATCOM Class B, work done by PJ14-02-02 was complementing SOL #109..			

Table 3 PJ14-02-02 COM solution: PJ14-02-02a & PJ14-02-02b Data Packs and relevant deliverables

Reference	Title	Delivery Date[7]	Dissemination Level[8]
	Description		
PJ.14-02-04	Data Pack for FCI TRL2	20/10/2018	PU
The Data Pack includes the mandatory deliverables for TRL2 (FRD)			
D5.2.010	SESAR2020 PJ14-02-04 Functional Requirement Document	20/12/2017	PU
This deliverable (D5.2.010) has been prepared aiming at specifying the Technical requirements of the PJ14-02-04 FCI that will support the FCI Initial Concept. The document also defines the existing interfaces within the project and identifies and recollects the gaps, assumptions, recommendations, and guidelines followed while writing the document.			
D5.2	Data Pack for FCI TRL4	20/10/2019	PU
The Data Pack includes the mandatory deliverables for TRL4 (TS/IRS, TVALR)			
D5.4.010	SESAR2020 PJ14-02-04 Final TS IRS	14/10/2019	PU
The objective of PJ14-02-04 project 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 at TRL4 Maturity level. The FCI is a new IP-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 SATCOM, LDACS, and AeroMACS.			
D5.3.040	SESAR 2020 PJ14-02-04 Technical	18/10/2019	PU

[7] Delivery data of latest edition

[8] Public or Confidential

	Validation Report (TVALR)		
This document is the Technical Validation Report [TVALR], TR4 maturity level, for SESAR PJ14-02-04 solution which considers of the validation platforms and prototype developed by Airtel, ENAIRE, Frequentis, Honeywell and Leonardo. This document discloses the results achieved by the accomplishment of the laboratory exercises defined in the document ref. D5.3.020 Technical Validation Plan [TVALP] and, moreover, the conclusions and recommendations for further applications.			
D5.3.060	Transversal and Complementary Studies	25/10/2019	PU
The document, not part of the Data Pack but relevant for the solution, aims to provide input requirements for the Future Communications Infrastructure (the FCI) in terms of safety and security design objectives. This document is based on the work described in the SESAR1 P15.02.04 deliverable "Deliverable D04 – Quality of Service (QoS) and Classes of Service (CoS)". Guidelines and methodologies on which this document is based are the same that have been followed for the SESAR1 P15.02.04 D04 and D05 Deliverables, in order to fill the gaps left open and to contribute to the FCI architecture design, as defined by the PJ14-02-04 FRD and TS-IRS documents.			

Table 4 PJ14-02-04 COM solution: Data Pack and relevant deliverables

Reference	Title	Delivery Date[9]	Dissemination Level[10]
	Description		
PJ.14-02-05	Data Pack for FIS-B for GA V1 Maturity Level	06/11/18	PU
The Data Pack includes the mandatory deliverables for ATM Solution V1 Gate (SPR-INTEROP/OSED, FRD, VALP, VALR)			
D6.1.010	SPR-INTEROP/OSED V1	19/09/2018	PU
This OSED Part I document of SESAR2020 solution PJ14-02-05 describes new services and applications for General Aviation (GA). These services will comprise the provision of additional FIS and TIS information to be transmitted to GA pilots during flight via a new data link for General Aviation, which will be based on existing mobile/cellular (LTE) technology. It also summarizes all components to be developed like a new App and a Ground Data Processing Unit (GDPU) and provides benefit and cost mechanisms for these new services.			

[9] Delivery data of latest edition

[10] Public or Confidential

D6.1.020	Validation Report	09/09/2018	PU
This document describes the results of the validation exercises for the V1 phase of the SESAR Solution PJ14-02-05. It describes the validation approach, objectives, the assumptions and the results of the V1 validation exercises. The V1 Validation of this solution is a pure Document Review (i.e. a literature study), which shall enable the solution to reach maturity level TRL 2.			
D6.2.010	Functional Requirements Document	09/09/2018	PU
This Functional Requirements Document (FRD) of SESAR2020 solution PJ14-02-05 has been derived from the OSED document of this solution, where the new services and applications are described. It summarizes all functional requirements for the new App to be developed, the new data link for General Aviation altitudes and the new Ground Data Processing Unit (GDPU) to be developed, as well. The FRD is a pre-requisite for the Technical Specification (TS), where the technical requirements for the App, the new data link and the GDPU are described.			
D6.1.021	Validation Plan V1	09/09/2018	PU
This document describes the V1 Validation Plan for the SESAR Solution PJ14-02-05 exercises. It describes the validation approach and activities, the validation objectives, the assumptions and the foreseen validation exercises lists and planning. The V1 Validation of this solution is a pure Document Review (i.e. a literature study), which shall enable the solution to reach maturity level TRL 2.			
PJ.14-02-05	Data Pack for FIS-B for GA V2 Maturity Level	01/10/2019	PU
The Data Pack includes the mandatory deliverables for ATM Solution V2 Gate (SPR-INTEROP/OSED, VALR, TS/IRS, CBA)			
D6.3.010	SPR-INTEROP/OSED V2 Part I, Edition 01.01.00	24/09/2019	PU
The document contains the operational concept with its new services and applications, the operational, safety, performance and interoperability requirements, the cost and benefit mechanisms and the assessment of the telecommunications coverage, bandwidth and data integrity.			
D6.3.031	SPR-INTEROP/OSED V2 Part II, Edition 0.01.00	02/09/2019	PU
This document represents the Safety Assessment Report (SAR), which summarizes the results of a number of Safety Assessment workshops performed with GA pilots.			
D6.3.021	V2 VALR, Edition 00.01.02	20/09/2019	PU
This Validation Report summarizes the results of the V2 validation exercises, EXE-14.02.05-V2-VALP-005 and -006 (Validation of the new service and its system components (App and GDPU prototypes) under laboratory conditions at a stationary place and in moving cars).			
D6.4.010	TS/IRS, Edition 00.01.00	23/09/2019	PU
This Technical Specification lists all functional requirements as well as non-functional requirements like performance, safety and interoperability requirements from the system's point of view (App, GDPU and data link).			

D6.4.030	CBA V2, Edition 00.01.02	29/11/2019	PU
This document represents the Cost Benefit Analysis of the Solution.			
D6.3.030	V2 VALP Part II, Edition 00.01.03	17/09/2019	PU
This document represents the Safety Assessment Plan relevant for the execution of the Safety Assessment workshops and the development of the SAR.			

Table 5 PJ.14-02-05 COM solution: PJ14-02-05 TRL2 & PJ14-02-05 TRL4 Data Packs and relevant deliverables

Reference	Title	Delivery Date[11]	Dissemination Level[12]
	Description		
PJ.14-02-06	Data Pack for AeroMACS TRL6 Maturity Level	19/11/2019	PU
The Data Pack includes the mandatory deliverables for TRL6 Gate (TS/IRS, TVALR)			
D7.3.010	Final TS/IRS	25/10/2019	PU
This Initial TS/IRS, targeting TRL6 maturity level, describes Architecture and Technical Requirements related to the Integration of AeroMACS System with the ATN/OSI Network. It also addresses Multilink in ATN/OSI environment. Integration with ATN/IPS Network in Multilink environment will be addressed in coordination with 14.02.04 Solution activities related to the definition of the Future Communication Infrastructure (FCI) of which AeroMACS will be a Subnetwork.			
D7.3.030	Technical Validation Report	10/10/2019	PU
This is the Technical Validation Report for Solution PJ14.02.06 (Completion of AeroMACS Development) describing the activities executed within the Solution PJ14.02.06 framework in order to make the Solution reach the planned TRL6 maturity level at the end of Wave 1, specifically through the execution of different Technical Validation exercises. In particular, this document contains a reference to the Technical Validation Plan previously delivered (with the context of the technical validation in terms of R&D needs, technical validation targets, stakeholders' expectations, objectives and details related to each planned technical validation activities), the detailed Technical Validation Report for the conducted Exercises, the analysis of results and conclusions.			
D7.10.010	Final Standardization Report	03/10/2019	PU
This document, relevant for the solution but not part of Data Pack, provides summary and high level record of the work performed in the SESAR2020 PJ14 AeroMACS solution (PJ14-02-06) activities,			

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and in particular within the solution task: 'International Standardization and Harmonization'. Overall, the document summarizes the current status and the solution contributions provided to various international standardization bodies addressing the standardization of AeroMACS, describes relevant global harmonization activities and captures the dissemination activities undertaken by PJ14-02-06 partners as well as at solution level in order to raise AeroMACS awareness and foster coordination with relevant bodies and parties.	

Table 6 PJ.14-02-06 COM solution: Data Packs and relevant deliverables

1.5.2 Navigation domain

The following tables are devoted to highlight a summary of the deliverables prepared by each NAV solution being part of the formal Data Pack together to additional relevant deliverables, where available.

Reference	Title	Delivery Date[13]	Dissemination Level[14]
	Description		
PJ.14-03-01a	Data Pack for GBAS GAST D Extended Scope TRL4 Gate	13/11/2019	PU
The Data Pack includes the mandatory deliverables for TRL4 Gate (TS/IRS, TVALR)			
D8.2.010.1	TS/IRS TRL4 GBAS Extended Scope	30/09/2019	PU
The TS/IRS covers the requirement specification for the task T3 GAST D Extended Scope of PJ14-03-01 GBAS solution. For activities related to assessing performance of GAST D in challenging environments (severe ionospheric conditions, RFI and jamming situations, among other), the relevant performance requirements are specified in ICAO Annex 10 Vol. I. Technical requirements for provision of GBAS Ground Station status data to external users (such as ATC staff and maintenance personnel) are specified herein. SNMPv2c is the proposed protocol, and a table containing candidate GBAS Ground Station status parameters is presented.			
D8.1.020.1	TVALR TRL4 GAST D Extended Scope, Ed. 00.01.01	06/09/2019	PU
This report provides the technical validation results of the PJ14-03-01 Task 3 GAST D Extended Scope. The validation exercises are defined in D8.4.010 TVALP TRL4 GAST D Extended Scope. The PJ14-03-01 T3 task consists of a number of subtasks, each of which address separate issues and thus have different validation objectives. Although there is not one common verification method for these tasks. for all tasks the main objective have been to verify an "extended scope" dealing with			

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scenarios not covered in SESAR 1; coverage of high and low latitudes' iono disturbances, radio frequency interference, measurements of multiple VDB implementation coverage, validation of VDB measurement equipment for flight tests, and validation of ATC and Maintenance interface.			
D8.4.010.1	TVALP TRL4 GAST D Extended Scope, Ed. 01.00.00	15/11/2018	PU
This document, not being part of the Data Pack, is the Technical Validation Plan for the "T3-GAST-D Extended scope" task in the PJ. 14-03-01 GBAS solution. The main goal of the T3 activity is to mature the extended functionality needed to ensure that the GAST D solution can operate efficiently and in a cost effective manner in different airport environments (of different complexity) anywhere in the world. An extensive roll out of the GBAS solution will allow the ATM community to more quickly reap the benefits linked to the solution.			
D8.1.070	Roadmap TVALP TRL6 GAST D Extended Scope	18/09/2019	PU
This document, not part of the Data Pack but relevant for the future development, is the TVALP TRL6 Roadmap for PJ14-03-01 subtask T3. GAST D Extended Scope within the SESAR 2020 project PJ14 EECNS. The proposed validation activities contribute to maturing the GAST D Extended Scope to TRL6 in a future TRL6 development phase.			
PJ.14-03-01b	Data Pack for GBAS GAST F TRL4 Gate	13/09/2019	PU
The Data Pack includes the mandatory deliverables for TRL4 Gate (TS/IRS, TVALR)			
D8.8.040.2	TS/IRS GAST F, Final version Ed. 00.01.05	03/09/2019	PU
This TS/IRS presents the Dual Frequency Multi Constellation Ground Based Augmentation System (DF/MC GBAS) solution in terms of the associated enabler, technical system, system ports in the frame of TRL4. The high level requirements, associated to DF/MC GBAS, are presented in terms of functional requirements as well as non functional ones. These requirements have considered the GAST D SARPs as starting point and then including DF/MC amendments wherever it has been deemed necessary. In addition to this, the DF/MC GBAS Conceptual Framework presented at ICAO Navigation System Panel in November 2018 is also included.			
D8.8.020.3	TVALR GAST F, Third version Ed. 00.01.00	09/09/2019	PU
This document describes the technical validation results associated to the technical validation plan of SESAR 2020 PJ14-03-01 WP8 ST 4.3, which is focused on the position domain accuracy associated to the DF/MC CAT II/III GBAS. The overall maturity level of the DF/MC GBAS solution is TRL4 on-going after the execution of this TVALR.			
D8.8.010.3	TVALP GAST F, Third version Ed. 00.01.01	08/10/2019	PU
This document, not being part of the Data Pack, provides the validation plan of the PJ14-03-01 WP8 ST4.3, which focussed on the upgraded differential processing consolidation associated to the DF/MC CAT II/III GBAS taking into account a higher number of DF/MC deployed satellites as well as several types of GBAS Reference Receiver Antennae (Choke Ring, MLA).			

This plan describes the activities necessary for the TRL3 validation of the GBAS DF/MC system by means of a ground station mock-up..			
D8.8.060	TVALP GAST F TRL4 Roadmap, Ed.00.00.03	16/10/2019	PU
This relevant document, not part of the Data Pack, describes the technical validation roadmap targeting completion of the TRL4-level of the DFMC GBAS system. It focuses on the demonstration of the ionospheric mitigation associated to the DF/MC CAT II/III GBAS as well as the performance assessment of the L5/E5a only fall-back mode. The INDRA GBAS Ground Subsystem Mock-up and Prototype and the EUROCONTROL Pegasus Tool will be the main tools used for the technical validation.			
PJ.14-03-01c	Data Pack for GBAS Non-MMR Avionics Architecture TRL2 Gate	13/11/2019	PU
The Data Pack includes the mandatory deliverables for TRL2 Gate (FRD)			
D8.9.010.1	FRD for A/C-56b TEN, non MMR Architecture, Ed. 00.01.01	29/01/2019	CO
This document is the FRD produced by task T4.4 reflecting the maturation of A/C56b up to TRL2 level, in the case a non MMR avionics is considered to support the different precision approach capabilities on board the aircraft.			
D8.9.040	Roadmap TVALP TRL2 for A/C-56b non MMR architecture, Ed. 00.01.00	20/09/2019	PU
This document is not part of Data Pack, but it is considered relevant for the prosecution of the solution. This document proposes a roadmap for further work allowing the maturation up to TRL4 of the key technical elements supporting the different precision approach capabilities considered by the non MMR architecture.			
PJ.14-03-01d	Data Pack for GBAS GAST D Expanded Service Volume TRL2 Gate	13/09/2019	PU
The Data Pack includes the mandatory deliverables for TRL2 Gate (FRD)			
D8.5.010	FRD TRL2 GAST D ESV, Ed.01.00.01	04/07/2019	PU
This document is the Functional Requirements Document for the task T3.1.3 GBAS Expanded Service Volume within the SESAR 2020 project PJ14 EECNS. It refers to the changes to ICAO SARPS (introduced as Amendment 91, applicable since November 2018) reducing the operational differences between GBAS and ILS by allowing advisory use of deviation guidance outside the GBAS approach service volume. The decoupling of Dmax and GBAS approach service volume and the new operational usages that this decoupling provides do not lead to any functional changes or new requirements to the GBAS Ground Station or the Airborne Equipment.			
D8.5.020	TVALR TRL2 GAST D ESV, Ed.01.00.01	14/11/2019	PU
This document, not part of the Data Pack, is the Technical Validation Report for the task T3.1.3 GBAS Expanded Service Volume. In this report GBAS GAST D availability is studied at large distances for two airports at different latitudes using simulations where the distances studied were 25 NM, 35 NM, 45 NM, 60 NM, 80 NM and 100 NM. In conclusion, using GBAS guidance at large maximum use distance is considered feasible from a landing service availability point of view.			

A Safety Impact analysis is included where it is found that the SESAR 1 GBAS Operational Safety Assessment performed prior to the decoupling of Dmax and service volume does not need to be changed.			
D8.5.030	Roadmap TVALP TRL4 GBAS ESV, Ed.01.00.01	10/07/2019	PU
This document, relevant for the future development but not part of the Data Pack, is the TVALP TRL4 Roadmap for PJ14-03-01 subtask T3.1.3 GBAS Expanded Service Volume. Changes to ICAO SARPs (introduced as Annex 10 Vol. I Amendment 91, applicable since November 2018) reduces the operational differences between GBAS and ILS by allowing advisory use of deviation guidance outside the GBAS approach service volume. The solution PJ14-03-01 GBAS studied the technical feasibility of the GBAS ESV concept in terms of GAST D availability for a range of Dmax values. This TVALP TRL4 roadmap outlines areas that are candidates for further analysis and validation prior to operational usage.			
D8.9.020	SESAR 2020 TRL2 Safety Security Assessment for A/C-56b non MMR Architecture, Ed. 01.00.00,	24/09/2019	PU
This document develops the safety and security considerations considered by the T4.4 of solution PJ14-03-01, investigating A/C 56b, non MMR Architecture to create necessary and sufficient evidence of Safety and Security Assessment compliant with V1 demonstration objective.			
D8.7.010	Technical Report Preparing GBAS Approval in Europe, Ed. 01.00.00,	25/10/2019	PU
This document contains a high-level overview of the approval basis and anticipated applicable standards and requirements to which Means of Compliance should be provided. The status of the situation in Europe in terms of approval authorities and mandates, and possible paths to a GBAS ground station approval are summarized.			
D8.3.030	Standardization and External Communication Report 2019, Ed.00.01.00	29/11/2019	PU
This relevant document, not part of the Data Pack, covers the reporting from the PJ14-3-1 activities concerning Standardisation and external Communications. It includes summary reports from the GBAS-relevant working groups LATO and IGWG, additional ad-hoc reports of GBAS relevant activities and the following standardisation groups: ICAO Navigation Systems Panel (NSP), ICAO Instrument Flight Procedures Panel (IFPP), ICAO FLighT OPerationS Panel (FLTOPSP), ICAO EUR All Weather Operations Group (AWOG), EUROCAE WG28 (GNSS), and RTCA SC-159 WG4 (GBAS).			

Table 7 PJ.14-03-01 NAV solution: PJ14-03-01a, PJ14-03-01b, PJ14-03-01c & PJ13-03-01d Data Packs and relevant deliverables

Reference	Title	Delivery Date[15]	Dissemination Level[16]
	Description		
PJ.14.03.02	Data Pack for MC/MF TRL4 Gate	13/10/2019	PU
The Data Pack includes the mandatory deliverables for TRL4 Gate (TS/IRS, TVALR)			
D9.1.020	PJ14-03-02 MC/MF TS IRS	30/09/2019	PU
This document provides the TS-IRS for PJ14-03-02 enabling maturation of technical enabler A/C02b "Enhanced precision and availability/continuity of positioning (based on GNSS dual frequency, Galileo, GPS L5)" up to TRL4. It investigates and presents a number of use cases providing operational improvements expected from MC/MF (DFMC) technology.			
D9.1.080	PJ14-03-02 Validation Report (TVALR) for TRL 4	21/10/2019	PU
The purpose of this validation report is to provide the results from the execution of the validation plan defined in the Validation Plan. The validation plan was divided in three main exercises and provides a detailed description of each scenario and test procedure used to validate every one of the specified objectives as well as the associated limitations. The validation was based on laboratory tests and simulation. Laboratory tests were conducted using the solution members' respective prototypes and live signals received through an antenna as well as signals generated using a GNSS simulator			
D9.2.030	PJ14-03-02: COST BENEFIT ANALYSIS	25/10/2019	PU
This document, not mandatory for technological solution, has been produced as relevant for the prosecution of the solution. The CBA assesses the economic feasibility of the Solution and compares different alternatives in order to provide a first order of magnitude of benefits and costs related to one of the Solution scenario. It is deriving a general methodology reusable by other stakeholders impacted by the implementation of DFMC GNSS, to assess costs and benefits of the SESAR Solution PJ14-03-02. The present version provides an initial view of CBA orientations in terms of scenario alternatives. It provides CBA results for one of the considered scenarios in the case of Schedule Aviation as part of Airspace User.			

Table 8 PJ.14-03-02 NAV solution: Data Pack and relevant deliverables

Reference	Title	Delivery Date[17]	Dissemination

[15] Delivery data of latest edition

[16] Public or Confidential

[17] Delivery data of latest edition

			Level[18]
Description			
PJ.14-03-04a	Data Pack for Short-term Alternative Position, Navigation and Timing TRL6 Gate	31/10/2019	PU
The Data Pack includes the mandatory deliverables for TRL4 Gate (TS/IRS, TVALR)			
D10.3.01	PJ14-03-04 Short Term APNT Solution TS-IR	24/10/2019	PU
This TS-IRS covers mainly performance requirements applicable to the ground DME infrastructure, in particular to the DME Transponders, in order to provide an alternative navigation service in case GNSS becomes unusable, and permit RNP 1 departure and arrival operations. The scope is limited to this particular 14-03-04 sub-solution, the Short-Term A-PNT solution.			
D10.3.03	14-03-04: Short-term A-PNT solution : Technical Validation Report (TVALR) for TRL4	23/10/2019	PU
This document is the Technical Validation Report for the Short-term APNT solution, supporting A/C-02d, a new aircraft technical enabler investigated in PJ14-03-04. This enabler provides multiDME positioning fully compliant with RNP Navigation requirements, allowing continuation of operation with RNP requirements in case of GNSS loss. The validation consisted in Real Time Simulation and Fast time simulation exercises performed by THALES avionics to validate the proposed solution up to on going TRL4 maturity.			
PJ.14-03-04b	Data Pack for Mid Term Alternative Position, Navigation and Timing TRL4 Gate	31/10/2019	PU
The Data Pack includes the mandatory deliverables for TRL4 Gate (TS/IRS, TVALR)			
D10.2.05	PJ14-03-04 TS-IRS for Mid Term APNT Solution	22/10/2019	PU
This document represents the TS-IRS of the mid-term A-PNT SESAR Technological Solution. The main objective of the document is to identify the requirements for this solution to support the reversion from GNSS to this A-PNT solution in case of GNSS outages when operating routes with RNP1 defined constraints, particularly SIDs and STARs according to European PBN-IR. The content is solution independent; it described “what” the SESAR Technological solution has to do but not the “how”.			
D10.2.03	14-03-04: Mid-term APNT solution : Technical Validation Report (TVALR) for TRL4	24/09/2019	PU
The purpose of this validation report is to detail the validation objectives and exercises required to validate the Mid term solution from PJ14.3.4 to partial TRL4. The object of the validation are the sub-set of the requirements provided in the TS-IRS, related to the			

[18] Public or Confidential

	new multiDME positioning aspects. The requirements related to the database with associated ground tools supporting the solution will be validated to TRL4 during wave 2. Main rationale for the repartition of the overall validation work in the two waves, is that modification impacting the FMS SW are heavy, and it was considered necessary to validate first the core of the solution (new multiDME positioning algorithms and reversion aspects), before going into the detailed implementation of database aspects		
PJ.14-03-04c	Data Pack for Long Term Alternative Position, Navigation and Timing TRL2 Gate	31/10/2019	PU
The Data Pack includes the mandatory deliverables for TRL2 Gate (FRD)			
D10.1.10	PJ14-03-04 Long-Term A-PNT Functional Requirements Document	28/10/2019	PU
This document represents a formal statement of the Long Term A-PNT SESAR Technological Solution related functional requirements. The main objective of the document is to identify the foreseen reversionary operations in case of GNSS outages for all phases of flight and define the functional requirements applicable in order to support these operations. The content is solution independent; it described "what" the SESAR Technological solution has to do but not the "how".			
D10.1.03	Civil-military navigation interoperability: Suitability of military inertial systems to sustain emerging navigation requirements	02/09/2019	CO
The present document, not part of the Data Packs, is the Technical Note on the investigation of the suitability of military inertial navigation systems (INS) to sustain emerging navigation requirements for State aircraft operations, which substantiates the civil-military interoperability contribution to Solution 14-03-04 Alternative Positioning Navigation and Timing (A-PNT). The main objective is to assess the performance of military inertial systems, and therefore, the viability of the use of these system solutions by State aircraft when conducting operations under General Air Traffic (GAT) status in a Performance-Based Navigation (PBN) environment. This has been achieved by simulating the accuracy of military inertial systems vis-à-vis stringent PBN requirements.			

Table 9 PJ.14-03-04 NAV solution: PJ.14-03-04a, PJ.14-03-04b & PJ.14-03-04c Data Packs and relevant deliverables

1.5.3 Surveillance domain

The following tables are devoted to highlight a summary of the deliverables prepared by each SUR solution being part of the formal Data Pack together to additional relevant deliverables, where available.

Reference	Title	Delivery Date[19]	Dissemination

[19] Delivery data of latest edition

	Description		Level[20]
PJ.14-04-01a	Data Pack for Surveillance Performance Monitoring for Cooperative and Non-cooperative sensors TRL4 Gate	10/10/2019	PU
The Data Pack includes the mandatory deliverables for TRL4 Gate (TS/IRS, TVALR). This solution provides two separate TS/IRS and two separate TVALR for cooperative and for non-cooperative. sensors.			
D11.2.020	Technical Specification (TS/IRS) for Surveillance Performance Monitoring (SPM) Tools for Cooperative Sensors (ADS-B, WAM, MLAT)	28/08/2019	PU
The aim of this document is to produce the technical requirements for the implementation of Surveillance Performance Monitoring (SPM) tools for the performance analysis at sensor level of Cooperative (ADS-B, WAM, MLAT), part of the Surveillance Performance Monitoring targeting TRL4. The SPM TS/IRS is dependent on the inputs standards for Cooperative Surveillance, the level of maturity of which are heterogeneous, at the time of the development of this TS/IRS. One of the objectives of PJ14-04-01 is the harmonisation of the tools. Recognising there is a trend of the standards towards harmonisation, the choice in this TS/IRS has been made to harmonise the various metric assessment methods in line with this trend started by ED129B and continued with the ongoing standards. During the project a number of standards open points were identified and used for exchanges with the related groups (EUROCAE).			
D11.2.040	Technical Specification (TS/IRS) for Surveillance Performance Monitoring (SPM) Tools for Non-Cooperative Sensors (SMR)	23/09/2019	PU
The aim of this document is to produce the technical requirements for the implementation of Surveillance Performance Monitoring (SPM) tools for the performance analysis at sensor level of Non-Cooperative part of the Surveillance Performance Monitoring targeting TRL4. This final TS/IRS with respect to the initial version consolidates the requirements after the execution of the technical validation exercises and focuses on the off-line and quasi real-time aspects. This SPM TS/IRS is dependent on the inputs standards for Non-Cooperative Surveillance, which are: • ED-116: dated January 2004 • GEN-SUR SPR still under development			
D11.1.070	TVALR for SPM Tools for Non-Cooperative Surveillance Sensors	23/09/2019	PU
This document provides the technical validation results for the Task 02 of the SESAR Technological			

[20] Public or Confidential

Solution PJ14-04-01 Surveillance Performance Monitoring (SPM) tools. Task 02 addresses the Non-Cooperative part of the Surveillance Performance Monitoring at sensor level (SMR). The document describes the exercises executed to confirm that the SPM prototype (AccPoDTool) meets the specification for Non-Cooperative Sensors in Surface environment (SMR - enabler CTE-S07d) and their positive results.			
D11.1.030	TVALR for SPM Tools for Cooperative Surveillance Sensors	12/07/2019	CO
This document provides the technical validation results for the Task 01 of the SESAR Technological Solution PJ14-04-01 Surveillance Performance Monitoring (SPM) tools. The performance results of surveillance systems of ANSPs are sensitive information that are reported as part of the Verification Report (TVALR). The results presented in this TVALR are focused in the performance evaluation of the developed tools and they are not focused in the performance of the sensors data provided by the ANSPs. For testing purposes, different scenarios have been chosen to be evaluated by the tools, where not all of them reflect the real system requirements of the evaluated system in operation. Therefore the results of the TVALR should not be considered for conclusions on the performance of the evaluated systems but rather for conclusions on the ability of the tools to assess the system performance correctly.			
D11.1.080	PJ14-04-01 TVALP defining Roadmap for TRL6 for SPM Tools for Non-cooperative Surveillance Sensors	19/09/2019	PU
This document, not part of the Data Pack, provides an initial Technical Validation Plan for TRL6 defining the roadmap for TRL6 for the Task 02 of the SESAR Technological Solution PJ14-04-01 Surveillance Performance Monitoring (SPM) tools. addressing the Non-Cooperative part of the Surveillance Performance Monitoring at sensor level (SMR). This document contains the description of the technical validation plan for the next maturity level TRL6 focusing in both offline and Quasi-Real Time aspects of the SPM Tool. Task 02 aims to confirm that the future SPM prototype, proposed by the solution, meet the specification regarding monitoring of the performance in line with newest standards following a performance based surveillance approach.			
D11.1.120	PJ14-04-01 TVALP defining Roadmap for TRL6 for SPM Tools for Cooperative Surveillance Sensors	19/09/2019	PU
This document, not part of the Data Pack, provides an initial Technical Validation Plan for TRL6 defining the roadmap for TRL6 for the Task 03 of the SESAR Technological Solution PJ14-04-01 Surveillance Performance Monitoring (SPM) tools. Task 03 addresses the Cooperative part of the Surveillance Performance Monitoring at sensor level (SMR).			
PJ.14-04-01b	Data Pack for Surveillance Performance Monitoring Tools for End-to-End TRL2 Gate	10/10/2019	PU
The Data Pack includes the mandatory deliverables for TRL2 Gate (FRD)			
D11.2.050	Functional Requirements (FRD) for Surveillance Performance Monitoring (SPM) Tools for End-to-end	28/06/2019	PU

	Surveillance Chain		
The aim of this document is to produce the technical requirements for the implementation of Surveillance Performance Monitoring (SPM) tools for the performance analysis at "end-to-end" (controller working position) level of the Surveillance Performance Monitoring. At the time of the development of this FRD, the level of maturity of the relevant standards, needed as input for the document and defining the methods, are heterogeneous. One of the objectives of PJ14-04-01 has been the harmonisation of the tools. Recognising there is a trend of the standards towards harmonisation, the choice in this FRD has been made to harmonise the various metric assessment methods. This document includes a number of standards open points that are identified and used for exchanges with the related groups (EUROCONTROL SSTF and EUROCAE WG102). In order to ensure the maximum consistency with Task 1 and 2, the content of this FRD is kept as close as possible to the TS/IRS from these tasks and this will pave the way for TRL4 in Wave 2.			
D11.1.110	PJ14-04-01 TVALR for Task 03 - SPM Tools for SUR Chain (ER-TMA)	08/07/2019	PU
This document, no part of the Data Pack, provides the Technical Validation Report (maturity level TRL 2) for the Task 03 of the SESAR Technological Solution PJ14-04-01 Surveillance Performance Monitoring (SPM) tools. Task 03 addresses the performance analysis at "end-to-end" (controller working position) level of the Surveillance Performance Monitoring. In particular, this TVALR addresses the enabler CTE-S07e.			
D11.1.40	PJ14-04-01 TVALP for Task 03 Roadmap for TRL4	29/08/2019	PU
This document describes the Technical Validation Plan for TRL6 defining the roadmap for TRL6for the Task 01 of the SESAR Technological Solution PJ14-04-01 Surveillance Performance Monitoring (SPM) tools. Task 01 addresses the Cooperative part of the Surveillance Performance Monitoring at sensor level (ADS-B, WAM and MLAT). It provides the foreseen steps to bring the solution to the maturity level TRL6 and provides some high-level information related to the validation context and validation objectives for the next phase.			

Table 10 PJ.14-04-01 SUR solution: PJ.14-04-01a, PJ.14-04-01b & PJ.14-04-01 Data Packs and relevant deliverables

Reference	Title	Delivery Date[21]	Dissemination Level[22]
	Description		
PJ.14-04-03	Data Pack for New use and evolution of	31/10/2019	PU

[21] Delivery data of latest edition

[22] Public or Confidential

	Cooperative and Non-Cooperative Surveillance TRL4 Gate		

The Data Pack includes the mandatory deliverables for TRL4 Gate (TS/IRS, TVALR). This solution provides five separate TS/IRS and five separate TVALR.

D12.2.020	Composite Cooperative and Non-cooperative Surveillance TS/IRS	20/09/2019	PU

The objective of this document is to produce the technical requirements that will lead the implementation of the following new functionalities of Independent Cooperative sensors (Mode S and WAM) and Independent Non Cooperative sensors (MSPSR) with integrated ADS-B.

D12.2.040	Improved Multi-sensor Data fusion TS/IRS	30/09/2019	PU

This document provides the requirements specification, covering functional, non-functional and interface requirements related to SESAR Solution PJ-14.04.03 Task 03 – Improved Multi-Sensor Data Fusion. The document reports the requirement aimed at adapting multi-sensor tracker systems for the new input data characteristics, especially MSPSR (CTE-S08a) and ADS-B data sourced from satellite (CTE-S08b) and implementing additional functionalities to improve Multi-Sensor Data Fusion (CTE-S08a)..

D12.2.060	Evolution of Non-cooperative Surveillance Systems TS/IRS	07/10/2019	PU

This TS/IRS establishes a new surveillance class for multi remote tower applications (MRT-SUR). It defines a set of requirements for the technical solution enabling surveillance for multiple remote tower control. These requirements address the electro-optical sensor, the non-rotating Mode-S ranging component as well as the data fusion component. In difference to what is currently understood as a surveillance layer, all three components are closely connected with one another to establish a surveillance layer..

D12.2.080	Secured Surveillance Systems (Single and Composite Systems) TS/IRS	22/10/2019	

This Technical Specification proposes requisites for the secured surveillance functionality associated to different cooperative surveillance sensors, including ADS-B & WAM technologies. This work is the continuation of the SESAR1 Project 15.04.06 that studied the enhanced ADS-B Ground Sensor security functionality and expands it to WAM and composite surveillance systems.
In 15.4.6 threat definition and classification, indication, mitigation means and requirements definition were developed. The main objective of the SESAR2020 solution is to improve the security functions to be able to assess the operational performance and to develop a set of minimum performances achieved by the security functionality, studying the behaviour of the system in long periods. It is intended to achieve a maturity level of TRL4.
All these activities will be in accordance with impact in SESAR 2020 architecture and its definition, meeting the requirements of PJ19 (Content Integration).

D12.2.100	Future ADS-B Communications Link (1090 phase overlay) TS/IRS	22/10/2019	PU

PJ.14-04-03 Task 06 solution addresses Phase Modulation for ADS-B and Mode S features. This document is focused on the Technical Specification and IRS aspects of the Phase Modulation, based

	on one hand in the preliminary ED73F/DO181E and ED102B/DO260C specifications, and on the other hand in the Initial TS-IRS document and the conclusions extracted from the validation exercise exposed in the TVALR document The objective of SESAR2020 is to guarantee performance and interoperability for TRL6 maturity with the current standard of the Phase Modulation waveform.		
D12.1.030	Composite Cooperative and Non-cooperative Surveillance TVALR	22/10/2019	PU
	This document describes the Technical Validation Report for the Task 02 of the SESAR Technological Solution PJ14-04-03 New use and evolution of Cooperative and Non-Cooperative Surveillance. Task 02 addresses Composite Cooperative and Non Cooperative Surveillance. It contains: the results for the technical validation exercises covered by the Technical Validation Plan D12.1.010 "PJ14-04-03 TVALP for Task 2 - Composite Cooperative and Non Cooperative Surveillance", an assessment of each Success Criteria (met/not met) attached to the validation objectives captured in the TVALP, the conclusions (maturity, technical feasibility) and recommendations arising from the analysis/interpretation of these results.		
D12.1.070	Improved Multisensor Data Fusion TVALR	30/09/2019	PU
	This document describes the Technical Validation Report for the Task 03 of the SESAR Technological Solution PJ14-04-03 New use and evolution of Cooperative and Non-Cooperative Surveillance. Task 03 is part of a panel of six tasks defined in the scope of PJ14-04-03 that progresses this solution from an initial maturity level TRL2 to an intended maturity level TRL4.		
D12.1.110	Evolution of Non-cooperative Surveillance Systems TVALR	07/10/2019	PU
	This document describes the Technical Validation Report for the SESAR Solution Pj14-04-03 Task 04 – Multi Remote Tower Surveillance (MRT-SUR) Module, D12.1.110: TVALR. It describes the validation approach and the validation activities performed in order to validate the validation objectives associated to their corresponding success criteria and requirements. The requirements to be verified are defined in the Technical Specification D12.2.060. For each requirement or set of requirements, validation objectives are formulated. The validation approach including the validation exercises, with respect to scope, expectations and procedures, are provided for the validation objectives in the Technical Validation Plan D12.1.090.		
D12.1.150	Secured Surveillance Systems (Single and Composite Systems) TVALR	22/10/2019	
	This document describes the Technical Validation Report for the SESAR Solution Pj14-04-03 Task 05 – Secured Surveillance Systems (Single and Composite Systems), D12.1.150: TVALR. It describes the validation approach and the validation activities performed in order to validate the validation objectives associated to their corresponding success criteria and requirements. The requirements to be verified are defined in the Technical Specification D12.2.080 for Task 05. For each requirement or set of requirements, validation objectives are formulated. The validation approach including the validation exercises, with respect to scope, expectations and procedures, are provided for the validation objectives in the Technical Validation Plan D12.1.130.		
D12.1.190	Future ADS-B Communications Link	22/10/2019	PU

	(1090 phase overlay) TVALR		
This document describes the Technical Validation Report for the Task 06 of the SESAR Technological Solution PJ14-04-03 Future ADS-B Communication Link. Task 06 addresses the Phase Modulated technology for ADS-B. 1 exercise has been identified to progress from an initial maturity level TRL2 to an intended maturity level TRL4 for both enablers CTE-S03c and A/C-48b.			
D12.1.010	Composite Cooperative and Non-cooperative Surveillance TVALP	15/07/2019	PU
This document, not foreseen in the Data Pack, describes the Technical Validation Plan for the Task 02 of the SESAR Technological Solution PJ14-04-03. The objective of this document is to describe the technical validation plan which will lead the implementation of the following new functionalities of Independent Cooperative sensors (Mode S and WAM) and Independent non Cooperative Sensors (MSPSR) with integrated ADS-B. It describes the validation approach and activities, the validation objectives associated to success criteria and to the requirements. The requirements to be verified by objectives are defined in the Initial Technical Specification "D12.2.010 PJ14-04-03 TS/IRS for Task 02". For each requirement or set of requirements, validation objectives are formulated. Validation exercises, with respect to scope, inputs, expectations and procedures, are provided for the validation objectives.			
D12.1.040	Composite Cooperative and Non-cooperative Surveillance Updated TVALP	16/10/2019	PU
This document, relevant for the future activities, describes the Technical Validation Plan for TRL6defining the roadmap for the SESAR Solution PJ14-04-03 Task 02 Cooperative and Non Cooperative Surveillance. It provides the foreseen steps to bring the solution to the maturity level TRL6 and provides some high-level information related to the validation context and validation objectives for the next phase.			
D12.1.050	Improved Multi-sensor Data fusion TVALP	01/07/2019	PU
This document, not part of the Data Pack, describes the Technical Validation Plan for the SESAR Solution PJ14-04-03 Task 03 Improved Multi-Sensor Data fusion. It describes the validation approach and activities, the validation objectives associated to success criteria and to the requirements. The requirements to be verified by objectives are defined in the Initial Technical Specification WP12.2.060 – PJ14-04-03 T03 Improved Multi-sensor Data Fusion (TS/IRS). For each requirement or set of requirements, validation objectives are formulated. Validation exercises, with respect to scope, inputs, expectations and procedures, are provided for the validation objectives.			
D12.1.080	Improved Multi-sensor Data fusion Updated TVALP	09/10/2019	PU
This document, not part of the Data Pack, describes the Technical Validation Plan for TRL6 defining the roadmap for the SESAR Solution PJ14-04-03 Task 03 Improved Multi-Sensor Data fusion. It provides the foreseen steps to bring the solution to the maturity level TRL6 and provides some high-level information related to the validation context and validation objectives for the next phase.			
D12.1.090	Evolution of Non-cooperative Surveillance Systems TVALP	03/10/2019	PU
This document, not part of the Data Pack, describes the Technical Validation Plan for the SESAR Solution PJ14-04-03 Task 04 Exercise 6 – Multi Remote Tower Surveillance (MRT-SUR), PJ14-4-3 D47, D12.1.090: TVALP. It describes the validation approach and activities, the validation objectives associated to success criteria and to the requirements. The requirements to be verified by objectives			

	are defined in the Technical Specification D12.2.050 For each requirement or set of requirements, validation objectives are formulated. Validation exercises, with respect to scope, inputs, expectations and procedures, are provided for the validation objectives.		
D12.1.120	Evolution of Non-cooperative Surveillance Systems Updated TVALP	15/10/2019	PU
	This initial Technical Validation Plan (TVALP) is part of PJ14-04-03 and describes the Technical Validation Plan for TRL6 defining the roadmap for the SESAR Solution PJ14-04-03 Task 04 – Multi Remote Tower Surveillance (MRT-SUR). The document, although relevant, is not part of the Data Pack. It provides the foreseen steps to bring the solution to the maturity level TRL6 and provides some high-level information related to the validation context and validation objectives for the next phase.		
D12.1.130	Secured Surveillance Systems (Single and Composite Systems) TVALP	21/03/2019	
	This document, not part of Data Pack, describes the Technical Validation Plan for the SESAR Solution PJ14-04-03 Task 05 – Secured Surveillance Systems (Single and Composite Systems),. It describes the validation approach and activities and the validation objectives associated to success criteria and to the requirements. The requirements to be verified by objectives are defined in the Technical Specification D12.2.080 for Task 05. For each requirement or set of requirements, validation objectives are formulated. Validation exercises, with respect to scope, inputs, expectations and procedures, are provided for the validation objectives.		
D12.1.160	Secured Surveillance Systems (Single and Composite Systems) Updated TVALP	16/10/2019	
	This relevant document describes the Technical Validation Plan for TRL6 defining the roadmap for TRL6 for the Task 05 of the SESAR Technological Solution PJ14-04-03. It addresses the Secured Surveillance Systems (Single and Composite Systems). It provides the foreseen steps to bring the solution to the maturity level TRL6 and provides some high-level information related to the validation context and validation objectives for the next phase.		
D12.1.170	Future ADS-B Communications Link (1090 phase overlay) TVALP	09/07/2019	PU
	This document, not part of Data Pack, describes the Technical Validation Plan for the Task 06 of the SESAR Technological Solution PJ14-04-03 addressing Phase Modulation for ADS-B and Mode S features. It describes the validation approach and activities, the validation objectives associated to success criteria and to the requirements. The requirements to be verified by objectives are defined in the Initial Technical Specification “D12.02.090”. For each requirement or set of requirements, validation objectives are formulated. Validation exercises, with respect to scope, inputs, expectations and procedures, are provided for the validation objectives..		
D12.1.200	Future ADS-B Communications Link (1090 phase overlay) Updated TVALP	29/10/2019	PU
	This relevant document describes the Technical Validation Plan for the Task 06 of the SESAR Technological Solution PJ14-04-03 addressing Phase Modulation for ADS-B and Mode S features This deliverable is the Initial TRL6 VALP - Validation Plan. It aims at initiating the definition of the validation activities to be performed to reach TRL6 maturity level in continuity with the solution PJ14-04-03 Task 6 using the results of work performed in the wave 1.		

Table 11 PJ.14-04-03 SUR solution: PJ.14-04-03 Data Pack and relevant deliverables

2 Links to SESAR Programme

2.1 Contribution to the ATM Master Plan

The CNS roadmap, resulting by the development of the transversal solution, has been used as input for the development of the 2019 edition of the European ATM Master Plan. As such, the concept of the roadmap went through the EATM MP review process. However, PJ14-01-01 solution being a transversal solution, there is no OIs or Enablers attached to it.

Code	Name	Project contribution	Maturity at project start	Maturity at project end
PJ14-02-01a	Future Communication Infrastructure (FCI) Terrestrial Data Link	The SESAR Solution PJ14PJ14-02-01 that addresses in this phase (Wave 1) primarily the Air to Ground Communications capability. This capability is captured by Enabler "CTE-C02e - New A/G datalink using ATN/IPS over L-band". This enabler shall achieve Technical Readiness Level TRL4.	TRL2	TRL4
PJ14-02-01b	Future Communication Infrastructure (FCI) Terrestrial Data Link	The future terrestrial datalink LDACS also provides an Air to Air Communications capability. This feature is covered by Enabler "CTE-C02g - Air to Air functionality of New A/G radio". This enabler shall achieve Technical Readiness Level TRL2.	TRL0	TRL2
PJ14-02-02	Future Satellite Communications (SATCOM) Data Link Class A	This solution is in charge of the definition, at mission and user level, of the SATCOM Service requirements and their technical validation by means of dedicated validation exercises execution. This feature is covered by the following Enabler:	TRL2	Class A: TRL4 in multi-link, integrated in the FCI

		- CTE-C02h "Future SATCOM for ATM - Long term Satcom/IRIS (class A SATCOM)". This enabler shall achieve Technical Readiness Level TRL4 in Wave 1.		
PJ14-02-04	FCI Network Technologies	The SESAR Solution PJ14-02-04 achieves a TRL4 maturity level supporting the following enablers: • CTE-C04- Future Communication Infrastructure - ATN/IPS and Multilink	TRL0	TRL4
PJ14-02-05	Development of new services similar to FIS-B to support ADS-B solutions for General Aviation.	▪ The SESAR Solution PJ14-02-05 achieves a V2 maturity level supporting the following OI and enablers: ▪ IS-0408 "Provision of FIS/TIS information to General Aviation during flight" (Dataset DS 19). ▪ CTE-C03d "Wireless telecommunications technologies for General Aviation (not for safety-critical services)" (Dataset DS 18) ▪ A/C-57c "Mobile device for FIS/TIS data display" (Dataset DS 19) ▪ FOC-007a "FIS/TIS Data Processing Unit" (Dataset DS 19)	V0	V2
PJ14-02-06	Completion of	The SESAR Solution PJ.14-02-	TRL6[23]	TRL6

[23] Technological Readiness Level of AeroMACS SESAR1 Solution #102

	AeroMACS Development	06 has confirmed full Maturity Level TRL6 at System Level, for SESAR1 Solution #102, now integrated with ATN, Multilink and Digital Voice Systems.		
PJ14-03-01a	GBAS	GASTD Extended Scope supported by the technical enablers: • CTE-N07e GBAS CAT II/III based on Single-Constellation / Single-Frequency GNSS (GPS L1) extension to equatorial and Nordic regions • CTE-N07f GBAS GS status data provision • CTE-N07g Enhanced GBAS robustness under ground threat conditions	TRL2	TRL4
PJ14-03-01b	GBAS	GAST F supported by the technical enablers: • CTE-N07c GBAS Cat II/III based on Multi-Constellation / Multi-Frequency (MCMF) GNSS (GPS + GALILEO / L1 + L5) • A/C-56b Flight management and guidance to support GBAS CATII/III using dual GNSS	TRL 2	TRL4 on-going
PJ14-03-01c	GBAS	Non MMR Architecture supported by the technical enabler: A/C-56b Flight management and guidance to support GBAS CATII/III using dual GNSS	TRL0	TRL2
PJ14-03-01d	GBAS	GAST D ESV: No new technical enabler required as the functionality required to support the GBAS	TRL1	TRL6

		Expanded Service volume and increased Dmax range concept is already provided by the core GAST D solution CTE-N07b.		
PJ14-03-02	Multi Constellation / Multi Frequency (MC/MF or DFMC) GNSS	Object of the solution was maturation to TRL4 of: A/C 02b — Enhanced precision and availability/continuity of positioning (based on GNSS dual frequency, Galileo, GPS L5)	TRL2	TRL4
PJ14-03-04a	Alternative Position, Navigation and Timing (A-PNT)	Short term solution : use of current avionics and improved DME infrastructure supporting RNP reversion concept	TRL4	TRL6
PJ14-03-04b	Alternative Position, Navigation and Timing (A-PNT)	The mid-term APNT fully compliant with RNP navigation to support RNP1 with current DME infrastructure	TRL2	TRL4
PJ14-03-04c	Alternative Position, Navigation and Timing (A-PNT)	The long-term APNT solution : new technology currently not existing on board the avionics to support RNP-X and timing.	TRL0	TRL2
PJ14-04-01a	Surveillance Performance Monitoring - Cooperative and Non-Cooperative Sensors	Surveillance Performance Monitoring Tools for new surveillance systems Wide Area Multilateration (WAM), surface Multilateration (MLAT), ADS-B and Surface Movement Radar (SMR) - sensor level	TRL 2 (Sensor level)	TRL 4 Sensor level)
PJ14-04-01b	Surveillance Performance Monitoring - "End-to-End"	Surveillance Performance Monitoring Tools for Surveillance Chain at "end-to-end" level	TRL0 (“end-to-end” level)	TRL 2 (“end-to-end” level)
PJ14-04-03	New use and evolution of Cooperative and Non-Cooperative Surveillance New use and evolution of	Composite surveillance Multi-sensor data fusion improvement integrating MSPSR Multi-sensor data fusion improvement integrating space-based ADS-B	TRL2	TRL4

	Cooperative and Non-Cooperative Surveillance New use and evolution of Cooperative and Non-Cooperative Surveillance	Multi Remote Tower Surveillance module Provision of a proposal for standardisation of security performance values Future ADS-B Communication Link		

Table 12: Project Maturity

Looking at the picture, from eATM portal[24], provides an overview of the 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. The three different domains, Communication Navigation & Surveillance, covered by the activities of PJ14 – EECNS COM are circled in blue in the following picture.

[24] https://www.atmmasterplan.eu/rnd/technical-systems-overview?sys=4B9F615F54C61152

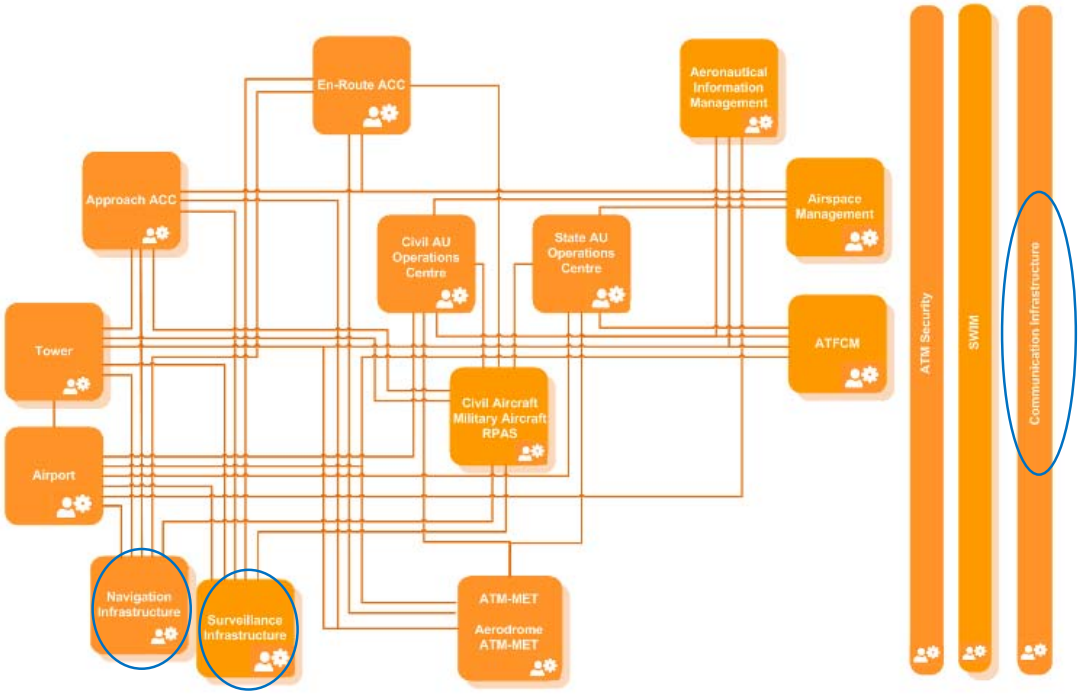

Figure 6 ATM system architecture

2.2 Contribution to Standardisation and regulatory activities

2.2.1 Communication Domain

PJ14-02-01 Future Communication Infrastructure (FCI) Terrestrial Data Link

In general, for a new aviation communication system there are different types of aviation specific standards which will be required to be developed by various standards development organisations (SDOs).

These aviation standards need to cover various aspects of the concerned system such as the frequency aspects (signal in space and interference), equipment requirements, performance aspects and requirements, avionics form, fit and function specifications, etc. Typically, the aviation standards that can be required/developed for a new aviation communication system comprise:

- SARPS and Manuals developed by ICAO
- MASPS and MOPS developed by EUROCAE/RTCA
- Avionics Form Fit and Function (FFF) Specifications developed by AEEC

SARPs and Manuals cover in general the air-ground interface (signal in space) and provide the overall system characteristics and requirements. MOPS and MASPS cover the equipment requirements and describe operating context of the new system, while Avionics FFF specifications address the specifications and interfaces of the avionics equipment.

The standardisation process and documents play also an important role in facilitating the certification process which is overseen by EASA in Europe and FAA in US. The certification of the equipment is required to enable the installation and usage of the avionics equipment and the operation of new systems and is particularly important and critical for the airborne side, while it is also required for the ground side.

The development and refinement of the LDACS specifications has been ongoing for some years at ICAO level: DRAFT LDACS SARPs have been produced by September 2018 and the requirements described herein shall be validated during the next years (until end of 2022).
SESAR will significantly contribute to the standardization activities by sharing the outcome of the SESAR Solution PJ14PJ14-02-01 activities with the standardization organizations.
Standardization initiatives (ICAO PT-T, EUROCAE WG-81) should consider the Technical Validation Report (D3.1.030) as an input for their further work.

PJ14-02-02 Future Satellite Communications data link

In general, for any aviation communication system there are different types of aviation specific standards, which are required to be developed by various standards development organizations (SDOs).
These aviation standards need to cover various aspects such as the frequency aspects (signal in space and interference), equipment requirements, performance aspects and requirements, avionics form fit and function specifications, etc. Typically the aviation standards that can be required/developed for an aviation communication system are:

- SARPS and Manuals developed by ICAO
- MASPS and MOPS developed by EUROCAE/RTCA
- Avionics Form Fit and Function (FFF) Specifications developed by AEEC

Figure 7: **Standardisation Framework**

Solution PJ14-02-02 is actively supporting the ICAO PT-S and EUROCAE-WG82 standardization groups:

- **ICAO**

  In ICAO, the COM (Communications) Panel (CP) is responsible in general for the development of the Standards and Recommended Practices (SARPs, Annex 10 material), as well as guidance material (Manuals) for all air-ground and ground-ground aeronautical communication systems, both for voice and data. The main goal of the ICAO documents has been to guarantee that systems are interoperable at a global level, operate without interfering with other aviation systems and meet the operational requirements.
  Within the ICAO CP, a dedicated subgroup, Project Team (PT) Satellite (referred to as PT-S) was established to oversee the update of the ICAO SATCOM documents.
  In summary, the PT-S activities aim to update the ICAO SATCOM provisions (AMS(R)S SARPs in Annex 10, volume III, Chapter 4 as well as the ICAO SATCOM Manual in Doc9925). The objective is to include more stringent performance requirements supporting in the short term ATS B2 services/operations (SATCOM Performance Class B systems) and in the future also ATS B3 operations (SATCOM Performance Class A systems).

The work to update the SARPs is very advanced and close to completion. Initially PT-S was planning to complete the update in 2018, aiming for an applicability date of the SARPs in November 2020. However, ICAO pushed the applicability date for all new CNS systems to 2022, Currently PT-S is planning to complete the SARPs update by end of 2019. The work in the Manual will start soon aiming for completion in 2020/2021.

- **EUROCAE**

  EUROCAE (and RTCA for US) is the European aviation voluntary industry standardization body addressing the system and equipment performance requirements for aviation systems.
  In Europe, EUROCAE WG-82 was established to develop the appropriate standards related to all new air-ground data link technologies. WG82 is now working on the development of documents for SATCOM.
  WG82 in cooperation with RTCA SC-222, and starting from the RTCA DO-262 MOPS and DO-343 MASPS, has developed and published in 2017 a new version of Next Generation Satellite System MOPS and MASPS covering the new SATCOM Class B services. This update focused primarily on the addition of the Inmarsat's Enhanced SB-Safety services (which effectively will be the first Class B implementation) but the update included number of other technical and editorial changes in the Inmarsat, Iridium as well as other generic parts of MOPS and MASPS. In EUROCAE, the SATCOM MASPS were published as ED-242 and the SATCOM MOPS for the airborne equipment were published as ED-243.
  WG82 is focusing on the INMARSAT SBB system, while RTCA SC222 also address the Iridium Next system.
  During 2017 and 2018 the WG-82 and SC-222 further updated these MOPS and MASPS. The main updates implemented in the EUROCAE SATCOM documents are the following:
    - Addition of the security layer (VPN) to the Packet Switched Voice (VoIP) service for the cockpit to improve the overall solution cyber security robustness.
    - Addition of a new MASPS appendix containing the security guidelines for implementation of the safety services over IP based SATCOM systems.
    - Addition of a new appendix to MASPS, containing analysis, system requirements and recommended regulations changes supporting the acceptance of dual SATCOM systems as a full alternative to High Frequency radios (HF)

  The updated ED242 and ED-243.documents have undergone the EUROCAE and RTCA final public review process (OC/Open Consultation in EUROCAE and Final Review and Comments/FRAC in RTCA) and the updates will be published as revision A of the ED242 and ED-243 in Q2 2019.
  Currently WG82 activities aim to address also the interference issue between INMARSAT SBB terminals and LTE in the airport environment.
  WG82 will continue to work in upgrades of the SATCOM documents and future revisions are expected to cover aspects such as: ATN/IPS, RPAS, future voice concepts and AIS/MET application, SATCOM Performance Class A.
  Standardisation initiatives (ICAO PT-S, EUROCAE WG-82) should consider PJ14.02.02 TS/IRS and TVALRs as input for their further work.

Considerations on Regulatory Framework:

Commission Implementing Regulation (EU) 310/2015 of 26 February 2015 amending Regulation (EC) No 29/2009 is the current regulation covering the coordinated introduction of data link services based on air-ground point-to-point data communications in the Single European Sky. The applicability date requiring equipage for the ground side was 5 February 2018 for the airspace of all

EU countries above FL 285, while the applicability date for aircraft operators (except specific cases) is the 5 February 2020. The aim of the rule is to ensure that all aircraft operating IFR flights above FL 285 within the EU airspace are capable to operate datalink services as of 5 February 2020.
Implementing Regulation 310/2015 identifies the datalink services to be supported, and today the only accepted means of compliance to provide these services is the VDL2 A/G datalink. The EUROCONTROL Specification on Data Link Services defines the initial set of air traffic services and provides the list of the documents and standards defining the requirements for the implementers in order to achieve compliance with the regulation. The specified services include the air-ground applications Context Management (CM) and Controller-Pilot Data Link Communications (CPDLC). Air traffic service providers and operators are required to support these services using a common standardised message set to ensure end-to-end interoperable implementations of data link services.
While today VDL2 is the only recognised means of compliance, in the longer term it is expected to be complemented by new datalinks such as SATCOM Class B/A, AeroMACS and LDACS. Today, in the light of some implementation issues with VDL2, SATCOM Class B is being considered to complement VDL2 and support the currently required datalink services and regulation 310/2015.

PJ14-02-04 FCI Network Technologies

For a new aviation communication system there are different types of aviation specific standards which will be required to be developed by various standards development organisations (SDOs).
These aviation standards need to cover various aspects such as the frequency aspects (signal in space and interference), equipment requirements, performance aspects and requirements, avionics form fit and function specifications, etc. Typically, the aviation standards that can be required/developed for a new aviation communication system are:

- SARPs and Manuals developed by ICAO
- MASPS and MOPS developed by EUROCAE/RTCA
- Avionics Form Fit and Function (FFF) Specifications developed by AEEC

SARPs and Manuals cover in general the signal in space and provide the overall system characteristics and requirements. MOPS and MASPS cover the equipment requirements and describe operating context of the new system, and Avionics FFF specifications address the specifications and interfaces of the avionics equipment.
The standardisation process and documents play also an important role in facilitating the certification process which is overseen by EASA in Europe and FAA in US. The certification of the equipment is required to enable the installation of the avionics equipment and the operation of new systems and is particularly important and critical for the airborne side, while it is also required for the ground side.
The development and refinement of the ATN/IPS specifications has been ongoing for some years at ICAO level, and has now been the focus of activities in other standardisation organisations such as AEEC, RTCA and recently EUROCAE which kicked-off WG-108 beginning of 2018.
SESAR will contribute significantly to the standardisation activities by sharing the outcome of the solution with the SDOs.
Standardisation initiatives (ICAO WG/I, EUROCAE WG-108) should consider the Technical Validation Report (D5.3.040) as input for their further work.

PJ14-02-05 Development of new services similar to FIS-B to support ADS-B solutions for General Aviation.

No Standardization or regulatory activities are necessary, as the aircraft/avionics, the ATM system and ATC/flight procedures do not need to be adapted. All responsibilities, tasks and duties remain unchanged.

PJ14-02-06 Completion of AeroMACS Development

Major part of the Standards related to AeroMACS had already been published in SESAR1. In SESAR2020 PJ14-02-06 has actively taken part in the activities of WMF and ETSI Groups: WMF has refined the certification procedures for Radio and Protocol Conformance Tests, besides arranging Interoperability Events among AeroMACS Manufacturers, to which Leonardo took part. ETSI TGAERO group has started work for the development of a Harmonised Standard for AeroMACS, for the CE Mark. In addition it is developing a Community Specification for AeroMACS following European Mandate 524 for compliance with the Essential Requirements of EASA Regulation 1139.

2.2.2 Navigation Domain

PJ14-03-01 GBAS

GBAS external relations and standardization activities for the period 2017-2019 are summarized in the yearly deliverables D8.3.010, D8.3.020, and D8.3.030. It includes summary reports from the GBAS-relevant working groups LATO and IGWG, additional ad-hoc reports of GBAS relevant activities and the following standardisation groups:

- ICAO Navigation Systems Panel (NSP);
- ICAO Instrument Flight Procedures Panel (IFPP);
- ICAO FLighT OPerationS Panel (FLTOPSP);
- ICAO EUR All Weather Operations Group (AWOG);
- EUROCAE WG28 (GNSS);
- RTCA SC-159 WG4 (GBAS)

Reporting from the Augmented Approaches to Land 2 (AAL2) project is included as far as GBAS relevant.

In particular, the following PJ14-03-01 contributions to standardization are highlighted:

- Contribution to RTCA/ICAO harmonization of VDB interference requirements (final agreement in NSP/5 in November 2018)
- Contribution to EUROCAE WG-28 work on ED-114B GAST D MOPS.
- Contribution to ICAO on GAST F – presented Concept papers on GAST F at ICAO/ RTCA SC159, Montreal November 2018 and in April 2019

PJ14-03-02 Multi Constellation / Multi Frequency (MC/MF) GNSS

The solution will have to support precision approach, but not only. The GNSS sensor in the solution will have also to support PBN area navigation based on DFMC GNSS. The following regulations documenting GNSS based navigation, precision approach and autoland exist or being developed for the airworthiness certification of legacy PBN and XLS navigation:

- CS-AWO All Weather Operations
- 120-29A - Criteria for Approval of Category I and Category II Weather Minima for Approach. Date Issued: August 12, 2002
- Draft Advisory Circular (AC 120-xLS) providing an FAA-approved means of obtaining and maintaining authorization of operations in ground-based Category I, Category II, and Category III landing weather minimums and IFR lower than standard takeoff minimums

- AC 20-191. Airworthiness Approval of Airborne Systems use for Takeoff, Precision Approach, Landing, and Rollout in low-visibility conditions SVS/SVGS standards
- AC-20-185 - Airworthiness Approval of Synthetic Vision Guidance System
- FAA AC 20-138D - Airworthiness Approval of Positioning and Navigation Systems (Including Change 2)
- EASA CS-ACNS Certification Specifications and Acceptable Means of Compliance for Airborne Communications, Navigation and Surveillance 17/12/2013

It is assumed that the solution will be designed in compliance with following standardisation framework:

- ICAO standards
  - ICAO Annex 10 - Volume 1, Aeronautical Telecommunications - Radio Navigation Aids, including, DRAFT SARPS GALILEO, DRAFT SARPS DFMC SBAS
  - PANS-OPS, (Doc 8168), Procedures for Air Navigation Services — Aircraft Operations Volume I
  - ICAO GNSS manual (ICAO Doc 9849)
  - CONCEPT OF OPERATIONS (CONOPS) FOR DUAL-FREQUENCY MULTI-CONSTELLATION (DFMC) GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS), Prepared by the ICAO Navigation Systems Panel, Version 6.4, 27 April 2018
  - ICAO PBN MANUAL, DOC 9613, 4th Edition, Performance Based Manual
- GNSS receiver standards
  - Draft MOPS on GPS/GALILEO + multi-constellation, multi-frequency SBAS
  - DO-253D, Minimum Operational Performance. Standards for GPS Local Area Augmentation. System Airborne Equipment. Issued 07-13-2017
  - DO-229E, Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment
- RNAV system standards
  - RTCA DO-187 - Minimum Operational Performance Standards for Airborne Area Navigation Equipment Using Multi-Sensor Inputs
  - RTCA DO-236C Change 1, Minimum Aviation System Performance Standards: Required Navigation Performance for Area Navigation Change 1 September 23, 2014
  - RTCA DO-283B - Minimum Operational Performance Standards for Required Navigation Performance for Area Navigation 12/15/2015
- Approach system standards
  - DO-315B Minimum Aviation System Performance Standards (MASPS) for Enhanced Vision Systems, Synthetic Vision Systems, Combined Vision Systems and Enhanced Flight Vision Systems Issued 06-21-11

DO-341 Minimum Aviation System Performance Standards (MASPS) for an Enhanced Flight Vision System to Enable All-Weather Approach, Landing and Roll-Out to a Safe Taxi Speed Issued 09-26-12

PJ14-03-04 Alternative Position, Navigation and Timing (A-PNT)

Long Term: A-PNT based on LDACS Datalink

The solution will support RNP0.3 reversion navigation based on new technologies: LDACS and eLORAN. This solution considers the existing European regulation framework with a necessity to update these regulations when deemed necessary.

- Commission Implementing Regulation (EU) 716/2014, known as the PCP IR,
- Commission Implementing Regulation (EU) 2018/1048, known as the PBN IR and
- EASA ED Decision 2018/013/R which provides Acceptable Means of Compliance and Guidance Material to PBN IR.

Mid Term: A-PNT based on Multi DME Positioning

The solution will have to support RNP1 navigation.

Regulation documenting RNP1 is currently based on GNSS based navigation. They are mainly

- FAA AC 20-138D - Airworthiness Approval of Positioning and Navigation Systems (Including Change 2)
- EASA CS-ACNS Certification Specifications and Acceptable Means of Compliance for Airborne Communications, Navigation and Surveillance

These regulations will need to be amended to include the use of multiDME and RAIM as an alternative means of compliance to GNSS for the positioning source supporting RNP1 navigation specification.

It is assumed that the solution will be designed in compliance with following standardisation framework

- ICAO Annex 10 - Volume 1, Aeronautical Telecommunications - Radio Navigation Aids, including, DRAFT SARPS GALILEO, DRAFT SARPS DFMC SBAS
- ICAO PBN MANUAL, DOC 9613, 4th Edition, Performance Based Manual
- DO-189, Minimum Operational Performance Standards for Airborne Distance Measuring Equipment (DME) Operating within the Radio Frequency Range of 960-1215 MHz
- DO-283B Minimum Operational Performance Standards for RNP for Area Navigation
- DO-236C Minimum Aviation System Performance Standards: Change 1 Required Navigation Performance for Area Navigation

The single aircraft standard targeting RNP navigation with DME is the current draft APNT MASPS under development by EUROCAE WG107. It's is expected that the mid term solution shall be included as a possible means of compliance to support the RNP reversion after the loss of GNSS.

Short Term: A-PNT based on DME-DME solution

The solution will support RNP1 reversion navigation based on ground navigation systems, i.e. DME network. Therefore the solution is in accordance with

- Commission Implementing Regulation (EU) 716/2014, known as the PCP IR,
- Commission Implementing Regulation (EU) 2018/1048, known as the PBN IR and
- EASA ED Decision 2018/013/R which provides Acceptable Means of Compliance and Guidance Material to PBN IR.

Currently the performance requirements and the use of ground and airborne DME systems for area navigation are standardised mainly through the following documents:

- ICAO Annex 10 - Volume 1, Aeronautical Telecommunications - Radio Navigation Aids,
- EUROCAE ED57 Minimum Performance Specifications for Distance Measuring Equipment Interrogator (DME/N and DME/P) (Ground Equipment)
- DO-189, Minimum Operational Performance Standards for Airborne Distance Measuring Equipment (DME) Operating within the Radio Frequency Range of 960-1215 MHz

- EUROCAE ED54 “Minimum Performance Specifications for Distance Measuring Equipment Interrogator (DME/N and DME/P) Operating within the Frequency Range 960 to 1215 MHz (Airborne Equipment)
- FAA TSO C166C: Distance Measuring Equipment (DME) Operating Within The Radio Frequency Range Of 960-1215 Megahertz
- ARINC 709: MARK 5 AIRBORNE DISTANCE MEASURING EQUIPMENT
- DO-283B Minimum Operational Performance Standards for RNP for Area Navigation
- DO-236C Minimum Aviation System Performance Standards: Change 1 Required Navigation Performance for Area Navigation
- ICAO PBN MANUAL, DOC 9613, 4th Edition, Performance Based Manual

The short-term A-PNT solution contributes to the update of EUROCAE ED57 in what regards the performance level of DME N. In addition, the MASPS under development by EUROCAE WG107 will describe the operational concept and an acceptable means of compliance for supporting RNP 1 reversion based on DE/DME. This reversion solution will not require the update of any of the other standards and specifications listed above.

2.2.3 Surveillance Domain

PJ14-04-01 Surveillance Performance Monitoring

During Wave 1 (end 2016 – end 2019), the Pj14-04-01 Solution focused on the “sensor” level for which developing Standards used as input had reached sufficient maturity to allow targeting TRL4 for the related SPM Tools Specifications (TS/IRS). During 2018, SSTF has started work on the development of draft ESASSP Ed.2, which therefore allowed initiating some “end-to-end” work (through close coordination between SESAR and SSTF team) on related SPM Tools Functional Requirements (FRD), targeting TRL2 maturity. In Wave 1, Pj14-04-01 provided continuous feedback to developing Surveillance Standards aiming at improving in particular the surveillance requirement test procedures within those Standards.

It is planned that during the period 2019 – 2020, the “end-to-end” level ESASSP Ed.2 Specification and the GEN-SUR SPR EUROCAE Standard will be finalised (ER & TMA). “Sensor” standards (ED129 and ED 142) may also be updated partially but full alignment with ESASSP Ed.2 and GEN-SUR SPR would probably be expected later on (see below).

PJ14-04-03 New use and evolution of Cooperative and Non-Cooperative Surveillance

The outcomes and experience of the solution can be used as feedback to ASTERIX standard.

The following standardization activities have been identified in the frame of the task 4: Standardization of the SDPS output similar to ED-87D by establishing of a Minimum Aviation System Performance Standard (MAPS) system concept for MRT-SUR). Standardization of Mini-MLAT performance (derivation of the Minimum Operational Performance Standards (MOPS) based on the MAPS for MRT-SUR) similar to ED-117. Standardization of the usage of video cameras as surveillance sensor in the ATC context. From an interface perspective, CAT 015 has officially been released in July 2019 by the ASTERIX Maintenance Group (AMG). EUROCAE WG-100 already specified in ED-240A the usage of cameras for RTC purposes, but not as surveillance sensors providing a CAT 015 output. A central goal of this task was to provide a situation awareness regarding Mode-S aircraft for small and medium airports without ADS-B equipage. Nevertheless aircraft which are ADS-B equipped can be detected with a much greater performance, but for them, the security issue regarding ADS-B has to be covered. CAT 021 contains currently only a single flag regarding the confidence level. The usage of partial measurements like range, range differences or angular measurements provides much more

information, than can currently be covered by this single flag. Therefore it is recommended to start a standardisation initiative regarding a new ASTERIX category as transponder deviation report. Interface standardization for the exchange of partial measurements for non-rotating Mode-S ranging especially the standardization of ASTERIX category which enables the transmission of range and range difference data. This might become part of CAT 020 (Mini-MLAT) and CAT 021 (ADS-B), but seems not to be necessarily limited to the enhancement of CAT 020 and CAT 021.
For the task 5, Current plans for evolution of standards and specification: It is planned that during the next phase, the “end-to-end” level ESASSP Ed.2 Specification and the GEN-SUR SPR EUROCAE Standard will be finalised (ER & TMA). “Sensor” standards (ED129 and ED142) may also be updated including the findings of this Task. Development of an ASTERIX category to forwards target validation information in a sensor independent manner is intended to be pursued.
For the task 6, Mode S and ADS-B is respectively standardised in ED73E and ED102A MOPS. Phase Modulation which is assessed in the PJ14-04-03 task 06 is update of the current waveform defined in these standards.
The objective is to introduce this new waveform as optional in the next release ED73F and ED102C documents.
These releases are planned today for mid-2020.

3 Conclusion and Next Steps

3.1 Conclusions

PJ14-01-01 CNS Environment Evolution

The integrated CNS concept should be developed further around the following tasks:

- Update and maintain the CNS evolution Roadmap and Strategy: new technologies or operational concept will need to be included in the next edition of the CNS Roadmap (for instance, use of AI, single pilot operations, formation flights….)
- Performance based CNS and CNS services: this concept will need to be further developed in order to support the future development of CNS services
- Support to the future CNS infrastructure. A key outcome of this solution is the CNS Roadmap and strategy that foresee the evolution of the CNS infrastructure towards a backbone of recent and global technologies (composed of datalink, DFMC GNSS and ground/space based ADS-B), supported by a minimum operational network of the legacy infrastructure. Ad-hoc studies that support the evolution of the CNS infrastructure toward this vision will be needed.
- Coordination and dissemination: The concept of CNS Services and Performance-Based CNS, as well as the CNS roadmap and Strategy, cannot be developed in isolation and requires a coordination and dissemination with all ATM actors.

The following long-term CNS strategy and recommendations, is part of the outcomes of the transversal solution.

To reach the operational, technological and human goals set out for the CNS domain through the long-term roadmap, it appears as urgent to take this domain in consideration and to dedicate proper effort. As outcomes of the CNS Symposium organized by EUROCONTROL on October 2018, and the feedback received from stakeholders at World ATM Congress 2018 & 2019, the following recommendations were identified:

- Strong leadership and a program management approach is required with the proper governance: a seat to all stakeholder should be ensured.
- Generate trust: confidence on the roadmap implementation is needed for investment plans
- Costs need to be compensated with benefits. Route charges need to evolve in order to:
    - better distribute the benefit from CNS evolution
    - better reflect what is being used by Airspace Users

In particular, these recommendations could be detailed as:

- To challenge and change the way spectrum is considered in aviation and to establish a proper spectrum management approach. This approach should ensure spectrum availability for future aviation operations by developing an agreed spectrum long-term view and strategy and by improving the collaboration between strategic policy makers, CNS development and spectrum experts.
- To tackle the security challenges, including cyber-security of evolving from fully open C-N-S services to a fully secured CNS service.
- To support standardisation, considering that an average of 10 years is necessary to develop a standard, this would alleviate the risk to have technology ready for the long-term objective but not implementable due to lack of associated standards.
- To strengthen the civil-military collaboration in strategic development to achieve a full and seamless interoperability.

- To prioritize the CNS development on the following critical areas:
  - Support the development of an efficient and high bandwidth datalink system:, AeroMACS for surface operation, LDACS for continental operation, SATCOM for oceanic or remote operation at first. SATCOM could be extended to continental operations over time, where its capabilities are able to meet the appropriate requirements in a more dense airspace
  - Study the potential use of a next generation datalink system for CNS services
  - Support the development of future IP-based communications
  - Support the development of DFMC GNSS for all phases of flight associated with the implementation of PBN procedure
  - Support the development of an Alternate Position Navigation and Timing (A-PNT) system that would meet the performance requirements, would be spectrum and cost efficient, and would provide backward compatibility and support legacy systems
  - Support the development of Performance-based Surveillance applications
  - Support the development of efficient Surveillance systems capability (ADS-B, MSPSR etc.) enabling ground and airborne applications
  - Support the development of integrated CNS Performance Based concept
- Develop incentive programmes to break the vicious circle of airlines not equipping because procedures do not exist and ANSPs not developing procedures because airlines are not equipped. These programmes should be inclusive, available for all and realistic in terms of required resource to claim them. An appropriate indicator of the relevance of such programme may be the consistency between the level of use of the network and the level of access to them.

3.1.1 Communication Domain

PJ14-02-01 Future Communication Infrastructure (FCI) Terrestrial Data Link

PJ.14-02-01 reached TRL4 Maturity Level for enabler CTE-C02e (New A/G datalink using ATN/IPS over L-band). Exercises were executed to validate physical layer requirements and to integrate LDACS Access Network with ATN/IPS Networks and in a Multilink environment. The scope of PJ.14-02-01 was to identify the target architecture supporting technology and to successfully execute the Technical Validation Exercises. For the test results it could be concluded that the LDACS prototypes:

- conform with the LDACS A/G Specification,
- can be interconnected with LDACS implementations from other manufacturers,
- conform with the hand-over procedures allows for handing-over an aircraft equipped with an LDACS airborne radio from one LDACS ground station to another.

PJ.14-02-01 reached TRL2 Maturity Level for enabler CTE-C02g Air to Air functionality of New A/G radio. For that, no explicit technical validation exercises were carried-out in Solution PJ.14-02-01. Taking simulations results from already carried-out in previous research activities into consideration, a Functional Requirements Document (FRD) was produced and the proposed technical validations, which shall be carried in the subsequent phase (TRL4), were documented in the Technical Validation Plan (TVALP) for the next phase.

PJ14-02-02 Future Satellite Communications data link

SATCOM Class B was already validated at TRL6 in SESAR 1 solution#109 (15.2.5), in a stand-alone mode. The Class B specifications (TS/IRS) defined in SESAR 1 solution#109 were relevant and applicable also for SESAR 2 PJ14.02.02 Class B activities.

The SESAR 2 PJ14.02.02 validation exercises went beyond the formerly validated SATCOM Class B link performance, to ensure that SATCOM Class B can be integrated within current ATN/OSI infrastructure and work in combination with VDL2 to support End to End communications for "multilink" (SATCOM+VDL2) equipped Aircraft .

The multilink aspects that have been investigated and checked within 14.02.02 were "dormant" capabilities already specified and standardized in the ICAO ATN/OSI manual (Doc 9705). These capabilities are features that make use of the SATCOM Class B, but are not part of the SATCOM Class B themselves. These are surrounding ATN/OSI protocol functions, essential to validate before deployment, but which are outside the scope of solution #109/PJ14.02.02.

An important finding is that VDL2 is slow to report loss of connectivity with an Aircraft. Consequently, if VDL2 is configured to be the preferred link and VDL2 connectivity is lost, uplink messages may not be timely rerouted via SATCOM. It is therefore recommended to privilege the selection of SATCOM over for multilink equipped aircraft. This is considered particularly suitable in the initial phases of the Iris deployment, when due to the relatively small and slowly increasing proportion of Iris-equipped aircraft, there should be a strong motivation to maximise getting experience on the use of SATCOM for continental datalink communications, and to make the best out of the SATCOM equipage by off-loading ATN traffic from the congested VDL/2 network

SATCOM Class A activities started from what performed in SESAR 1 P15.02.06. The main conclusions from the activities performed in PJ14.02.02 are:

- SATCOM Class A datalink is able to support the multilink functionality expected from ATN/IPS subnetworks;
- It would be advisable that, at least for the SATCOM radio link, the aircraft is in control of the decision to use SATCOM or not;
- Interface between airborne router and air-ground router should carry information, through each link, about the status of all links;
- From the datalink RCP and RSP perspective, the SB-Safety SATCOM latency performance is at least comparable to that of VDLm2. This confirms that SB-Safety is a solid candidate to complement VDLm2 in the continental airspace as an enabler for the B1 and B2 datalink applications.

Based on the work and results achieved in the solution PJ14.02.02, SATCOM Class A is recommended for further improvement in Wave 2 through solution#107 "Future SATCOM Data Link".

PJ14-02-04 FCI Network Technologies

PJ14.02.04 reached TRL4 Maturity Level building on the work and results of TRL2 Maturity Gate. The solution PJ14.02.04 further developed the Technical Requirements within the deliverable D5.4.010 and based on this developed a prototype at two test bed locations.

The solution validation demonstrates that multiple mobile prefixes residing inside an aircraft can be announced over multiple radio paths. Traffic routing is done according to a predefined policy residing inside the airborne router. Through the newly introduced IF2, link status and quality information can be communicated from the radio to the airborne router. This information can then be used as a parameter for routing decisions made by the airborne router.

Multiple aircraft can communicate with multiple sites on the ground by utilizing ATN and IPS traffic.

Backwards compatibility towards currently deployed airborne and ground OSI end systems has been demonstrated with the OSI IPS Gateway that has been successfully integrated within the FCI.

PJ14-02-05 Development of new services similar to FIS-B to support ADS-B solutions for General Aviation.

Having developed and submitted the solution deliverables as described in section 1.5 and noting that these deliverables have been approved by the SJU, the solution has achieved Maturity Level V2 and is ready for transition to the V3 Phase. In particular, it could be demonstrated that:

- The proposed new in-flight FIS/TIS data service is capable to increase safety for General Aviation pilots;
- There is promising potential as an additional information means on-board of GA aircraft;
- An extended LTE based mobile cellular network covering GA altitudes up to 10,000 ft. MSL is a key factor for the success of this Information Service;
- The new in-flight FIS/TIS Information Service is particularly advantageous in case of a possible implementation all over Europe.
- The Solution concept defined in the OSED Part I document has been clarified. The initial assumption that by displaying real-time traffic and updated flight information on board the GA aircraft would increase safety of operations have been acknowledged by the participants (GA pilots) in the V2 validation exercises. Moreover, the availability of an App with the characteristics of the proposed prototype makes the solution desirable by the GA community, especially if they are operating today without any other similar information display (e.g. NAV display).

PJ14-02-06 Completion of AeroMACS Development

The Exercises executed within the Solution allowed to technically validate the integration of AeroMACS with any ATN System, including Multilink, and VoIP.

In order to differentiate Solution #102 and PJ14.02. 06 Solutions, a new Enabler (CTE-C02d0) with Maturity Level TRL6 in 2014 has been created and assigned to Solution #102 via CR. In addition, a further CR has been developed to set CTE-C02d TRL6 date in 2019.

AeroMACS is mature for supporting any ATM Solution in Airport, allowing the following benefits:

- Higher throughput for airport surface communications
- Reduction of congestion of VHF spectrum at airports and delays consequently
- Supporting integration of critical communications for all the Airport Stakeholders (Airport Authorities, ANSPs, Aus)
- Provision of increased security capabilities
- Enhances situational awareness on the airport's surface
- Potential to reduce overall costs (via synergies of sharing infrastructure)

3.1.2 Navigation Domain

PJ14-03-01 GBAS

The GBAS ESV technical feasibility was validated through GAST D Ground Station protection level availability simulations for different values of Dmax. The simulations concluded that Expanded Service Volume and use of GBAS for situational awareness at relevant large Dmax values is technically feasible. The technical validation did not conclude on performance assessment as this needs to be evaluated operationally. A safety impact analysis was carried out, and a number of new safety requirements were identified in the categories: pilot training, approach controller training, and procedure design requirement. The final maturity assessment of GBAS ESV concluded with a maturity level approaching TRL6.

The GAST D Extended Scope, aiming at maturing the SESAR 1 GAST D core solution to handle challenging conditions in non mid-latitude regions and operate efficiently and cost-effectively at large airports with complex environments, is validated to have achieved TRL4 maturity supporting

the enablers CTE-N07e, CTE-N07f, and CTE-N07g. GAST D activities included the technical validation of VDB measurement tool in a multiple VDB transmitter antenna scenario and the development of a Runway coverage simulation tool - providing means of verifying fulfilment of regulatory and operational requirements, a Multipath prediction tool for GBAS Ground Station (GS) siting purposes, and GAST D GS ATC and maintenance interface for providing GBAS service data status to external users.

The GAST F validation objectives focussed on several aspects finalized to achieve the partial TRL4 Maturity level. First, verifying different candidate DFMC processing modes, mainly from the accuracy point of view. For this technical validation, both real GNSS data and simulated GNSS data were used. Second, verifying different algorithms to assess the robustness of the DF solution in presence of ionospheric threats. These ionospheric threats include ionospheric front gradients and scintillation. Simulated data or real post processed data were used. Third, new integrity monitoring algorithms, considering the DF capability, were proposed and technically validated. Further maturing of the GAST F concept will take place in wave 2.

The Non-MMR Architecture sub-solution, focussed on achieving TRL2, is an airborne segment activity aiming to derive the requirements for non-MMR architecture of a non-mainline aircraft targeting basically CATII operations supported by XLS guidance, including GAST D and GAST F, and optionally CATIII. Although not foreseen for TRL2, a first step of validation of the requirements proposed in the FRD document was performed through a preliminary safety and security assessment.

The Civil-Military GBAS Interoperability task investigated the potential use of Ground-Based Augmentation System (GBAS) solutions by State aircraft to be considered in a Military precision approach and landing system transition strategy. The suitability of the use of GBAS options by State aircraft as well as the technical interoperability between military Landing Differential Global Positioning Service (LDGPS) and GBAS was assessed.

PJ14-03-02 Multi Constellation / Multi Frequency (MC/MF) GNSS

PJ14.03.02 partners focused on the finalization of the CBA, TS-IRS, TVALP as well as TVALR.

For the CBA, a qualitative approach was used for 2 architectures, but the quantitative approach was used for 1 of the chosen architectures by Airbus, in agreement with SJU.

The TS-IRS and TVALP were updated to take into account SJU's feedback, while the final validation exercises were carried-out to allow the solution members to deliver the TVALR.

The Civil-Military interoperability study from Eurocontrol concluded that the introduction of civil-alike DFMC GNSS on State aircraft is not currently predicted to heighten the operational benefits to a level that justifies an avionics modification from single-frequency GNSS to DFMC GNSS for GAT operations. The expected operational benefits for State aircraft operations under GAT status are enabled by the recognition of governmental GNSS elements to sustain those operations.

The v2 Maturity Gate being planned for 22nd October 2019, the members liaised with SJU to discuss the impact of the delay of deliverables and a way forward to secure that date was agreed on.

PJ14-03-04 Alternative Position, Navigation and Timing (A-PNT)

Short Term: A-PNT based on DME-DME solution

The Technical System which is in the scope of the Short-Term APNT solution (DME Enhanced / CTE-N08c) has demonstrated TRL6 Maturity taking advantage of actual performance of modern transponders already deployed and used in operational environments without on-board changes. CTE-N08c is the enabler of the GNSS reversion for RNP 1 operations and therefore supports OI AOM-603 and PCP-IR / PBN-IR related to the implementation of RNP1 SIDs and STARs.

The CBA for the short-term A-PNT was carried out to estimate the financial benefits brought by the availability of the GNSS reversion capability in different TMAs. Overall the business case shows mostly positive results (depending on the assumed frequency and duration of the GNSS outages).The assessment estimates also the ATFCM delay resulting from a capacity breakdown at two different airports caused by a GNSS outage.

Mid Term: A-PNT based on Multi DME Positioning

The validation exercises have demonstrated that the proposed APNT Mid-term solution is suitable candidate to fully support RNP1 and to maintain RNP Navigation operations in case of GNSS unavailability. More in detail, the solution meets successfully its performance objective:

- The RNP navigation is not discontinued for performance of RNP operations in case of GNSS loss. From flight crew perspective, no Navigation alert indicating the loss of capacity is experienced.
- The proposed solution can be used in the major European TMA with current existing DME infrastructure.

The impact would be limited to a modification of the DME positioning algorithms inside the FMS on board the aircraft.

Long Term: A-PNT based on LDACS Datalink

The long-term APNT solution considers new technology currently not existing on board the avionics.

The scope of the activity is to define the high level architecture of the long term A-PNT solution in order to derive the functional requirements that will be targeted by the system. The achieved TRL2 level highlights the fact that the long-term solution is the right candidate to provide a reversionary solution in case of GNSS outages based on new technologies (LDACS, eLORAN or even an enhanced DME sensor) and to have a major impact in the ground and airborne systems.

3.1.3 Surveillance Domain

PJ14-04-01 Surveillance Performance Monitoring

Previous versions of the SPM tools are already used by many ANSPS for the performance assessments of the sensors and “end-to-end” surveillance chain (based on previous version of Standards and Specification) and therefore the technical feasibility of SPM tools development has been largely proven. Regarding the SPM tools requirements developed in the PJ14-04-01 Tasks 1 and 2 context for aligning SPM tools functionalities to developing standards, the validation results presented in the Task 1 and Task 2 TVALR have demonstrated the feasibility of the integration of the TS/IRS requirement in the four SPM prototypes.

The Sensor part of the solution PJ14-04-01 (Tasks 1 and 2), aiming at developing the requirement for the SPM tools based on the last versions of the Surveillance Standards and Specifications, is demonstrated to be mature enough for TRL4 phase supporting the enablers CTE-S07a, CTE-S07b (Cooperative Sensors for ER&TMA and Surface respectively) and CTE-S07b (Non-Cooperative Sensors Surface). This maturity level is linked to the current state of the Standards and Specification that are still developing, therefore aiming at TRL6 in the future, once fully completed and available.

The “end-to-end” part of the solution PJ14-04-01 (Task 3), is demonstrated to be mature enough for TRL2 phase supporting the enablers CTE-S07e. This maturity level is linked to the current state of the Standards and Specification that are still developing, therefore aiming at TRL4 in the future, once fully completed and available.

PJ14-04-03 New use and evolution of Cooperative and Non-Cooperative Surveillance

The Cooperative part of the solution PJ14-04-03 Task 2, aiming at developing a Cooperative surveillance + ADS-B composite system, is demonstrated to be mature enough for TRL4 phase supporting the enabler CTE-S06a. This maturity level is linked to the current state of the Standards and Specifications that are still developing, therefore aiming at TRL6in the future, once fully completed and available.

The Non-Cooperative part of the solution PJ14-04-03 Task 2, aiming at developing a Non Cooperative surveillance + ADS-B composite system using MSPSR DVB-T/ADS-B sensor configuration, is demonstrated to be mature enough for TRL4phase supporting the enabler CTE-S06b.

The activities conducted within the PJ14-04-03 Task 3 support the conclusion that it is technically feasible to correctly process INCS data within the ARTAS Multi-Sensor Tracker. After proving the technical concept of the use of MSPSR in TMA using the Thales TopSky-Tracking, there are many interrogations on the viability of the passive MSPSR (FM and DVBT) from a safety perspective. The safety assessment of external transmitters used by opportunity is an issue and compromises the future of the technology in the ATM domain. The on-line monitoring of the sensor and tracking performance as well tested in the frame of the task 3 would be a part of the solution for reinforcing the integrity of the passive MSPR sensors from a safety perspective.

The Technical Validation results demonstrate that Space-Based ADS-B data encoded in ASTERIX CAT 021 Ed 2.4 can be seamlessly integrated into ARTAS V8B4-U2 multi-sensor tracker.

The activities conducted within the PJ14-04-03 Task 4 support the conclusion that a fusion based surveillance system with a tailored performance, which is cost effective, can be realized. Such a system enhances the situation awareness for small and medium sized airports. Multi Remote Tower Control is a concrete application, where an enhanced situation awareness enables new possibility.

It has been proven, that a Mini-MLAT can enhance the situation awareness, although such a system does not comply with the dedicated ED-117 standard. Regarding the performance of such a system, no final judgment can be currently made. Nevertheless we are certain, that the performance required in the ED-117 in its current form will not be achieved by the Mini-MLAT. Therefore a new performance for a Mini-MLAT must be address by a dedicated standard in addition to ED-117 in its current form, which covers MLAT systems for large airports. The performance enhancement by electro-optical systems at the testbed in Erfurt could not be evaluated; video data is only available at the laboratory in Vienna.

The usage of wireless data links for the data connection of the ground stations to the central processing system (CPS) of the Mini-MLAT has been proven reliable. These wireless links are not only a significant cost saviour, but also reduce the required time for setting up such a system at a specific airport significantly.

Limited to missing redundancy is another cost saviour. The potential unavailability of the sensor must then be compensated by operational means. With respect to Multi Remote Tower operations, this has to be clearly defined in close cooperation with projects like PJ05.

The Security Functionality and the derived Security Performance metrics developed and obtained within this solution PJ14-04-03 Task 05, is demonstrated to be mature enough to achieve the targeted level of TRL4phase supporting enabler CTE-S09 and the Performance Operational Improvement defined as POI-0007-CNS. Further work is needed to achieve a TRL6 maturity as a prerequisite of the operational use of the respective security functions. Based on the current results it can be concluded that on one hand a warning on a detected threat can be forwarded to later validation by a subsequent instance as well as full threat validation with a comparably small false alarm rate within the sensor. Initial considerations on the needed accuracy are based on applicable

standards. Nevertheless the results so far indicate that higher accuracies are achievable by the validation step of the security function.
The activities conducted within the PJ14-04-03 Task 6 support the conclusion that the evaluations of Phase Modulation and surveillance performance as well as initial evaluation of operational acceptability and interoperability, is demonstrated to be mature enough for TRL4phase supporting the enablers A/C-48b and CTE-S03c (Air broadcast of aircraft data (ADS-B OUT) compliant with new ED102B/DO260C standard And New ADS-B station for future ADS-B applications). This maturity level is linked to the current state of the Standards and Specification that are still developing, therefore aiming at TRL6 in the future, once fully completed and available.

There is therefore a need to extend this project into Wave 2 in order to reach the TRL6 level foreseen in the MAWP.

3.2 Plan for next R&D phase (Next steps)

Before looking at the detailed R&D phase for each one of the proposed solutions, it could be useful to summarize the CNS Roadmap as evaluated by transversal considerations and studies.
Given that the objective of the roadmap is to provide an integrated view of the CNS evolution, the operational and technological views provided in this section are not structured in the usual Communication, Navigation and Surveillance domain. Instead, the operational evolutions are organized according to the ATM key features defined in the European ATM Master Plan: optimized network services, advanced air traffic services and high performing airport operations. Concerning the underlying technologies, the evolution will be grouped under the following functional domains: aircraft trajectory negotiation, clearance and exchange; aircraft positioning and identification for oceanic, remote, polar, continental and terminal areas; and the aircraft positioning and guidance for airport access.
The figure below provides a graphical view of the CNS Roadmap.
There is one arrow per technology or type of technology, grouped under the functional domain “Trajectory negotiation, clearance and exchange”, “Aircraft positioning and identification”, and “Aircraft position and guidance for airport access. The arrow’s colour is driven by the framework under which the technology is implemented, either Performance Based Communication, Navigation, Surveillance or in the future, CNS. The objective infrastructure backbone have been identified using grey boxes, whereas the technology expected to be deployed or rationalized in minimum operational network have been identified with pink boxes.
On top of the technological arrows, the applications supported by the underlying technologies have been identified. The applications have been categorized according to the ATM key features defined in the European ATM Master Plan: optimized network services, advanced air traffic services and high performing airport operations. The colour of the application label is linked with these categories.
Finally, a time reference has been added on the top of the roadmap, identifying the ~5-years block from now to 2025, 2025-2030, 2030-235 and beyond 2035. These time references should be seen as indication and not as firm implementation date. The objective of this roadmap is not to provide a project management plan on the future CNS implementation, but rather to provide an executive view on which CNS application and infrastructure should be ready by when.
The scope of the roadmap below has been limited to the Safety-Of-Life applications, therefore, some non-Safety-Of-Life applications are not indicated in the roadmap (for instance the open connectivity and the application based on 3G/4G/5G networks).

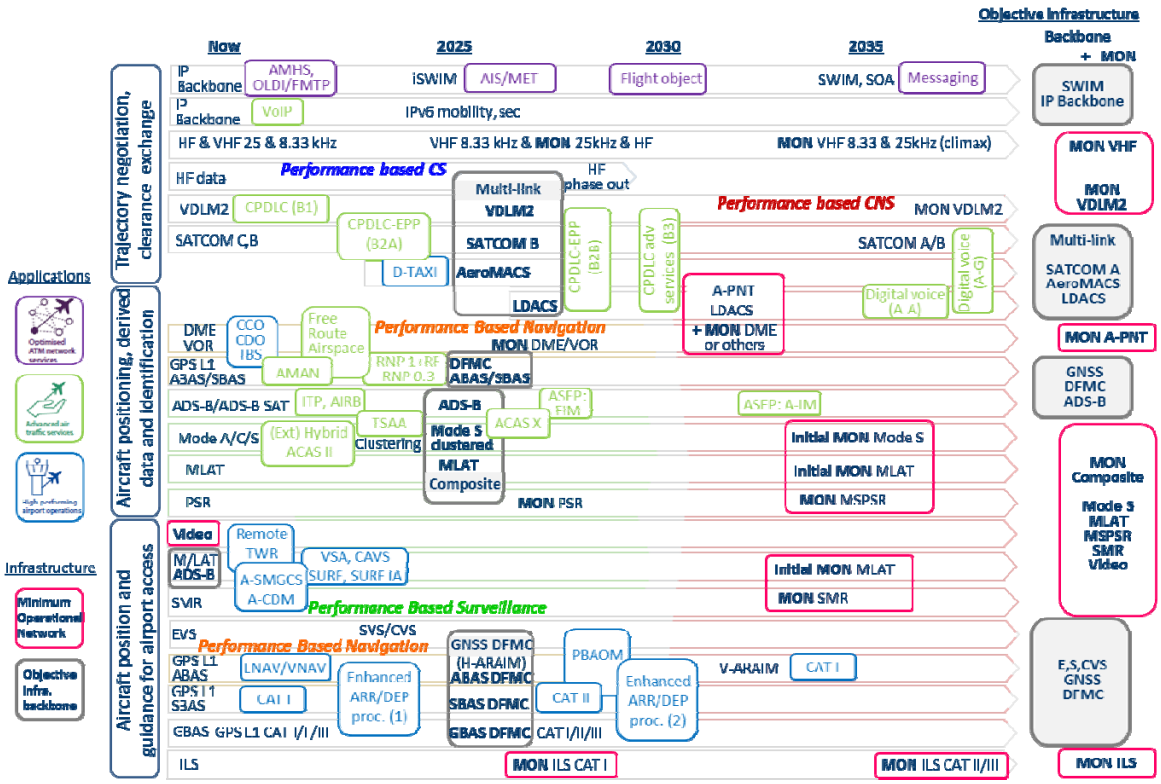

Figure 8 CNS Roadmap

PJ14-01-01 CNS Environment Evolution

The next phase of SESAR2020, Wave 2, foresees the development of the transversal solution " PJ14-W2-76 Integrated CNS and spectrum". This solution aims to identify potential technological and functional synergies across the Communications, Navigation and Surveillance domains, and spectrum efficiencies and to take benefit from common infrastructure and/or system capabilities for both airborne and ground segment. The work done in Wave 1 under PJ14-01-01 developed an integrated vision for the CNS evolution. This solution will follow up on this work and pave the way for the development of a dual Service-Based and Performance-Based approach. The Solution will act as the Federating Solution for the Project and all its Solutions to ensure a harmonized and integrated approach.

3.2.1 Communication Domain

PJ14-02-01 Future Communication Infrastructure (FCI) Terrestrial Data Link

Some advanced aspects still require further detailed investigations and comprehensive testing. Such aspects comprise e.g. A/A functionality, digital A/G voice functionality and A-PNT (Alternative Positioning Navigation and Timing) functionality.

Operation of LDACS together with other L-band systems, considering mutual interference, shall be separately tested in follow-on activities. It may be required to revisit, justify and update (if required) some radio aspects in SESAR2020 PJ.14-02.01 D3.3.030 LDACS A/G Specification considering the

results of interference tests, e.g. requirements related to the AS/GS TX spurious emissions or AS/GS RX selectivity.
It is recommended to plan an interoperability test session that involves not only radio features but shall cover other aspects as:

- the fully functional LDACS prototype focusing in security features,
- the requirements expressed by Solution 77 (FCI Services) in the view to support A/G ATN-B1, ATS B2 and AOC applications and be expandable to support ATS-B3,
- the New Digital VOICE communication over an L-band air/ground data link using the ATN/IPS protocol;
- Involvement of prototype ground systems developed each by more than one manufacturer during the validation.
- Flight trial to validated an L-band air/ground data link communications

Support standardization of Avionics Prototype specification AEEC covering the Form Fit and Function (FFF) aspects of the LDACS avionics box and facilitate the LDACS integration on the aircraft.

PJ14-02-02 Future Satellite Communications data link

The activities on the Long Term SATCOM will continue in Wave 2 with Solution 107 “Future SATCOM data Link”. The objectives of Wave 2 solution 107 are to continue the work performed in Wave 1 in PJ14-02-02, increasing the maturity of the work for the future SATCOM data link services to support the ATM evolution moving from ATN/OSI towards ATN/IPS. The work will be performed in coordination with solution 77 “FCI” for the integration of the SATCOM data link in the FCI and for the definition of the multilink approach.
Wave 2 Solution 107 Future SATCOM Data Link will cover the following main tasks:

- Completion of Technical Specifications for SATCOM Class A
- Completion of the development and specification of a performance monitoring and control concept for Long Term SATCOM in ATN/IPS
- Contribution to the functional FCI architecture developed by and under responsibility of Solution 77 (FCI Services)
- Development of SATCOM voice as full HF alternative in oceanic and remote continental airspace
- Coordination with ESA Iris Long Term and harmonisation at global level of proposed solution
- Required technical validation at TRL-5 with initial steps towards TRL 6 of satellite Air-Ground Datalink for Long Term SATCOM integrated in the FCI
- Support to the elaboration of required standards at global level

PJ14-02-04 FCI Network Technologies

The activities of the next phase (Wave 2 – PJ14.W2.77) aim at achieving and validating the TRL6 maturity level to support ATN-B1 services, ATN-B2 services, future ATN-B3 services, AOC services and safety SWIM services, as well as interoperability with ATN/OSI systems and infrastructure.
The Technical Validation Plan (TVALP) TRL6 provides an initial roadmap with the following validation scope:

- FCI Multi-Link and IPS Mobility Management.
- FCI Security Infrastructure.
- FCI scalability and performance.FCI digital voice communicationLab tests with ATN/OSI FANS B or C airborne systems: to validate interoperability with ground ATN/IPS system through a ground OSI/IPS Gateway.

- Lab tests with an ATN/IPS Airborne Router prototype integrated with a SATCOM (IPS capable) and with VDLm2. Focus of the test would be on performance, security and multilink. But no test on mobility (static and heavy test infrastructure).

Future work on air-ground signalling interface (referred to as IF7) is needed to design a solution compatible with ICAO WG/I mobility subgroup requirements and aligned with router vendors implementation roadmap. The air-ground signalling interface was the performance bottleneck for the handover and link establishment procedures. It should be considered if Layer 2 mechanism should be added to replace or extend the air-ground signalling interface in these scenarios to improve the corresponding performance.

Future work on signalling interface between ground-based Access Router and ground based Air-Ground Router is needed to design a solution that would communicate radio link quality information to the Access Router.

Work on security should be aligned with ICAO WG/I security subgroup.

For reaching TRL4 the utilization of two data links was sufficient to validate the mobility concept, the component and its functionality. For reaching TRL6 it is suggested to use three different radio links. Also, the use of real LDACS and AEROMACS radio links are recommended to further evaluate the system performances. Testing should also be done simulating a significant number of aircraft and sites and applications on the ground.

Multiple GB-LISP (ground-based list processing) domains should be tested according to the latest LISP Uberlay proposals. The interoperability between the commercial and the complete open source implementations shall be verified. DSCP-based forwarding with policy-based routing (PBRs) established by the GB-LISP control plane should be tested once this information could be transported by LISP implementations. Selective subscriptions should be also verified once they become available.

Integration of GB-LISP with other local mobility solutions (e.g. PMIPv6) should be investigated and verified when such solutions become available. Hybrid mobility solutions are currently being defined at ICAO WG-I Mobility Subgroup.

FCI supports A/G digital voice by ensuring a low-latency, low-jitter service relying on a single access subnet. As the operational concept for digital voice is not well defined yet, relevant performance parameters for this new Class of Service are scope of Wave 2.

PJ14-02-05 Development of new services similar to FIS-B to support ADS-B solutions for General Aviation.

It is recommended to conduct a V3 Phase in order to create further progress on this subject and finally, to increase safety for General Aviation pilots after implementation of the new service.

In a V3 phase, real flight conditions should be prepared and appropriate validation exercises performed together with GA pilots. This is explained in more detail in section “Recommendations and Additional activities” of this document. This means in detail that

- LTE based ground station prototypes with up-tilted antennas from a telecom service provider, covering GA altitudes up to 10,000 ft., should be installed and operated on a test basis. This should comprise a limited prototype network with at least two to three adjacent ground stations in order to test the correct handover between the stations and the support of adjacent cells at the edge of the test network as well as to investigate interference effects.
- The App and the GDPU should be further developed, also coping with those TS/IRS requirements, which have not yet been met in the V2 phase; in particular, the own aircraft position should be processed on the ground in order to integrate it into the overall air traffic picture to be subsequently transmitted to other aircraft. In this way, surrounding VFR traffic could be displayed more completely, assumed a widespread usage of the new App.

- Real flight tests with GA aircraft should be conducted to validate the progress made on the system's development side and on the concept's and service's side during the V3 phase.

In addition, it is recommended to further refine the CBA by validating their input data, particularly as far as the number of potential service users in future and the telecom providers' costs are concerned.

PJ14-02-06 Completion of AeroMACS Development

AeroMACS is a mature Solution, and no further R&D activity is expected. It is already being deployed in many Airports world-wide (especially China, Japan, US) for mobile and fixed services. Concerning support of ATS services onboard, it is deemed necessary that coordination be put in place within the aeronautical community, in order to implement the steps foreseen by the European ATM CNS Roadmap.

3.2.2 Navigation Domain

PJ14-03-01 GBAS

GAST D Extended Scope

It is recommended to continue the ionosphere and scintillation data logging over a longer validation period in order to complete the technical validation of the GAST D solution for anomalous ionospheric conditions. The detected ionospheric events (gradients and scintillation data) and the performance of the Ionospheric Gradient Monitor should continue to be analysed for a consolidation of the monitoring architecture in order to develop mitigation techniques.

Based on the work conducted on the technical validation of the VDB ground measurement equipment, it is recommended validating the ICAO Document 8071 Volume II 3 dB measurement uncertainty requirement and, specifically, the contribution from the measurement antenna.

GAST D Extended Scope will continue in wave 2 PJ14-W2-79.

GAST F

It is recommended to continue the DFMC GBAS activities in different areas, in order to increase the maturity level:

- Consolidation of the conceptual framework, in liaison with RTCA and ICAO/NSP
- Consolidation of the technical specifications, as basis for the definition of the related RTCA DO documents and ICAO Annex 10 SARPS
- Improvement of the Ground Station prototype, and installation in a representative platform (upgrade of the Barcelona Airport platform planned for Wave 2)
- Improvement of the monitoring tools
- Improvement of airborne receivers
- Continue the verification and validation exercises, covering
    - Basic performances, like ionospheric mitigation capabilities
    - Fall back modes
    - Backward compatibility
    - End-to-end performance test, at ground level
    - Flight trials.

GAST F will continue in wave 2 PJ14-W2-79.

Non MMR Architecture

The proposed roadmap for the maturation of non MMR architecture up to TRL4 would require the following activities

1. Further refinement and validation of the proposed high-level requirements supporting operations between 100 and 200ft DH, through RTS and FTS, to reach sufficient confidence in their validity and to get a consensus on their acceptability by the civil aviation community consensus. The RTS shall be performed by pilots in aircraft simulators landing manually in CATII visibility conditions with erroneous guidance up to a maximum limit for validation of the navigation high level requirements
2. Further refinement and validation of hybrid positioning algorithm through the use of simulated signals and real signals from flight tests or data collection, enabling to reach TRL5
3. Further refinement and performance validation of XLS dissimilar monitoring
4. CBA of the architecture supporting all the targeted XLS capabilities, and taking into account the optimisation enabled by the dissimilar XLS channel

Going further in the solution and particularly investigating the dissimilar monitoring aspects would require considering "how" the non-MMR architecture would be implemented, and not only "what" is has to do, and then it would require going deep into the details of physical implementation.
Investigating on point 1 and 2 is the activity foreseen in solution PJ02-W2-17 during wave2.

PJ14-03-02 Multi Constellation / Multi Frequency (MC/MF) GNSS

The operational improvements expected from the solution will come if the ground counterparts are also implemented. This means modifications on the following component:

- SBAS and GBAS component and interfaces,
- GNSS monitoring component to add monitoring features for new signals,
- AIM component for new DFMC publications (GNSS elements approval and ISM) in the AIP, modification of the related databases,
- the navigation performance predictions tools modification in the AU FLT OPS for mid-term flight planning.

The main identified issue is the fact that standardisation of DFMC technology is progressing very slowly at ICAO and RTCA/EUROCAE levels due to a lot of issues for which consensus are not reached e.g.:

- Maturity of constellations and/or signals definition
- Political aspects for state Approval, mandates
- Required technical Needs (Backup navigation on L5, Positioning Mode management, reversion between modes …)

Activities foreseen to further mature the development of DFMC technology are in principle dedicated to further refinement and consequent validation including the operational impact assessment of the solution scenario used during the Wave 1 execution.

- for Wave 1.

In order to develop further the technical solution supporting such new operational capabilities, there is a need to get a consensus on these high level requirements at ICAO level, inside the NSP, and in the different All Weather operations groups, and to get acceptance of the requirements and the supporting possible technical solution by the certification authorities.
This standardisation and regulatory work will need further development before deployment of the technical solution supporting these new capabilities.

PJ14-03-04 Alternative Position, Navigation and Timing (A-PNT)

Long Term: A-PNT based on LDACS Datalink

Additional activities are foreseen in Wave 2 to consolidate the LDACS architecture. The interoperability with DME will have to be also considered in order to use both systems to improve

coverage and integrity. Investigations will comprise also the mitigation of inter system interferences to guaranty.
Multipath mitigation techniques will also have to be investigated in order to increase the accuracy of the system.
During the Wave 2, standardization activities for LDACS will be started in order to pave the way towards the deployment of the LDACS based A-PNT.

Mid Term: A-PNT based on Multi DME Positioning
The technical implementation of the prototype done for SESAR2020 wave 1 has considered simplified connection of the multiDME positioning algorithm with the database for the selection of DME along the RNP route supporting RNP1, and has not considered the potential improvements for navigation performance coming from the use of baro or inertial measurements.
The recommendation is to carry on the research work on this solution in wave 2 on the following aspects

- Assessment of performance for others TMA, or for en-route
- DME Selection fully connected with database aspects for complete representative FMS implementation
- Potential Improvements of MT APNT solution performance to target RNP0.3 for RNP-APCH through addition of Baro altimeter and inertial aiding
- CBA assessment taking into account potential additional benefits if RNP-APCH is supported, and clarified assumptions retained by ANSP for TMA airspace redesign strategy.

These additional works planned for wave 2 shall allow on-going TRL6 assessment.
At longer term, flight tests will be required for full TRL6 to verify that the MT APNT solution performs with true DME ranges measurements, with same expected performance.

Short Term: A-PNT based on DME-DME solution
The initial planning of WG107 activities envisaged the delivery of the MOPS and MASPS documents by end 2019, in the same time frame with the end of SESAR 2020 wave 1. Currently the updates in what regards the performance requirements have been identified, however, further work is needed in order to finalize additional updates regarding:

- Testing procedures
- Spectrum mask improvements (to accommodate spectrum sharing with other aeronautical systems, e.g. LDACS)
- Multipath errors overbound
- Common design integrity demonstration methodology

Therefore the delivery of both documents been delayed for end 2020. It is recommended that the A-PNT solutions that are continued in wave 2 contribute to finalizing these documents.

3.2.3 Surveillance Domain

PJ14-04-01 Surveillance Performance Monitoring

For performance monitoring of surveillance systems a reliable tool is needed that obtains the system performance according to the latest standards following a performance based surveillance (PBS) approach. Thereby the reliability and trustworthiness of the obtained tool results on the sensor and “end-to-end” performance are essential. A major goal in the validation is therefore to have harmonized tool results, which will be steered by a detailed specification (new TS/IRS). Beside the offline performance monitoring capability additionally the Quasi Real Time aspects of performance monitoring are covered, such as to identify degradation trends early.

During the next phase, the solution will target TRL 6 at sensor level, supported by the maturity level of the Surveillance Standards and Specifications. At "end-to-end" level, the solution will target TRL 6. The solution will refine the functional requirements with the future updates of the Standards.
Together with the validation objectives, the outstanding R&D needs to be addressed are:

- Adaptation of the methods and tools to take into account the evolution of the emerging standards,
- Specification and development of the quasi real time functionality,
- Validation of the methods and the tool prototypes.

It is also planned to cover a bigger number of requirements increasing the confidence of the obtained results.

PJ14-04-03 New use and evolution of Cooperative and Non-Cooperative Surveillance

For the WAM & ADS-B composite secure surveillance prototype, it is recommended to limit the capability demonstration to mainly the new or adapted security features that will be developed and to focus more on the live traffic analysis based on statistical analysis.
For the MSPSR & ADS-B composite surveillance, some active/passive hybrid MSPSR could be envisaged making the MSPSR solution manageable from a safety perspective.
Some benefits of the composite surveillance such as the primary ADS-B validation and the Mode-S data enhancement are redundant with the benefit of an SDPS multi-sensor data fusion. For the next phase, an analysis can be conducted to determine which are the most significant features such as the 1090 MHZ footprint reduction and statically assess the benefit. Recommendations for updating ATM Master Plan Level 2
For the next maturity phase of the PJ14-04-03 Improved Multi-sensor Data Fusion, a follow up technical validation addressing the elaborated objectives should be executed, provided that:

- Space-Based ADS-B data is mature (ED-129B [42] compliance demonstrated, formal EASA certification for TMA and En-route).
- a formal release of ASTERIX CAT 015 is available and a formal test tool is available to support quantitative assessment of the system performance.
- Performance-based data fusion is covering both INCS/MSPSR and Space-Based ADS-B.

The following recommendations for the next phase of the PJ14-04-03 Multi Remote Tower Control Surveillance have been identified to increase the maturity to reach a pre-industrial prototype stage:

- For MRT-SUR only an initial OSED is currently available. It is recommended that an operational project e.g. PJ05 is commissioned with the creation of such a document.
- ADS-B validation using partial (incomplete) measurements of azimuth only, range only and range difference only.
- Track initialization with multiple partial measurements e.g. multiple cameras at different locations or camera and ranges/range differences from a Mini-MLAT. A single partial (incomplete) sensor source is not capable to initialize a track in the latitude/longitude domain expect for projection solutions.
- It is recommended to follow the approach to establish a MRT-SUR sensor. And to fully establish the data fusion and sensor environment at the airport in Erfurt.
- It is furthermore recommended to validate the MRT-SUR sensor with respect to the operational feasibility of the sensor in coordination and collaboration of PJ05 (provision of surveillance data in shadow mode)
- It is furthermore recommended to derive reliable performance figures for the complete sensor setup in the field. This is currently only done partially under laboratory conditions.

- To check / clarify the needs for standardization adaptation and to develop a proposal for that.

The following recommendations for the next phase of the PJ14-04-03 Secured Surveillance Systems have been identified to increase the maturity to reach a pre-industrial prototype stage:

- Consolidate requirements on the operational performance of the SUR-security functions.
- Prepare the standardisation as a prerequisite for the operational use
- Use of both developed prototypes in same environment in order to conclude about the harmonization of both prototypes.
- Focus more on the Security Performance metrics collection.
- update the requirements (TS/IRS) following the update of the currently developing Surveillance Standards and Specifications.
- extend the sensor based threat validation capabilities (THALES). This includes the identification, implementation and further evaluation of the most suitable measurement principles such that the possible range for the trade-off between continuity and integrity will be increased and with this the adaptability for different airspaces is increased.
- further refine and confirm the performance of a surveillance systems security function and to clearer define the operational needs and related performance requirements. In this context it is useful the clarify whether a combined approach, addressing GEN-SUR-SEC together with GEN-SUR-SPR could be beneficial. In this context also a performance allocation in the SUR chain and responsibilities should be clarified.
- further define means to forward information on detected target related security threats or ADS-B validation failures to downstream processing. In this context a separate ASTERIX category allowing to forward validation information independent from the actual sensor in an interoperable way is advisable. This message would allow to provide manufacturer independent and sensor independent validation & security information to all relevant instances in the SUR chain.

It is recommended for the next phase of the PJ14-04-03 Future ADS-B communication link to update the requirements (TS/IRS) following the update of the currently developing Mode S Standards and Specifications. It is also recommended to reuse to the maximum extend of the Wave 1 exercises, adapted to the updated TS/IRS requirements. It is also recommended to multiply tests in different environments, such as operational environments.

It is recommended for the next phase of the PJ14-04-03 to produce a Safety Assessment analyzing the impact on safety requirements.

4 References

[1] European ATM Master Plan, Edition 2015

[2] SESAR European ATM Master Plan L3, 2018

[3] Project Handbook Ed 01.00.01, 2017, SESAR Join Undertaking

[4] ICAO Global Air Traffic Management Operational Concept, Doc 9854, First Edition 2005

[5] ICAO Doc 9983, 37th Session of the Assembly, Executive Committee Report, October 2010

[6] ICAO Global air Navigation Plan 2016-2030, Doc 9750-AN/963 Fifth Edition 2016

4.1 Project Deliverables

All the documents described in Paragraph 1.5 can be considered as reference for this document.
In addition to the previous list, the following documents were used to provide input, guidance or further information:

- ✓ European ATM Master Plan, Edition 2015
- ✓ SESAR European ATM Master Plan L3, 2018
- ✓ Project Handbook Ed 01.00.01, 2017, SESAR Join Undertaking
- ✓ ICAO Global Air Traffic Management Operational Concept, Doc 9854, First Edition 2005
- ✓ ICAO Doc 9983, 37th Session of the Assembly, Executive Committee Report, October 2010

4.2 Project Communication and Dissemination papers

The Communication and Dissemination activities have been performed in order to achieve the widest dissemination of knowledge from the project. The activities have been expanded in two directions: towards the marketing activities in order to enhance the commercial potential of the results and towards the notification of project's results in the International and standardization working groups. Communication and Dissemination are horizontal activities and concentrate on disseminating the results of PJ14 project itself to a wide range of existing or potential stakeholders.
The following three tables reports in details the events at which each solution, depending on the Domain, participated, with a clear indication of the "Event", the "Location", the "Date", the "Participant ", intended as PJ14 solution. The column "Remark" reports the kind of participation correspondent to the solution, on the "Participant" column. Where "Remark" is empty, the solution was present as participant only. When Paper N. is indicated, in the "Remark" column, the "CTRL + click" on the number brings to the fourth table where the details of the paper are reported.

Communication Domain

Event	Location	Date	Link	Participant	Remark
Word ATM Congress	Madrid	March 2017		PJ14-02-06	Survey

FCI-Task force#7	Brussels	March 2017		PJ14-02-04 PJ14-02-06	Presentation Survey
EUROCONTROL CNS Team group	Brussels	May 2017		PJ14.01.01	Presentation
AEEC DLUF-Task force#8	Brussels	September 2017		PJ14-02-01 PJ14-02-02 PJ14-02-04 PJ14-02-05 PJ14-02-06	Presentation Presentation Presentation Presentation Presentation
AEEC Mid Term	Brussels	October 2017	https://www.aviation-ia.com/products/aeec-mid-term-session-2017-report	PJ14-02-01 PJ14-02-02 PJ14-02-04 PJ14-02-06	Presentation Presentation Presentation Presentation
FCI-Task Force#9	Brussels	February 2018		PJ14-02-04 PJ14-02-06	Presentation Presentation
ICNS Conference	Virginia	April 2018	https://i-cns.org/icns-2018/	PJ14-01-01 PJ14-02-01 PJ14-02-04 PJ14-02-06	Presentation Paper N 1 Paper N 2
Word ATM Congress	Madrid	March 2018	https://www.worldatmcongress.org/conference-programme	PJ14-01-01 PJ14-02-06	Presentation Demo
EUROCONTROL CNS Team group	Brussels	May 2018		PJ14.01.01	Presentation
ICAO WG-I IPS Security and Mobility		May 2018		PJ14-02-04	
WG-		June 2018		PJ14-02-04	

108/SC-223					
EUROCAE WG-82 Meeting	Cologne	June 2018		PJ14-02-02	Presentation
SESAR PJ14-02-06 Open Day	Florence	July 2018	https://www.sesarju.eu/node/3028	PJ14-02-06	Organization, Presentation, demo
EASA CNS Expert group	Brussels	July 2018		PJ14.01.01	
AEEC DLUF-Task Force#10	Brussels	September 2018		PJ14-02-01 PJ14-02-02 PJ14-02-04 PJ14-02-05 PJ14-02-06	Presentation Presentation Presentation Presentation Presentation
DASC - Digital Avionics Systems Conference	Brussels	September 2018		PJ14-02-01	
CNS Symposium	Brussels	October 2018		PJ14-01-01 PJ14-02-02	Organization Presentation and stand
Ka and Broadband Communications Conference	Niagara Falls, Canada	October 2018	WG-28	PJ14-02-02	Paper N. 7
EASA CNS Expert group, EASA	Brussels	November 2018		PJ14.01.01	Presentation
JURG	Brussels	February 2019		PJ.14.01.01	Presentation

Word ATM Congress	Madrid	March 2019	https://www.worldatmcongress.org/conference-programme	PJ14-01-01 PJ14-02-02 PJ14-02-06	Presentation Presentation Demo
FCI-Task Force#11	Brussels	March 2019		PJ14-02-01 PJ14-02-02 PJ14-02-04 PJ14-02-06	Presentation Presentation Presentation Presentation
NATO HQ C3B	Brussels	April 2019		PJ14-02-01	Presentation
ICNS 2019 Westin Washington Dulles	Herndon, VA (US)	April 2019	https://i-cns.org/icns-2019/	PJ14-01-01 PJ14-02-01 PJ14-02-02 PJ14-02-04 PJ14-02-05 PJ14-02-06	Presentation Paper N 3 Paper N. 6 Paper N. 5 Presentation
AERODays 2019 conference	Bucharest, Romania	May 2019	https://www.sesarju.eu/node/3206	PJ14-02-01	Presentation
MNWG 2019	Garmisch-Partenkirchen (Germany)	June 2019		PJ14-02-01	Presentation
DASC - Digital Avionics Systems Conference	San Diego, CA (US)	September 2019	https://10times.com/dasc-california	PJ14-02-01	Paper N. 4
AEEC DLUF	Dublin	September 2019		PJ14-02-01 PJ14-02-02	Presentation Presentation

				PJ14-02-06	
FCI-Task Force#12 *SESAR PJ14 COM Open Day*	Brussel es	October 2019	https://twitter.com/SESAR_JU/status/1191339102026846210 https://www.linkedin.com/posts/triona-keaveney-2a741b13_sesar-research-innovation-activity-6597114407333965824-yr7J	PJ14-01-01 PJ14.02.01 PJ14-02-02 PJ14-02-04 PJ14-02-05 PJ14-02-06	Presentation “ “ “ “ “

Table 13 PJ14 Communication Domain and PJ14-01-01 transversal solution Event participation

Navigation domain

Event	**Location**	**Date**	**Link**	**Participant**	**Remark**
International GBAS Working Group (WG-28)	Brussels	April 2017		PJ14-03-01	Presentation
ICAO JWGs	Brussels	June 2017		PJ13-03-01	Presentation
ICAO NSP/JWGs	Brussels	June 2017		PJ14-03-01	Paper N. 8
EOROCAE WG-107	Brussels	June 2017		PJ14-03-04	
ICAO NSP/4 WP6	Brussels	October 2017		PJ14-03-01 PJ14-03-04	Paper N. 9
Word ATM Congress	Madrid	March 2018		PJ14-03-01	
ICAO NSP	Brussels	April 2018		PJ14-03-01 PJ14-03-02	Paper N. 11 GNSS presentation
ICNS 2018 Westin Washington Dulles	Herndon, VA (US)	April 2018	https://i-cns.org/icns-2018/	PJ14-03-04	
International	Kracov	May		PJ14-03-	Organizatio

GBAS Working Group (I-GWG) (organizatio n)		2018		01	n, presentatio n
EUROCAE WG62 CNS-Navigation	Brussels	June 2018		PJ14-03-02	Presentatio n CONOPS for DMFC GNSS presentatio n CBA presentatio n TS-IRS presentatio n
EUROCAE WG28	Brussels	July 2018		PJ14-03-01	Paper N. 12 Presentatio n N.
ICAO NSP	Brussels	Novembe r 2018		PJ14-03-01	Paper N. 13 Paper N. 15 Paper N. 15
ICNS 2019 Westin Washington Dulles	Herndon, VA (US)	April 2019	https://i-cns.org/icns-2019/	PJ14-03-01	
ICAO NSP		April 2019		PJ14-03-01 PJ14-03-02	Paper N. 17 Presentatio n
AERODays 2019 conference	Buchares t, Romania	May 2019	https://www.sesarju.eu/node/3206	PJ14-03-01	Paper N. 18
International GBAS Working Group	Denver	June 2019		PJ14-03-01	

Table 14 PJ14 Navigation Domain Event participation

Surveillance domain

Event	Location	Date	Link	Participa nt	Remark

SSTF Meeting/EUROCAE WG-102:	Skyguide Geneva	March 2018		PJ14-04-01 PJ14-04-03	
SSTF Meeting/EUROCAE WG-102:	Egis Avia Toulouse	June 2018		PJ14-04-01 PJ14-04-03	
ESAVS	Berlin	October 2018	https://www.dgon-esavs.org/index.php?id=24	PJ14-04-01 PJ14-04-03	Presentation N. 19 Presentation N. 20 Presentation N. 21 Presentation N.22
SSTF Meeting/EUROCAE WG-102:	NAV Portugal Lisbon	October 2018		PJ14-04-01 PJ14-04-03	
SSTF Meeting/EUROCAE WG-102:	EUROCONTROL HQ Brussels	December 2018		PJ14-04-01 PJ14-04-03	
SSTF Meeting/EUROCAE WG-102:	EUROCAE Saint Denis France	March 2019		PJ14-04-01 PJ14-04-03	
SSTF Meeting/EUROCAE WG-102:	DFS Langen	June 2019		PJ14-04-01 PJ14-04-03	
SSTF Meeting/EUROCAE WG-102	EASA Brussels	October 2019		PJ14-04-01	
ASTERIX Maintenance Group Meeting #2	*Karlsruhe/Germany*	October 2018		PJ14-04-03	

ASTERIX Maintenance Group Meeting #3	*Brussels*	March 2019		PJ14-04-03	
ASTERIX Maintenance Group Meeting #4	*Brussels*	May 2019		PJ14-04-03	
Eurocontrol CNS symposium	*Brussels*	October 2018		PJ14-04-03	
World ATM Congress 2019	*Madrid*	March 2019		PJ14-04-03	
Aerodays 2019 Romania	*Bucarest*	May 2019		PJ14-04-03	
- ICAO ADS-B Implementation meeting	*Ottawa*	August 2019		PJ14-04-03	

Table 15 PJ14 Surveillance Domain Event participation

Papers and relevant presentations

No	Title	Main authors	Number, date or frequency	Place of publication	Year of publication
1.	*L-band Digital Aeronautical Communications System (LDACS) Activities in SESAR2020*	*C. Rihacek, B. Haindl, P. Fantappie, S. Pierattelli, T. Gräupl, M. Schnell, and N. Fistas*	*in Proc. Integrated Communications Navigation and Surveillance Conf.,*	Herndon, VA	*2018*
2.	*L-band Digital Aeronautical Communications System (LDACS) Flight Trials in the National German Project MICONAV*	*T. Gräupl, N. Schneckenburger, T. Jost, M. Schnell, A. Filip, M. A. Bellido-Manganell, D. M. Mielke, N. Mäurer, R.*	*in Proc. Integrated Communications Navigation and Surveillance Conf.*	Herndon, VA	*2018*

		Kumar, O. Osechas, G. Battista, T. Bögl, and T. Richter			
3.	*L-DACS Spectral Efficiency*	*P. Fantappié*	in Proc. Integrated Communications Navigation and Surveillance Conf.	Herndon, VA	*2019*
4.	*L-band Digital Aeronautical Communications System (LDACS) – Technical Validations in SESAR2020*	*C. Rihacek, M. Sajatovic, J. Meser, and T. Gräupl*	in Proc. 38th Digital Avionics Systems Conf.	San Diego, CA	2019
5.	*IPS Technology Validation"*	*M. Olive, M. Skorepa*	*in Proc. Integrated Communications Navigation and Surveillance Conf*	*Herndon, VA,*	*2019*
6.	*FUTURE SATELLITE COMMUNICATIONS DATA LINK IN SESAR 2020 AND ESA IRIS PROGRAMME*	*A Miglietta, S. La Barbera, S. Sureda-Perez, K. Mineck, N. Fistas, R. Zaruba,S. Tamalet, L. Albiol Schnitger*	*In Proc. Integrated Communications Navigation and Surveillance (ICNS) Conference*	*Herndon, VA,*	*2019*
7.	*Iris with IOC : The Space based Solution for Air Traffic Management communications*	*Stefano La Barbera, Paolo Conforto, Alessia Miglietta, Luca Pighetti, Roberto Winkler*	*In Proc. Ka and Broadband Communications Conference*	*Niagara Falls, Canada*	*2018*
8.	*GBAS VDB Desired-to-Undesired Signal Power Ratios for Rollout Scenario at Frankfurt Airport.*	*Stefan Naerlich/Winfried Dunkel*	*In Proc. ICAO JWGs/2 IP9*	*Brussels*	*2017*
9.	*Improved Success Criteria for VDB Field Strength*	*Stefan Naerlich/Winfrie*	*In Proc. ICAO NSP/4 WP6*	*Brussels*	*2017*

	Measurements.	*d Dunkel*			
10.	*New standards for GBAS approach*	*Jenny Beechener*	*Jane's Airport Review Journal*	*Coulsdon, Surrey*	*2017*
11.	*VDB Ground Coverage Simulations for Frankfurt Airport*	*Stefan Naerlich/Winfried Dunkel*	*In Proc. ICAO NSP JWGs/4-IP4*	*Brussels*	*2018*
12.	*GBAS D/U Flight Measurements Bremen & Frankfurt*	*Stefan Naerlich/Winfried Dunkel*	*In Proc. EUROCAE WG28 N39/9*	*Brussels*	*2018*
13.	*GBAS Status in Germany*	*Stefan Naerlich/Winfried Dunkel*	*In Proc. ICAO NSP JWGs/5-IP12*	*Brussels*	*2018*
14.	*GBAS VDB Inspection below 200 ft. Nov. 2018; Appendix A: IFIS Paper 2018 "Challenges with GBAS VDB Flight Inspection".*	*Mike Spanner*	*In Proc. ICAO NSP/5 IP34*	*Brussels*	*2018*
15.	*DFMC GBAS conceptual framework*	*F. Salabert/Pere Durba*	*In Proc. ICAO NSP/5 WP41*	*Brussels*	*2018*
16.	*Design of a Multiband Global Navigation Satellite System Radio Frequency Interference Monitoring Front-End with Synchronized Secondary Sensors,*	*Morrison A., Sokolova N. and Curran J.*	*In SENSORS 2018, 18(8):2594, doi:10.3390/s18082594.*	*Basel, Switzerland*	*2018*
17.	*How to implement GAST D on large airports with severe ionospheric conditions*	*Linda Lavik/Morten Topland*	*In Proc. ICAO NSP JWGs/4 WP19*	*Brussels*	*2019*
18.	*Ground-based augmentation systems (GBAS) CAT II/III*	*Hugo Moen*	*In Proc. Tandem Aerodays Conference*	*Bucharest*	*2019*
19.	*Model-based Performance Assessment of a*	*Arberita KUSARI, Holger*	*Presentation at ESAVS*	*Berlin*	*2018*

	Multilateration System	*NEUFELDT, Diego JIMENEZ-OROSTEGUI, André SCHÜTTPELZ, Thales Deutschland GmbH, Ditzingen, Germany*			
20.	*A Cost-Effective Surveillance Solution for Multi Remote Tower*	*Klaus Pourvoyeur, André Schüttpelz2, Adolf Mathias,Holger Neufeldt ,Werner Wohlfahrter, Thomas Oster4*	*Presentation at ESAVS*	*Berlin*	*2018*
21.	*Extension of a Surveillance Service with Partial Measurements*	*Adolf Mathias, Klaus Pourvoyeur, Ha Son Nguyen*	*Presentation at ESAVS*	*Berlin*	*2018*
22.	*Security functions in cooperative surveillance sensors*	*André SCHÜTTPELZ, Holger NEUFELDT, Thales Deutschland GmbH, Ditzingen, Germany Stefan STANZEL, DFS Deutsche Flugsicherung GmbH, Langen, Germany*	*Presentation at ESAVS*	*Berlin*	*2018*

Table 16 PJ14 Papers and relevant presentations

Appendix A Glossary of Terms, Acronyms and Terminology

A.1 Glossary of terms

Term	Definition	Source of the definition
A-DSB	Automatic dependent surveillance—broadcast (ADS–B) is a surveillance technology in which an aircraft determines its position via satellite navigation and periodically broadcasts it, enabling it to be tracke	*ICAO ADS-B Operational guidance*
AeroMACS	AeroMACS is a wireless broadband technology that supports the increasing need for data communications and information sharing on the airport surface for both fixed and mobile applications, ATS and AOC services.	*ATM Master Plan*
ATM Master Plan	It provides the main direction and principles for the SESAR Programme. The ATM Master Plan has regular updates; amendments are submitted to the SJU Administrative Board for adoption. The ATM Master Plan establishes key elements for R&I such as performance objectives and needs, regulatory and standardisation roadmap, business case and risk management plan. The ATM Master Plan also provides the means (via the definition of Operational Improvements) by which the requirements on the stakeholders involved can be identified in terms of the Enablers and level of interoperability that they need to be compliant with. Finally, one key element included in the ATM Master are the Standardization and Regulation Roadmaps which will allow the standardisation and regulatory organisations to consider and plan new activities in a timely manner, thus enabling a timely rollout and deployment of technology. The ATM Master Plan architectural elements are integrated into	

	EATMA content. The ATM Master Plan will make reference to this content when applicable.	
A-PNT	The alternative position, navigation and timing pursues fallback capabilities in case of GNSS unavailability for the short, medium and long term, by the use of a number of sensors, each of which is a potential source of complementary information to support navigation.	*ICAO Navigation System Panel*
CBA	The CBA deliverable is required to assess the affordability of a solution or set of solutions with respect to the expected benefits of each SESAR Solution under the responsibility of ATM Solution	*Project Handbook –SESAR Joint Undertaking*
Class A SATCOM	Class A SATCOM is an enhancement of existing geostationary AMSS satellite systems designed to meet the future stringent, high-integrity, requirements in the high density continental airspace and act as an enabler to support 4-D trajectory information exchange.	*ATM Master Plan*
CPDLC	The Controller-Pilot Data Link Communication application provides air-ground data communication for the ATC service.	*ATM Master Plan*
4D trajectory	A trajectory representing the business/mission intentions of the Airspace Users and integrating ATM and airport constraints is elaborated and agreed for each flight, resulting in the trajectory that a user agrees to fly and the Air Navigation Service Provider (ANSP) and airport agree to facilitate.	*SESAR Concept of Operations Step 2 Edition 2014*
EATMA	It is the common architecture framework for SESAR 2020. It is the sole means of integrating the ATM operational and technical content developments produced by SESAR 2020 Projects in a consistent and coherent way.	
Enabler	New or modified technical system/infrastructure, human factors	*European ATM Architecture*

	element, procedure, standard or regulation necessary to make (or enhance) an operational improvement.	
ESA/Iris Programme	The Iris Programme aims to make aviation safer, greener and more efficient by developing a new satellite-based air–ground communication system for Air Traffic Management (ATM), in partnership with Inmarsat. By 2028, Iris will enable full 4D trajectory management over airspaces across the globe and the data link will be the primary means of communications between controllers and cockpit crews.	*https://artes.esa.int/iris*
FRD	The Functional Requirements Document is a formal statement of a SESAR Technological Solution related functional requirements. The content is solution independent; it described "what" the SESAR Technological solution has to do but not the "how".	*Project Handbook –SESAR Joint Undertaking*
Future Communications Infrastructure	The FCI (Future Communication Infrastructure) includes all the components needed for the ANSP, AOC (Airline Operational Communications), and aircraft to communicate with each other.	*ATM Master Plan*
GALILEO	Europe's own global navigation satellite system	
GAST D	Approach service to enable CAT-II/III precision approach operations (standards finalized, not approved yet)	
GAST F	Approach service which supports CAT II/III, defined for multi-frequency and multi-constellation including GPS L1/L5 and Galileo E1/E5	
GBAS	A Ground-Based Augmentation System (GBAS) is a civil-aviation safety-critical system that supports local augmentation –at airport level– of the primary GNSS constellation(s) by providing enhanced levels of service that support all phases of approach, landing, departure and surface	*ICAO Navigation System Panel*

	operations. Surface Operation is not implemented in the existing GBAS installations nor SARPs provisions developed to support it.	
Ka band	The 26.5-40 GHz portion of the electromagnetic spectrum in the microwave range of frequencies.	
Key Performance Area	Key Performance Areas are a way of categorising performance subjects related to high level ambitions and expectations. ICAO Global ATM Concept sets out these expectations in general terms for each of the 11 ICAO defined KPAs.	*ICAO Doc 9883 Manual on Global Performance of the Air Navigation System*
Key Performance Indicator	Current/past performance, expected future performance (estimated as part of forecasting and performance modelling), as well as actual progress in achieving performance objectives is quantitatively expressed by means of indicators (sometimes called Key Performance Indicators, or KPIs). To be relevant, indicators need to correctly express the intention of the associated performance objective. Since indicators support objectives, they should not be defined without having a specific performance objective in mind. Indicators are not often directly measured. They are calculated from supporting metrics according to clearly defined formulas, e.g. cost-per-flight-indicator = Sum(cost)/Sum(flights). Performance measurement is therefore done through the collection of data for the supporting metrics."	*ICAO Doc 9883 Manual on Global Performance of the Air Navigation System*
LDACS	LDACS is a multi-application cellular broadband system operating in the L-Band and capable of simultaneously providing various kinds of Air Traffic Services (ATS) and Aeronautical Operational Control (AOC) communications services from deployed Ground Stations (GS).	
Multi-constellation receiver	Receiver accessing signals from several constellations (GPS, GLONASS, BeiDou, Galileo etc), the use of which produces	

	some benefits: Reduced signal acquisition time. Improved position and time accuracy. Reduction of problems caused by obstructions such as buildings and foliage. Improved spatial distribution of visible satellites, resulting in improved dilution of precision	
Multi Frequency receiver	Receiver used to remove ionospheric error from the position calculation, providing more immunity to interference	
Multi-Static Primary Surveillance Radar	It is an independent surveillance technology that uses a distributed transmitter and receiver architecture to detect aircraft, even when they are not equipped with cooperative surveillance systems such as transponders or ADS-B. We are researching how it could be used for separation services as part of future operations.	
Operational Improvement Step	The elementary level of an operational improvement	*ATM lexicon*
Performance-based communication and surveillance concept	It provides objective operational criteria to evaluate different and emerging communication and surveillance technologies, intended for evolving air traffic management (ATM) operations.	*ICAO document*
RNP	Required Navigation Performance (RNP) is a family of navigation specifications under Performance Based Navigation (PBN) which permit the operation of aircraft along a precise flight path with a high level of accuracy and the ability to determine aircraft position with both accuracy and integrity	*ICAO PNB Manual*
RPN0.1	RNP1 is a navigation specification family. An RNP0.1 means that a navigation system must be able to calculate its position to within a circle with a radius of 0.1 nautical miles.	*ICAO PNB Manual*
RNP1	RNP1 is a navigation specification family. An RNP1 means that a navigation system	*ICAO PNB Manual*

	must be able to calculate its position to within a circle with a radius of 1 nautical miles.	
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.	
SESAR Technological Solution	New technology that enables future SESAR ATM Solutions, verified as feasible, safe and to support or enable Performance Improvements.	*Project Handbook –SESAR Joint Undertaking*
SPR-INTEROP/OSED	It includes the operational, safety and performance Requirements and Interoperability Requirements related to a SESAR Solution. It includes as well the definition of the operational environment and the relevant hypothesis that has been used as the basis for establishing those requirements	*Project Handbook –SESAR Joint Undertaking*
SWIM	A global Air Traffic Management industry initiative to harmonize the exchange of Aeronautical, Weather and Flight information for all Airspace Users and Stakeholders	*ATM Master Plan*
TRL2	Theory and scientific principles are focused on very specific application area(s) to perform the analysis to define the concept. Characteristics of the application are described. Analytical tools are developed for simulation or analysis of the application.	*H2020 – Work Programme*
TRL4	Component/subsystem validation in laboratory environment: Standalone prototyping implementation and test with integration of technology elements and conducting experiments with full-scale problems or data sets.	*H2020 – Work Programme*
TRL6	System/subsystem model or prototyping demonstration in a relevant end-to-end environment (ground or space): Prototyping implementations on full-scale realistic problems using partial integration with existing systems. While limited	*H2020 – Work Programme*

	documentation is available, the Engineering feasibility is fully demonstrated in actual system application.	
TS/IRS	The TS/IRS deliverable describes functional, non-functional and interface requirements addressing the "what" and not the "how".	*Project Handbook –SESAR Joint Undertaking*
TVALP	It provides a technical validation Plan per TRL phase for a SESAR Technological Solution (s), describing the required technical validation exercises designed by the project in order to progress a SESAR Solution to the next maturity level	*Project Handbook –SESAR Joint Undertaking*
TVALR	It provides for a given SESAR Technological Solution and a TRL, the consolidated technical validation results at SESAR Technological Solution level, and the relevant conclusions and recommendations	*Project Handbook –SESAR Joint Undertaking*
VALP	It provides a validation Plan per V phase for a SESAR Solution (s), describing the required validation exercises designed by the project in order to progress a SESAR Solution to the next maturity level	*Project Handbook –SESAR Joint Undertaking*
VALR	It provides for a given SESAR Solution and a V phase, the consolidated validation results at SESAR Solution level, and the relevant conclusions and recommendations	*Project Handbook –SESAR Joint Undertaking*
VHF Data Link Mode 2	Means of sending information between aircraft and ground stations	*ICAO document "Annex 10 Volume III - Communication Systems*
Validation Targets	Validation targets are the targets that focus the development of enhanced capabilities by the SJU Projects. They aim to get from the R&D the required performance capability to contribute to the achievement of a Strategic Target and, thus, to the SES high level goals.	*ICAO Doc 9883 Manual on Global Performance of the Air Navigation System*

WG-28	EUROCAE Working Group on Ground Based Augmentation System (CNS-Navigation Domain)	*https://www.eurocae.net/about-us/working-groups/*
WG-49	EUROCAE Working Group reactivated to perform maintenance on the Mode S Transponder MOPS ED-73E and ED-115. It will work joint with RTCA SC-209.	*https://www.eurocae.net/about-us/working-groups/*
WG-51	EUROCAE Working group on Development of SPR documents for ADS-B airborne and ground surveillance applications as well as aircraft system MOPS (and possibly MASPS) material	*https://www.eurocae.net/about-us/working-groups/*
WG-62	EUROCAE WG-62 was created in 2002 in the context of GALILEO definition phase and of GPS modernisation plans. Since then, the ToR have been approved in 2003, revised in 2007 and 2013 to accommodate the changes in the planning of Galileo satellite deployment and GPS modernisation. WG-62 works in coordination with RTCA SC-159 Global Positioning System. (CNS-Navigation domain)	*https://www.eurocae.net/about-us/working-groups/*
WG-82	EUROCAE Working Group on New Air-Ground Data Link Technologies (CNS-Communication Domain). WG-82 is tasked to develop a set of documents, some of which are envisaged to be used in the context of ICAO SARPS development or to be recognised as a means of compliance	*https://www.eurocae.net/about-us/working-groups/*
WG-102	EUROCAE Working Group on GEN-SUR-SPR, is tasked to specify generic surveillance safety and performance requirements. These are based on operationally driven ATC surveillance requirements that are levied onto a logical end-to-end ATC surveillance function and its respective sub-functions (resembling typical physical ATC surveillance components).	*https://www.eurocae.net/about-us/working-groups/*
WG-107	EUROCAE Working Group is tasked to revise the existing EUROCAE Document ED-57 “Minimum Performance	*https://www.eurocae.net/about-us/working-groups/*

	Specification for Distance Measuring Equipment (DME/N and DME/P) – Ground Equipment" and to develop a new document "Minimum Aviation Systems Performance Specification (MASPS) for RNP Reversion using DME/DME Positioning".	
WG-108/SC-223	In coordination with the AEEC IPS and RTCA SC-223 activities, EUROCAE WG-108 will determine what exactly is needed to ensure the deployment of ATN/IPS	*https://www.eurocae.net/about-us/working-groups/*

Table 17: Glossary

A.2 Acronyms and Terminology

Term	Definition
AIM	Aeronautical Information Management
A/G	Air/Ground
ABAS	Aircraft Based Augmentation System
ACARS	Aircraft Communications Addressing and Reporting System
ACAS	Airborne Collision Avoidance System
ACC	Area Control Center
ACID	AirCraft Identification
ACNS	Airborne Communications, Navigation and Surveillance
ACSS	Aviation Communication and Surveillance Systems
ADC	Air Data Computer
ADD	Architecture Description Document
ADF	Automatic Direction Finder
ADIRS	Air Data Inertial Reference Unit
ADS-B	Automatic Dependent Surveillance-Broadcast
ADS-C	Automatic Dependent Surveillance-Contract

AEEC	Airlines Electronic Engineering Committee
AEEC DLUF	Airlines Electronic Engineering Committee Data Link User Forum
AeroMACS	Aeronautical Mobile Airport Communications System
AFTN	Aeronautical Fixed Telecommunication Network
AIC	Aeronautical Information Circular
AIDC	ATS Interfacility Data Communication (ICC)
AIP	Aeronautical Information Publication
AIRB	AIRBorne situational awareness
AIRM	Aeronautical Information Referece Model
AIS	Aeronautical Information Service
AMC	Acceptable Means of Compliance
AMHS	Aeronautical Message Handling System
ANS	Air Navigation Services
ANSP	Air Navigation Service Provider
AO	Aircraft Operators
AOA	Airport Operations Area
AOC	Airline Operational Communications
AOP	Airport Operation Plan
APC	Aeronautical Passenger Communications
APCH	APproaCH
A-PNT	Alternative-Position, Navigation and Timing
APT	AirPorT
APV	Approach Procedure with Vertical guidance
ARES	Airspace REServation
ARINC	Aeronautical Radio, INCorporated

A-RNP	Advanced-Required Navigation Performance
ARTAS	ATM Surveillance Tracker and Server
AS	Aerospace Standard
ASA	Aircraft Surveillance Applications
ASAS	Airborne Separation Assurance Systems
ASM	AirSpace Management
A-SMGCS	Advanced-Surface Movement Guidance and Control Systems
ASTERIX	All purpose STructured Eurocontrol surveillance Information eXchange
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATF©M	Air Traffic Flow (and Capacity) Management
ATM	Air Traffic Management
ATN	Aeronautical Telecommunication Network
ATS	Air Traffic Services
ATSA	Air Traffic Situational Awareness
ATSAW	Air Traffic Situational Awareness
ATSU	Air Traffic Service Unit
ATSMHS	ATS Message Handling System
AUP	Airspace Use Plans
BaroVNAV	Barometric Vertical NAVigation
B-RNAV	Basic aRea NAVigation
CAA	Civil Aviation Authority
CAT	Category
CDFA	Continuous Descent Final Approach
CDM	Collaborative Decision Making

CDMA	Code Division Multiple Access
CFR	Code of Federal Regulations
CIDIN	Common ICAO Data Interchange Network
CMF	Communications Management Function
CNS	Communication Navigation Surveillance
CONOPS	Concept of Operations
COTR	COordination and TRansfer
COTS	Commercial Off-The-Shelf
CPDLC	Controller-Pilot Data Link Communications
CS	Certification Specifications
CSP	Communication Service Provider
DAMA	Demand-Assigned Multiple Access
DAP	Downlink Aircraft Parameters
DATIS	Digital Automatic Terminal Information Service
DCL	Departure Clearance
DF	Downlink Format
DFMC	Dual Frequency Multi Constellation
DGPS	Differential GPS
DLS	Data Link Services
DME	Distance Measuring Equipment
DMPR	DME Passive Ranging
DOD	Detailed Operational Description
DSP	Datalink Service Processor
DVB-T	Digital Video Broadcasting-Terrestrial
EAD	European AIS Database

EASA	European Aviation Safety Agency
EATMN	European Air Traffic Management Network
E-ATMS	European Air Traffic Management System
EC	European Commission
ECAC	European Civil Aviation Conference
EGNOS	European Geostationary Navigation Overlay Service
EHS	EnHanced Surveillance
ELS	ELementary Surveillance
EN	Enabler
ENR	En-Route
E-OCVM	European operational concept validation methodology
EPU	Estimated Position Uncertainty
ES	Extended Squitter
ESASSP	EUROCONTROL Specification for ATM Surveillance System Performance
ETSO	European Technical Standard Order
EU	European Union
EUROCAE	European Organisation for Civil Aviation Equipment
FAA	Federal Aviation Administration
FAB	Functional Airspace Block
FANS	Future Air Navigation System
FCI	Future Communications Infrastructure
FCI-TF	Future communication Infrastructure Task force
FOC	Final Operational Capability
FCOM	Flight Crew Operations Manual
FDE/ICD	Flight Data Exchange / Interface Control Document

FDPS	**Flight Data Processing System**
FIR	**Flight Information Region**
FIS	**Flight Information Service**
FIS-B	**Flight Information System-Broadcast**
FMC	**Flight Management Computer**
FMS	**Flight Management System**
FMTP	**Flight Message Transfer Protocol**
FO	**Flight Object**
FOC	**Flight Operations Centre**
FRUIT	**False Replies Unsynchronized with the Interrogation Transmissions**
FSS	**Fixed Satellite Service**
FUA	**Flexible Use of Airspace**
FTI	**FAA Telecommunications Infrastructure**
FTS	Fast Time Simulation
G/G	**Ground/Ground**
GA	**General Aviation**
GANIS	**Global Air Navigation Industry Symposium**
GAST	**GBAS Approach Service Type**
GAT	**General Aviation Traffic**
GBAS	**Ground Based Augmentation System**
GCA	**Ground Controlled Approach**
GEN-SUR SPR	**Generic Surveillance Safety and Performance Requirements**
GFT	**Global Flight Tracking**
GLONASS	**GLObal NAvigation Satellite System**
GNSS	**Global Navigation Satellite System**

GPS	Global Positioning System
HDOP	Horizontal Dilution of Precision
HF	High Frequency
i4D	initial 4D
IA	Indicators and Alerts
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ICC	Inter Center Communication
ICD	Interface Control Document
ICNS	Integrated CNS
IFF	Identification Friend or Foe
IFP	Instrument Flight Procedures
IFR	Instrument Flight Rules
II	Interrogator Identifier
ILS	Instrument Landing System
IM	Interval Management
INS	Inertial Navigation System
INTEROP	Interoperability Requirements
IOC	Initial Operational Capability
IP	Internet Protocol
IPS	Internet Protocol Suite
IR	Implementing Regulation
iRBT	initial Reference Business Trajectory
iRMT	initial Reference Mission Trajectory
IRS	Inertial Reference System

iSBT	initial Shared Business Trajectory
iSMT	initial Shared Mission Trajectory
ISO	International Standards Organization
ISRM	Information Service Reference Model
ITP	In Trail Procedure
ITU	International Telecommunication Union
ITU-T	ITU Telecommunication Standardization Sector
JPALS	Joint Precision Approach and Landing System
KPA	Key Performance Area
LAN	Local Area Network
LARA	Local And sub-Regional Airspace Management support system
L-DACS	L-band Digital Aeronautical Communications System
LF	Low Frequency
LNAV	Lateral NAVigation
LORAN	Long Range Navigation
LPV	Localiser Performance with Vertical guidance
LTE	Long Term Evolution
LVO	Low Visibility Operation
LVP	Low visibility procedures
MAWP	Missed Approach WayPoint
MC/MF	Multi-constellation/Multi-Frequency
MEMS	Micro-ElectroMechanical Systems
MHS	Message Handling System
MLAT	Multilateration
MLS	Microwave Landing System

MM	Military Messaging
MMHS	Military Message Handling System
MMR	Multi-Mode Receiver
MMS	Military Mission System
MOPS	Minimum Operational performance Specification
MPS	Minimum Performance Standard
MSPSR	Multi-Static Primary Surveillance Radar
MTCD	Medium Term Conflict Detection
MTOW	Maximum Take Off Weight
NAF	NATO Architecture Framework
NATO	North Atlantic Treaty Organization
NAV	NAVigation
NAVAID	NAVigation AIDs
NDB	Non-Directional Beacon
NGSS	Next Generation Satellite System
NM	Network Manager
NO	Network Operations
NOP	Network Operations Plan
NOTAM	Notice To AirMen
NPA	Non Precision Approach
NRA	Non-Radar Airspace
NSA	National Supervisory Authority
NSP	Navigation Systems Panel
NSV	NAF System View
NTP	Network Time Protocol

OBPMA	On-Board Performance Monitoring and Alerting
OCL	Oceanic Clearance
OFA	Operational Focus Area
OFDM	Operational Flight Data Monitoring
OI	Operational Improvement
OPMA	On Board Performance Monitoring and Alerting
OSED	Operational Service and Environment Definition
OSI	Open Systems Interconnection
PA	Precision Aproach
PALS	Precision Approach and Landing System
PAR	Precision Approach Radar
PBN	Performance Based Navigation
PCL	Passive Coherent Location
PCP-IR	Pilot Common Projects Implementing Rule
PENS	Pan-European Network Service
PKI	Public Key Infrastructure
PNT&D	Positioning, Navigation, Timing, and Data
POA	Plain Old ACARS
PPS	Precise Positioning Service
PRF	Pulse Repetition Frequency
P-RNAV	Precision aRea NAVigation
PRS	Public Regulated Service
PSR	Primary Surveillance Radar
QoS	Quality of Service
RA	Resolution Advisory

RAD	RADar airspace
RAIM	Receiver Autonomous Integrity Monitoring
RAP	Recognised Air Picture
RCP	Required Communication Performance
RF	Radius to Fix
RMT	RuleMaking Task
RNAV	aRea NAVigation
RNP	Required Navigation Performance
RPA	Remotely Piloted Aircraft
RPAS	Remotely Piloted Aircraft Systems
RSP	Required Surveillance Performance
RTA	Required Time of Arrival
RTCA	Radio Technical Commission for Aeronautics
RTS	Real Time simulation
SARPS	Standard and Recommended Practices
SATCOM	Satellite Communications
SBAS	Satellite Based Augmentation System
SBB	Swift BroadBand
SDDS	Surveillance Data Distribution System
SDPDS	Surveillance Data Processing and Distribution System
SDR	Software-Defined Radio
SES	Single European Sky
SESAR	Single European Sky ATM Research Programme
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SI	Surveillance Identifier

SID	Standard Instrument Departure
SJU	SESAR Joint Undertaking
SJU Work Programme	The programme which addresses all activities of the SESAR Joint Undertaking Agency
SMR	Surface Movement Radar
SMT	Simple Message Text
SMTP	Simple Mail Transfer Protocol
SOA	Service Oriented Architecture
SoS	System of Systems
SPI	Surveillance Performance and Interoperability requirements
SPR	Safety, Performance Requirements
SSR	Secondary Surveillance Radar
STAM	Short Term ATFCM Measures
STANAG	STANdarization Agreement
STAR	Standard Terminal Arrival Procedure
STATFOR	STATistics and FORecasts
STCA	Short Term Conflict Alert
STDMA	Self-organising Time Division Multiple Access
SURF	situational awareness on the SURFace
SV	Satellite Vehicle
SWIM	System Wide Information Management
TACAN	TACtical Air Navigation system
TAD	Technical Architecture Description
TAS	True Air Speed
TCAS	Traffic alert and Collision Avoidance System
TCP	Transmission Control Protocol

TDMA	Time Division Multiple Access
TDOA	Time Difference Of Arrival
TIS-B	Traffic Information Services-Broadcast
TMA	Terminal Manoeuvring Area
TRL	Technology Readiness Level
TS	Technical Specification
TSO	Technical Standard Order
TTA	Target Time Arrival
TTO	Target Time Over
Tx	Transmitter
UAS	Unmanned Aircraft Systems
UAT	Universal Access Transceiver
UAV	Unmanned Aerial Vehicle
UDP	User Datagram Protocol
UTC	Coordinated Universal Time
UUP	Updated airspace Use Plans
VDB	VHF Data Broadcast
VDL	VHF Data Link
VDL2	VDL Mode 2
VNAV	Vertical NAVigation
VoIP	Voice over IP
VOR	VHF Omnidirectional Radio Range
VORTAC	VOR+TACAN
VPN	Virtual Private Network
VSA	Visual Separation on Approach

VSATS	Very Small Aperture Terminal
WAIC	Wireless Avionics Intra-Communications
WAM	Wide Area Multilateration
WAN	Wide Area Network
WOC	Wing Operations Centre

Table 18: Acronyms and Terminology

Additional Material

B.1 Final Project maturity self-assessment

PJ14-01-01 CNS Environment Evolution

No maturity Assessment was planned for PJ14-01-01 CNS Environment Evolution since it is a transversal solution, aiming at providing technical studies in support to the development and future implementation of an integrated CNS environment..

B.1.1 Communication Domain

PJ14-02-01 Future Communication Infrastructure (FCI) Terrestrial Data Link

A maturity assessment of the PJ14.02.01 Technological solution has been provided in STELLAR, based on SESAR Maturity criteria, after the Technical Validations for CTE-C02g — Air to Air functionality of New A/G radios.

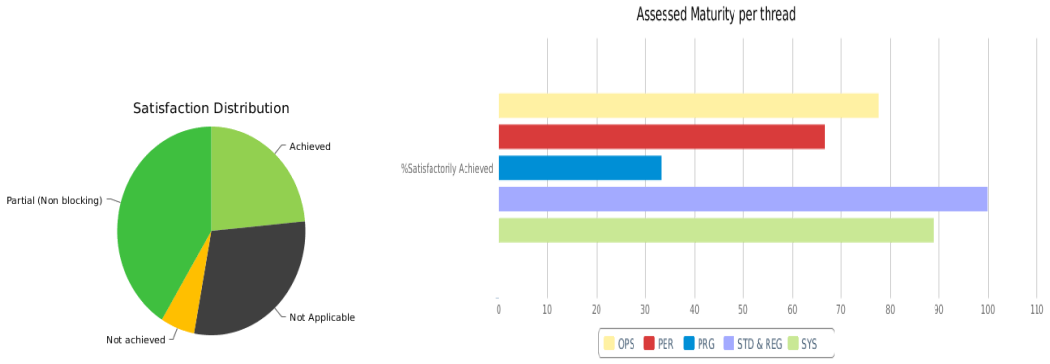

Figure 9 PJ14-02-01 Future Communication Infrastructure (FCI) Terrestrial Data Link TRL2 Self-Maturity Assessment

A maturity assessment of the PJ14.02.01 Technological solution has been provided in STELLAR, based on SESAR Maturity criteria, after the Technical Validations for CTE-C02e — New A/G datalink using ATN/IPS over L-band.

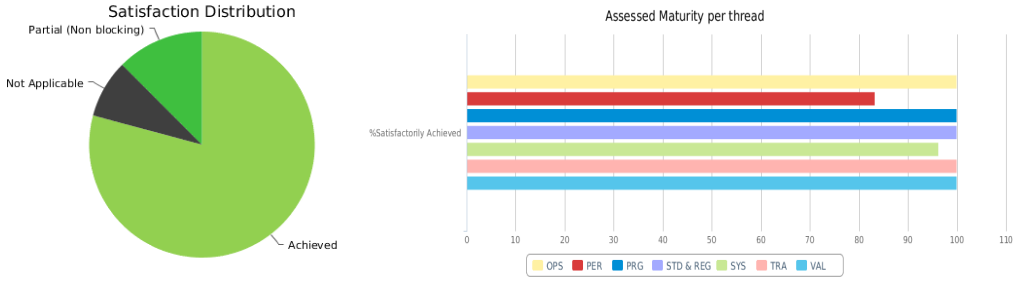

Figure 10 PJ14-02-01 Future Communication Infrastructure (FCI) Terrestrial Data Link TRL4 Self-Maturity Assessment

PJ14-02-02 Future Satellite Communications data link

This content will be provided once the maturity assessments for SATCOM Class B and Class A are consolidated

Figure 1110 PJ14-02-02 Future Satellite Communications data link TRL4 Self-Maturity Assessment

PJ14-02-04 FCI Network Technologies

The results of the self-maturity assessment (reviewed by the SJU during the Maturity Gate) are:

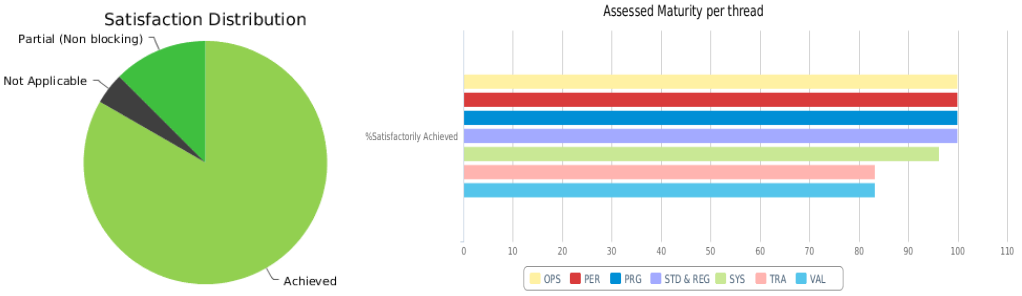

Figure 1211 PJ14-02-04 FCI Network Technologies TRL4 Self-Maturity Assessment

PJ14-02-05 Development of new services similar to FIS-B to support ADS-B solutions for general Aviation.

The results of the self-maturity assessment (reviewed by the SJU during the Maturity Gate) are:

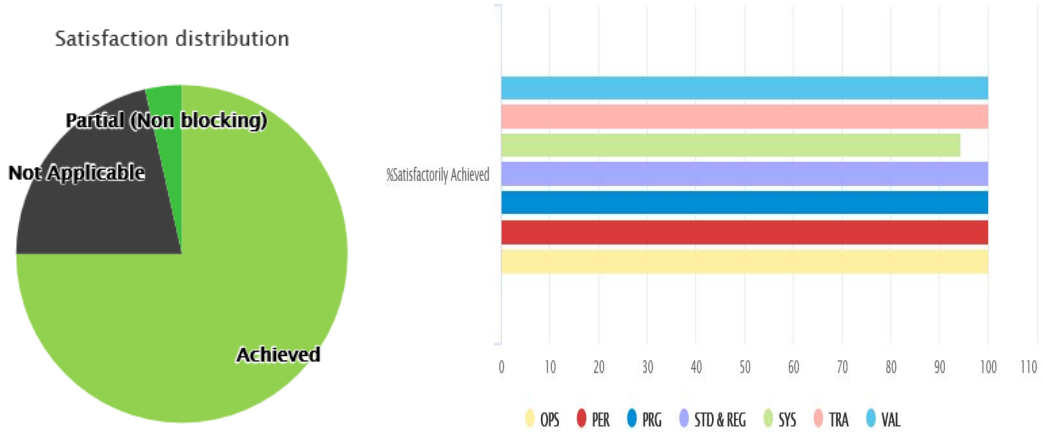

Figure 13~~12~~ PJ14-02-05 Development of new services similar to FIS-B to support ADS-B solutions for general Aviation V2 Self-Maturity Assessment

PJ14-02-06 Completion of AeroMACS Development

The results of the self-maturity assessment (reviewed by the SJU during the Maturity Gate) are:

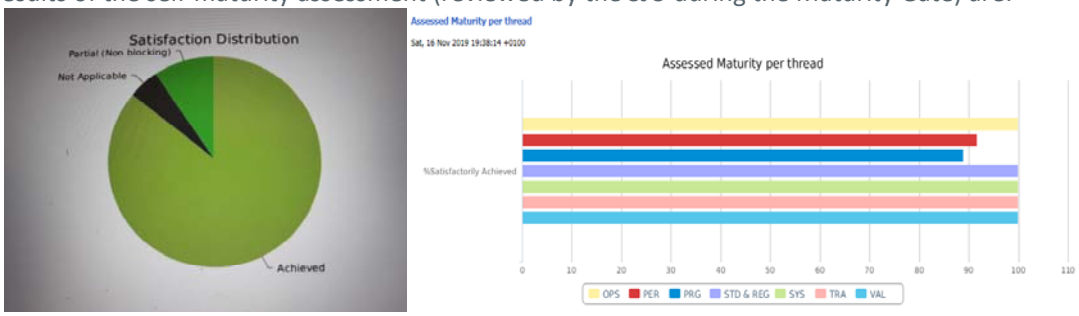

Figure 14~~12~~ PJ14-02-06 Completion of AeroMACS Development TRLS6 Self-Maturity Assessment

B.1.2 Navigation Domain

PJ14-03-01 GBAS

The solution has addressed three maturity gates and the results obtained below.

The results of the self-maturity assessment for GAST D ESV (reviewed by the SJU during the Maturity Gate) are:

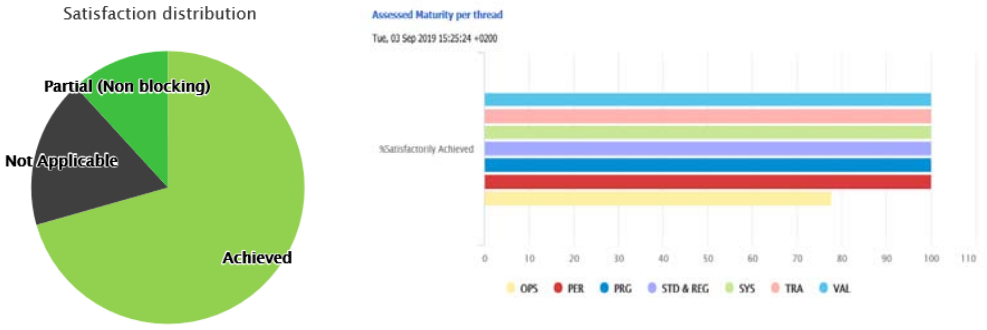

Figure 15~~13~~ PJ14-03-01 GBAS: GAST D ESV TRL2 Self-Maturity Assessment

The results of the self-maturity assessment for GAST F (DFMC GBAS) are:

Figure 16~~13~~ PJ14-03-01 GBAS: GAST F TRL4 Self-Maturity Assessment

The results of the self-maturity assessment for No MMR Architecture are:

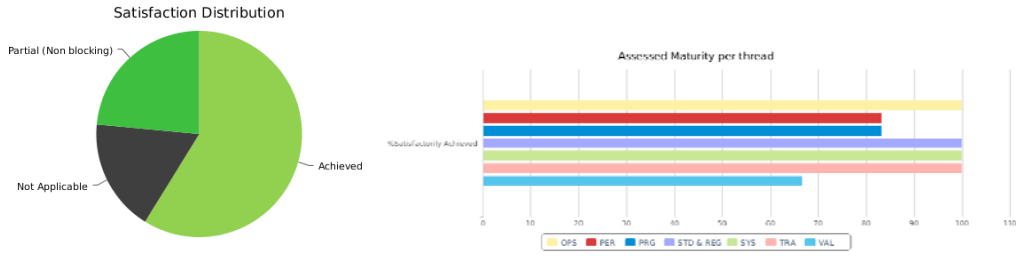

Figure 17~~13~~ PJ14-03-01 GBAS No MMR Architecture TRL2 Self-Maturity Assessment

The results of the self-maturity assessment for GAST D Extended Scope are:

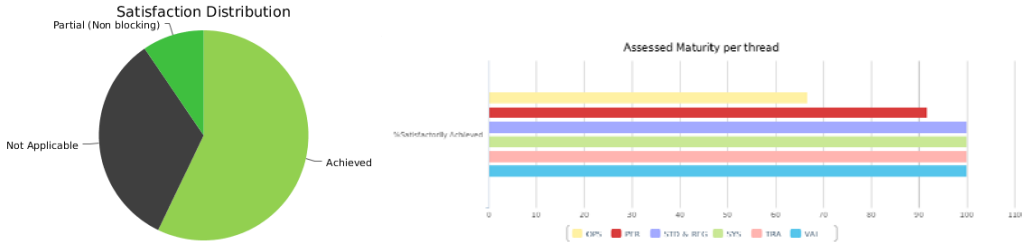

Figure 18~~13~~ PJ14-03-01 GBAS: GAST D Extendedn Scope TRL2 Self-Maturity Assessment

PJ14-03-02 Multi Constellation / Multi Frequency (MC/MF) GNSS

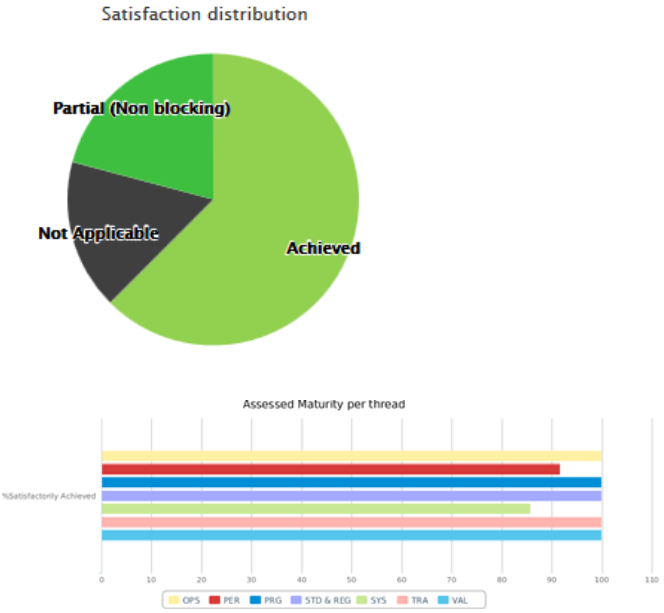

Figure 19~~14~~ PJ14-03-02 Multi Constellation / Multi Frequency (MC/MF) GNSS TRL4 Self-Maturity Assessment

PJ14-03-04 Alternative Position, Navigation and Timing (A-PNT)

The solution has addressed three maturity gates and the results obtained below.

The results of the self-maturity assessment for Long Term A-PNT (reviewed by the SJU during the Maturity Gate) are:

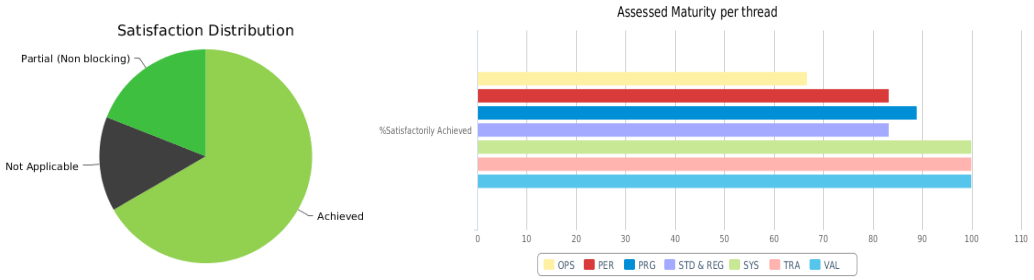

Figure 2015 PJ14-03-04 Alternative Position, Navigation and Timing (A-PNT) TRL2 Self-Maturity Assessment

The results of the self-maturity assessment for Mid Term A-PNT (reviewed by the SJU during the Maturity Gate) are:

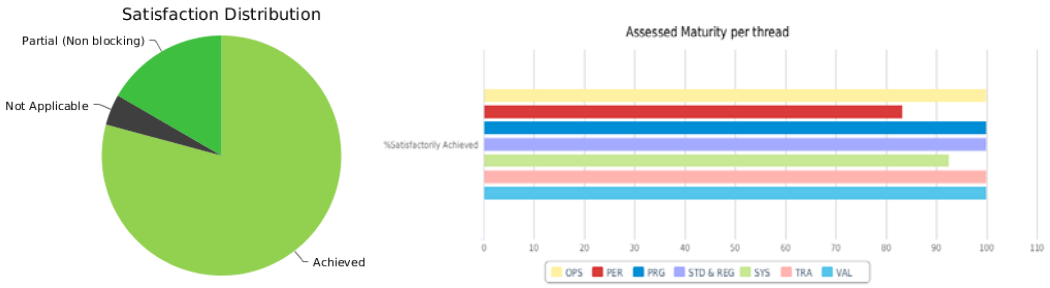

Figure 2116 PJ14-03-04 Alternative Position, Navigation and Timing (A-PNT) TRL24 Self-Maturity Assessment

The results of the self-maturity assessment for Short Term A-PNT (reviewed by the SJU during the Maturity Gate) are:

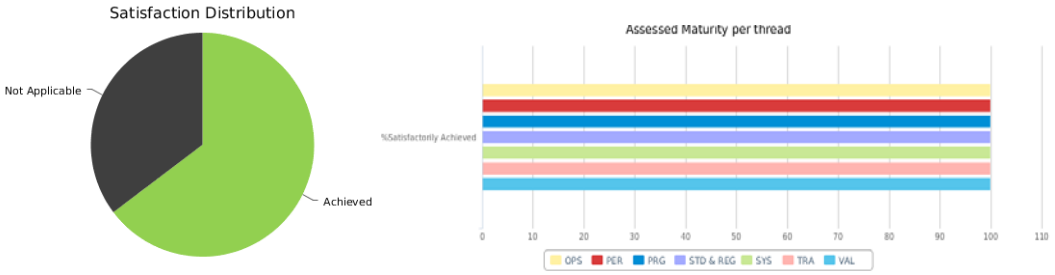

Figure 2217 PJ14-03-04 Alternative Position, Navigation and Timing (A-PNT) TRL6 Self-Maturity Assessment

B.1.3 Surveillance Domain

PJ14-04-01 Surveillance Performance Monitoring

The results of the self-maturity assessment (reviewed by the SJU during the Maturity Gate) are:

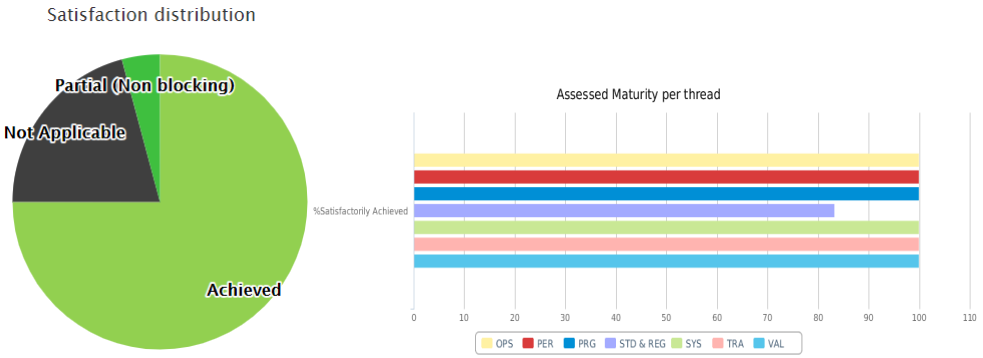

Figure 2318 PJ14-04-01 SPM Tools for Cooperative Sensors TRL4 Self-Maturity Assessment

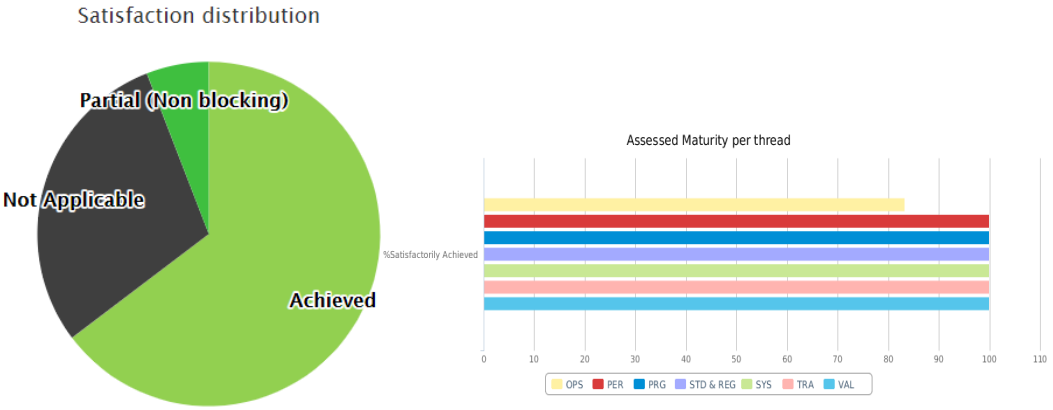

Figure 2419 PJ14-04-01 SPM Tools for Non-Cooperative Sensors TRL2 Self-Maturity Assessment

PJ14-04-03 New use and evolution of Cooperative and Non-Cooperative Surveillance

The results of the self-maturity assessment (reviewed by the SJU during the Maturity Gate) are:

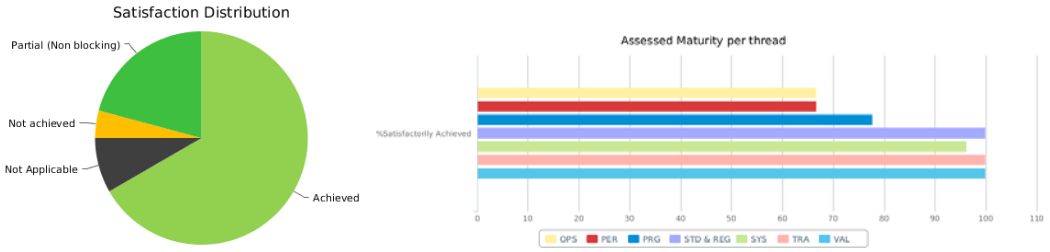

Figure 2520 PJ14-04-03 New use and evolution of Cooperative and Non-Cooperative Surveillance TRL4 Self-Maturity Assessment


LEONARDO
FREQUENTIS
SESAR
PARTNERS
COMPANS
REAL COOPERATION, REAL RESULTS
Honeywell
THALES
ENAIRE
NATS
EUROCONTROL
dgac
DSNA
DFS Deutsche Flugsicherung
DASSAULT
AVIATION
B4
CONSORTIUM
AT-One
indra
AIRBUS
NATMIG
AIRTEL ATN