**SESAR Solution PJ14-02.06**

**AeroMACS integrated with ATN, Digital Voice and Multilink**

***Contextual note – SESAR Solution description form for deployment planning***

# Purpose

*This contextual note introduces the SESAR Solution PJ14-02-06 that addresses the Air to Ground communications on the Airport Surface. This capability is captured by Enabler "CTE-C02d - New Airport Datalink technology (AEROMACS)". This enabler shall achieve Technical Readiness Level TRL6. Maturity Gate will take place in November 2019 as foreseen in the H2020 Grant Agreement n°734168.*

*This contextual note also provides to any interested reader (both external and internal to the SESAR Programme) an introduction to the concerned SESAR Solution in terms of its scope, main operational and expected performance benefits and relevant system impacts. Furthermore, it addresses the technical validation of the integration of AeroMACS technological solution (system enabler) with ATN/OSI and ATN/IPS Systems, in Multilink environment, and with Digital Voice Systems. This is done in laboratory tests, involving AeroMACS, ATN and VoIP products. The complete system is validated with ATN B1/B2 applications and fulfilling the essential operational Use Cases.*

*This contextual note complements the technical TRL6 data pack comprising the SESAR deliverables required for further industrialization/deployment.*

# Improvements in Air Traffic Management (ATM)

Air Traffic Management (ATM) communications capacity is reaching saturation in Europe and the United States, because of the increasing air-traffic volumes and density. The problem is most severe on the airport surface where the large concentration of aircraft is combined with pre-flight and post-flights operations increasingly relying on the data communications capacity.

The SESAR Solution PJ14.02.06 (“AeroMACS integrated with ATN, Digital Voice and Multilink”) builds upon Solution #102 (AeroMACS) published in the SESAR 1 catalogue.

Both Solutions #102 and PJ14.02.06 respond to a specific demand agreed by ICAO in 2008 following the ICAO Air Navigation Conference 2003 and ICAO Future Communication Study (Action Plan 17). AeroMACS is part of the Future Communication Infrastructure supporting the Airport Surface Component and is reflected within the ICAO Global Air Navigation Plan (GANP) and the ICAO Communication Roadmap in the GANP.

The SESAR Solution PJ14.02.06 answers the need to finalize the development of AeroMACS Datalink started in SESAR1, technically validating the integration of AeroMACS Access Network with ATN/OSI and ATN/IPS Networks, in Multilink environment, and with Digital Voice Systems (activities left pending in SESAR1 Solution #102 activities).

AeroMACS provides a mature and validated option to support the future ANSP, Airline and Airport Authority datalink communication exchanges in the airport environment between mobile and fixed users. It provides worldwide interoperability and integration of critical communications.

The solution addresses air-ground data communications at airports, which will otherwise continue to experience crowding and ultimately saturation as air traffic grows. In particular AeroMACS can offload the saturated VHF datalink communications in the airport environment, as identified in the recommendations of the EASA Data Link report (2014), as well as enable the future concepts considered in SESAR.

The AeroMACS system will enable:

* high capacity information exchanges, thanks to higher throughput in airport surface communications;
* worldwide interoperability and integration of critical coms for ANSPs, Airspace Users and Airports;
* advanced security capabilities and increased safety levels;
* advanced surface Communication Navigation Surveillance (CNS) systems, leading to more efficient airport surface operations.
* support enhanced communications and information distribution at lower costs (considering synergies of sharing infrastructure among various stakeolders);

AeroMACS is based on IEEE 802.16-2009 (WiMAX) standard, operates in reserved aeronautical frequency band and is customised for Air Navigation Service Providers (ANSP), Airline Operations Centre (AOC) and Airport Authority communications, in compliance with the SESAR Future Communication Infrastructure (FCI) Multilink requirements. AeroMACS is an international standard and supports globally harmonised and available capabilities according to ICAO GANP and European ATM Master Plan.

# Operational Improvement Steps (OIs) & Enablers

**OI Steps under the scope of the SESAR Solution**

* POI-0029-COM -\_ATM High Performance Airport Datalink

The implementation of AeroMACS will provide Air/Ground datalink capabilities supporting ATC and AOC as well as voice services on airport surface, based on ATN/OSI and/or ATN/IPS networks, either in stand-alone or Multilink environments. The implementation of AeroMACS will provide high capacity datalink capabilities meeting ATS-B2 (and beyond, B3) performance requirements (latency, availability, continuity and integrity) and secure communication.

The coverage of the OI step by the SESAR Solution is full.

**Enablers supporting the SESAR Solution**

* CTE-C02d - New Airport Datalink technology (AEROMACS)

New wireless technology for the Airport Datalink AEROMACS over ATN/OSI and ATN/IPS, based on IEEE 802.16 WiMax, as a new standard for airport surface communications (ATS, AOC and Airport Authority Communications) for the Aircraft and Vehicles.

Applicable Integrated Roadmap Dataset is DS19.

It has to be noted that two Change Requests have been submitted, on PJ19/SJU request, in order to:

* create an Avionic Enabler for AeroMACS, with the following Title/Description:
  + Title: “Avionic Technology for the new Airport Data Link (AEROMACS) integrated with ATN/OSI and ATN/IPS”
  + Description: “Avionic Technology for the new Airport Datalink (AEROMACS), based on IEEE 802.16 WiMax and supporting datalink exchanges over ATN/OSI and over ATN/IPS, both in standalone or multi-link environments. AeroMACS also supports the use of Digital Voice.”
* update CTE-C02d Enabler Title and Description as follows:
  + New CTE-C02d Title: “Ground Technology for the new Airport Datalink (AEROMACS) integrated with ATN/OSI and ATN/IPS”
  + New CTE-C02d Description: “Ground Technology for the new Airport wireless Datalink (AEROMACS), based on IEEE 802.16 WiMax and integrated with ATN/OSI and ATN/IPS, both in standalone or multi-link environments, as a new standard for airport surface communications (ATS, AOC and Airport Authority Communications) for the Aircraft and Vehicles. AeroMACS also supports the use of Digital Voice.”

In addition, it is to be specified that the initial Solution title was “Completion of AeroMACS Development”, but PJ14-02-06 and SJU agreed on its update, in order to better describe the activities executed by the Solution. For this reason a Change Request was submitted to update PJ14-2-6 Solution Title and Description. The Change Request has been discussed with positive feedback from SJU:

* New PJ14-2-6 Title: “AeroMACs integrated with ATN, Digital Voice and Multilink”
* New PJ14-2-6 Description: “The solution consists of the integration of AeroMACs with ATN systems, in both ATN/OSI and ATN/IPS options, with (VoIP) digital voice communication and multilink in ATN/OSI environment (beyond solution #102 in SESAR 1).”

**Pre-requisite SESAR Solution(s), OI steps and enablers that are assumed for this SESAR Solution.**

The SESAR Solution PJ14.02.06 builds upon Solution #102 (AeroMACS) published in the SESAR 1 catalogue. AeroMACS Solution #102 reached TRL6 Maturity Level as Data Link in 2014, however in SESAR1 no technical validation was done on integration of AeroMACS with ATN/OSI, ATN/IPS and Multilink. This was the main scope of PJ14-02-06 Solution.

In order to better differentiate Solution #102 (SESAR1) from Solution PJ14-02-06 (SESAR2020), a new Enabler CTE-C02d0 linked with Solution #102, and different from CTE-C02d, was created.

CTE-C02d0 description: New wireless technology for the Airport Datalink AEROMACS, based on IEEE 802.16 WiMax, as a new standard for airport surface communications (ATS, AOC and APOC) for the Aircraft and Vehicles.

Enabler CTE-C02d0 is linked to CNS-0001-B OI Step.

# Background and validation process

Main focus of the work carried-out in this solution PJ14-02-06 was to integrate the AeroMACS Datalink defined in SESAR1 by Solution#102 with the Systems listed below, and to technically validate the integration through execution of specific exercises:

* ATN/OSI
* ATN/IPS
* Multilink in ATN/OSI environment
* Digital Voice
* Multilink in ATN/IPS environment (in this case exercises were performed by PJ14-02-04 Solution with AeroMACS devices developed by PJ14-02-06 Solution)

In order to reach these objectives, technical requirements to be implemented were described in Initial TS/IRS Deliverable; subsequently, a Technical Validation Plan (TVALP) and Availability Note (AN) were produced to describe the Technical Validation Platforms implemented in Leonardo Laboratories.

After the successful execution of Exercises, a Technical Validation Report (TVALR) was delivered describing the results, and a Final TS/IRS was released, containing the consolidation of requirements at the end of the Solution activity.

# Results and performance achievements

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

The Platforms implemented in Leonardo Laboratories were composed of AeroMACS, ATN and VoIP products, connected, when necessary, to ATN B1/B2 Tools implementing the complete set of CM/CPDLC and ADS-C messages.

For all the Exercises, realistic operational scenarios were reproduced in the Validation Platforms. Proper behaviour of the different devices under test was verified, demonstrating feasibility of all the integrations, in all the operational scenarios reproduced. Measured performance figures demonstrated compliance with performance requirements indicated by the relevant EUROCAE Standards: in case of ATN exercises, Transactions Times measured during the B1/B2 exchanges between Pilot and Controller were orders of magnitude lower than the performance figures required by the relevant EUROCAE Standards; in case of VoIP over AeroMACS, jitter and Packet Error Rate were compliant with performance requirements indicated by the relevant EUROCAE Standard.

The following potential benefits have been identified, for the various stakeholders:

* Airlines and airspace users
  + AeroMACS provides better support to ATN/AOC data traffic with its large bandwidth and high throughput. The large bandwidth coupled with QoS management and data prioritization capability enables AeroMACS to reliably transfer large amount of essential operational data, also providing a high level of flexibility in case of different users needs.
  + AeroMACS can easily support the increasing level of automation expected for ATM services on the airport surface, offering good business opportunities to Airlines/AUs.
  + Security features offered by AeroMACS can offer a valid protection against intentional attacks, resulting highly beneficial also in terms of Safety.
* Air Navigation Service Providers
  + AeroMACS provides the capacity needed with a guaranteed quality of service on a secured communication link that can facilitate and enable the implementation of emerging services like ATS/B2-CM/CPDLC and secure ADS-C (Automatic Dependent Surveillance – Contract). AeroMACS is also expected to serve the emerging ATS/B3 services.
  + AeroMACS provides ATS service at airports at parking/apron areas and during taxiing, before take-off and after landing.
  + Measured performance figures demonstrated compliance with ATN B2 performance requirements indicated by the relevant EUROCAE Standard, with great margin.
* Communication Service Providers
  + AeroMACS provides AOC service at airports at parking/apron areas and during taxiing, before take-off and after landing.
  + CSP networks can transport A/G data communications supporting the increasing level of automation expected for ATM services at the airport surface.
* Airport Authorities:
  + AeroMACS System can be used for a high number of heterogeneous applications, hence not only to serve ANSPs/CSPs or Airspace Users, but also emergency airport services, gate, luggage, airport service vehicles, etc, also for fixed services like videosurveillance or replacement of physical cables, in order to support any kind of other services on the airport surface (e.g. multilateration).
  + For the reason stated above, AeroMACS can highly reduce overall costs (via synergies of sharing infrastructure)

# Recommendations and Additional activities

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.

# Actors impacted by the SESAR Solution

Actors impacted by the AeroMACS Solution are the following:

* Airspace Users and Airlines
* ANSPs
* CSPs
* Airport Authorities

# Impact on Aircraft System

This is a new Technological Solution, so AeroMACS System needs to be installed onboard; A/C ATN System might need to be upgraded to ATN/IPS according to the CNS Roadmap for FCI Multi-link implementation.

# Impact on Ground Systems

This is a new Technological Solution, so AeroMACS System needs to be installed at Ground; Ground ATN System might need to be upgraded to ATN/IPS according to the CNS Roadmap for FCI Multi-link implementation.

# Regulatory Framework Considerations

* Single European Sky Interoperability Regulation 552/2004
* EASA Regulation 2018/1139
* Need to develop an AeroMACS Community Specification for compliance with the Essential Requirements for ATM/ANS and air traffic controllers, contained in the EASA Basic Regulation (EU) 2018/1139, following EC Mandate M/524. This Task is ongoing in ETSI TGAERO.

Need to develop an Harmonized European Norm (EN) for AeroMACS covering the essential requirements of article 3.2 of the Radio Equipment Directive (RED).

# Standardization Framework Considerations

The following set of Standards is available for AeroMACS:

ICAO:

* AeroMACS SARPS
* AeroMACS Technical Manual DOC 10044

EUROCAE / RTCA:

* ED-222/DO-345, Aeronautical Mobile Airport Communications System (AeroMACS) Profile
* EUROCAE/RTCA ED-223/DO-346, Minimum Operational Performance Standards (MOPS) for the Aeronautical Mobile Airport Communication System (AeroMACS)

EUROCAE:

* EUROCAE ED-227, Minimum Aviation System Performance Standards (MASPS) for the Aeronautical Mobile Airport Communication System (AeroMACS)

ARINC AEEC:

* Form Fit and Function (FFF) avionics AeroMACS standard

# Considerations of Regulatory Oversight and Certification Activities

The WiMAX Forum is currently leading the AeroMACS Certification, thanks to the development of the following material:

* AeroMACS PICS
* AeroMACS CRSL
* AeroMACS PKI Certificate Policy
* AeroMACS Radio Conformance Test (RCT)
* AeroMACS Protocol Conformance Tests (PCT)

Coordination should be put in place with EASA.

# Solution Data pack

The TRL6 data package for the SESAR Solution PJ14-02-06 includes the following documents:

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| --- | --- | --- | --- |
| **Deliverable** | **Code** | **Edition** | **Delivery** |
| Final TS/IRS | D7.3.010 | 01.00.02 | 06 November 2019 |
| Technical Validation Report (TVALR) | D7.1.030 | 01.00.02 | 10 October 2019 |

In addition, the following SESAR1 Deliverables need to be considered, as they contain Security and Safety requirements validated in SESAR1 and still applicable to AeroMACS.

|  |  |  |  |
| --- | --- | --- | --- |
| **Deliverable** | **Code** | **Edition** | **Delivery** |
| AeroMACS Safety Analysis | D08.1 | 00.01.00 | 28 March 2014 |
| AeroMACS Security Analysis | D08.2 | 00.01.00 | 27 March 2014 |

Finally, the following SESAR1 Deliverable contains general guidelines on how to deploy AeroMACS at the airport surface

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| --- | --- | --- | --- |
| **Deliverable** | **Code** | **Edition** | **Delivery** |
| AeroMACS Deployment & Integration Analysis | D04 | 00.01.00 | 21 September 2012 |

# Intellectual Property Rights (foreground)

The foreground is owned by the SJU.