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## Authoring & Approval

### Authors of the document

Name/Beneficiary	Position/Title	Date
Antonio Strano / Leonardo	PJ.17-01 Solution leader	02/03/2020

### Reviewers internal to the project

Name/Beneficiary	Position/Title	Date
José Ángel Álvarez Quirós / Indra	PJ.17-01 Member	20/01/2020
Beatriz Sánchez López / ENAIRE	PJ.17-01 Member	20/01/2020
Jan Van Meenen / EUROCONTROL	PJ.17-01 Member	21/01/2020
Frederic Antonio / AI DS CYBER	PJ.17-01 Member	20/01/2020
Arman Daraei / AI DS CYBER	PJ.17-01 Member	20/01/2020

### Approved for submission to the SJU By - Representatives of beneficiaries involved in the project

Name/Beneficiary	Position/Title	Date
Antonio Strano / Leonardo	PJ.17-01 Solution leader	28/02/2020
Leonard Glaser-Opitz / LPS	PJ.17-01 Member	28/02/2020
Didier Lorigo / THALES Avionics SAS	PJ.17-01 Member	28/02/2020
Jean-Pierre Becker / EUROCONTROL	PJ.17-01 Member	28/02/2020
Rowan Stewart / AIRTEL	PJ.17-01 Member	02/03/2020
Stéphane Abbas / AIRBUS	PJ.17-01 Member	28/02/2020
Xavier Jourdain / THALES AIR SYS	PJ.17 PjC	28/02/2020
José Luis Santiago Navarro / Indra	PJ.17-01 Member	02/03/2020
Jesus Mario Garcia Cano / ENAIRE	PJ.17-01 Member	28/02/2020
Harald Milchrahm / FREQUENTIS	PJ.17-01 Member	28/02/2020
Flavie Pontailier / Honeywell SAS	PJ.17-01 Member	28/02/2020

### Rejected By - Representatives of beneficiaries involved in the project

Name/Beneficiary	Position/Title	Date
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# PJ.17-01

## SWIM-TI PURPLE PROFILE FOR AIR/GROUND ADVISORY INFORMATION SHARING

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### Abstract

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This TRL6 Contextual note provides to any interested reader (external and internal to the SESAR programme) an introduction to the SESAR Solution PJ.17-01 (SWIM-TI Purple Profile for Air/Ground Advisory Information Sharing) in terms of scope, main operational and performance benefits, relevant system impacts. Taking into account PJ.17-01 maturity level (TRL6), this context note contains as well additional activities to be conducted during the industrialization phase or as part of deployment. It introduces the technical data pack comprising the SESAR JU deliverables.

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# 1 Purpose

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This contextual note provides to any interested reader (external and internal to the SESAR programme) an introduction to the SESAR Solution PJ.17-01 (SWIM-TI Purple Profile for Air/Ground Advisory Information Sharing) in terms of scope, main operational and performance benefits, relevant system impacts. Taking into account PJ.17-01 maturity level (TRL6), this context note contains as well additional activities to be conducted during the industrialization phase or as part of deployment. It introduces the technical data pack comprising the SESAR JU deliverables proposed to support industrialization/deployment.



## 2 Improvements in Air Traffic Management (ATM)

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SESAR 2020 PJ.17-01 technological solution aims at designing and validating up to TRL6 the SWIM-TI Purple Profile (PP) for Air/Ground Advisory Information Sharing. This SWIM Profile consists of open standards based, reliable and secure SWIM technical infrastructure enabling the integration of the aircraft into the SWIM network, thus giving it access to air/ground SWIM services (e.g. uplink and downlink of meteorological and aeronautical information). The solution supports ATM operational improvements that depend on Air/Ground (A/G) information exchanges to enable a better situational awareness and collaborative decision making, with a focus on advisory information (supplemental information that is not necessary for and not directly interfering with the command and control of an aircraft).

Building on top of SESAR 1 Purple Profile (SESAR 1 P14.01.04 D44-006), the solution aims at validating the SWIM A/G infrastructure necessary to support ATM operational improvements based on non-safety-critical services (e.g. ED-151, and in particular reference scenarios described in the ED-151 §4.1). It will enable operational applications to uplink meteorological and aeronautical information using SWIM. It will also enable downlink (e.g. aircraft provided meteorological observations) of information using SWIM.

Ground-based systems, air traffic managers and flight crews will all benefit of this timely and open standards based bi-directional information exchange expected to contribute to increase predictability, flexibility and efficiency.

Flight crews may benefit of SWIM enabled uplink information exchange in improving common situational awareness between flight crews and ground operations, while promoting strategic/tactical planning and more informed decision making.

Ground-based systems and air traffic managers may benefit of SWIM enabled downlink information exchange in obtaining near real-time information about surrounding airspace conditions (e.g. atmospheric conditions).

The Purple Profile infrastructure is supposed to enable the provisioning and the consumption of Air/Ground SWIM services in any airspace and operational environment (Airport, En-route, etc.): the specific airspace and operational environment depend on the specific SWIM service.

The Purple Profile infrastructure is designed to provide a rich set of messaging QoS (e.g. durability, delivery guarantees, etc.) configurable according to the SWIM service level requirements.

In addition to messaging QoS, the Purple Profile provides also security functions including, but not limited to, authentication, authorization, integrity, message screening and overload protection. Also in this case, some details about security functions are configurable per-SWIM service.



### 3 Operational Improvement Steps (OIs) & Enablers

Table 1 provides the SESAR Enablers relevant for the Purple Profile together with coverage. Applicable Integrated Roadmap Dataset is DS19.

SESAR Solution ID and Title	Enabler ID (from EATMA)	ID (from EATMA)	Enabler Title (from EATMA)	Enabler coverage
PJ.17-01, Purple Profile For Air/Ground Advisory Information Sharing	SWIM-TI	SWIM-INFR-06b	Ground side SWIM technical infrastructure for Air-Ground Advisory Information Sharing	Fully
		SWIM-INFR-06c	Air side SWIM technical infrastructure for Air-Ground Advisory Information Sharing	Fully

**Table 1: SESAR Solution PJ.17-01 Enablers**

The technological solution supports the OI step POI-0017-IS: SWIM technical infrastructure for Air-Ground advisory information sharing.





## 4 Background and validation process

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The SESAR Solution covered maturity phases TRL4 and TRL6 and it has been validated through a series of activities based on laboratory test validation technique and involving validation platforms distributed across several European countries.

TRL4 activities were built on top of SESAR1 TRL2 results. In particular TRL4 design and specification activities aimed at harmonizing and improving baseline SESAR1 TRL2 in different areas including, but not limited to, architecture description completeness, security controls and QoS.

Main purpose for TRL4 technical validation activities was to validate and to properly assess the target Technical Specification mainly in terms of completeness and correctness (technical feasibility). Technical validation objectives have been grouped as follows:

- Technical Validation Objectives concerning the technical use cases.
- Technical Validation Objectives concerning the data link modes.
- Technical Validation Objectives concerning the security controls.
- Technical Validation Objectives concerning the NFRs.
- Technical validation objectives linked to technical architecture deployment options.

Technical feasibility of the key elements concerning technical architecture, messaging capabilities, information exchange level security controls and interface requirements has been successfully validated at solution level. Medium level of confidence in the validation results concerning some security controls (e.g. monitoring) and NFRs indicates the needs to further refine these aspects during next maturity phase.

Taking into account TRL4 results and recommendations, TRL6 validation activities were characterized as follows:

- Technical metrics including performance (time behaviour, capacity), reliability (e.g. fault tolerance, delivery guarantees) and security (e.g. authorization, end to end message integrity, etc.).
- Technical interoperability metrics evaluated in exercises involving Purple Profile infrastructure, services and applications from different industry members.
- Integration of the Purple Profile with Future communication infrastructure multilink prototypes (e.g. AeroMACS, SATCOM).

TRL6 Technical specification was successfully validated by 4 exercises (TRL6 TVALP), validation results consolidated in the TRL6 TVALR and, finally, the TS updated accordingly.



## 5 Results and performance achievements

The solution has delivered a number of key achievements, of which the following are considered most important:

- **Purple Profile architecture viewpoints:** A structured Purple Profile for A/G Advisory Information Sharing has been provided by defining (design and requirements) functional, technical, deployment, and EATMA viewpoints.

Among other aspects, it is considered important to mention avionics considerations provided in the technical and deployment viewpoints. Avionics architectural considerations in the technical viewpoint address avionics specificities and provide the technical aspects governing avionics architectural choices. In the deployment viewpoint, avionics installation options (minimum impact to certified avionics' equipment) are described targeting minor avionics impacts and assuming EFB level2 installation compliance.

Functional and technical viewpoints definitions cover non-functional requirements concerning reliability (e.g. delivery guarantees), performance (e.g. capacity, time-behaviour) and security (e.g. authentication, authorization, integrity, audit, overload protection).

The Purple Profile infrastructure has been designed to provide rich set of messaging QoS (e.g. durability, delivery guarantees, etc.) and security controls that are configurable according to the SWIM service level requirements.

- **Validation activities:** Purple Profile Technical Specification has been validated by 3 exercises in TRL4 and 4 exercises in TRL6. 88% of requirements (315) have been fully covered, 6% (20) have been partially covered and 6% (23) have not been implemented. Technical validation activities results validated the completeness and correctness (technical feasibility) of the Purple Profile. Validation activities also demonstrated the configurability and flexibility of the Purple Profile that allow to configure capabilities (e.g. delivery guarantees, message screening, authorization, etc.) according to SWIM service level requirements.

Performance efficiency validation objectives (time behaviour, ordering guarantees, on-the-fly compression) have been validated reporting only partial results for time behaviour objectives.

Reliability efficiency validation objectives (delivery guarantees) have been successfully validated. End-to-end at-most-once (message loss), at-least-Once (message duplication), and exactly-once (message duplicates detection) delivery guarantees QoSs for both uplink and downlink request/response and publish/subscribe Purple Profile enabled SWIM services have been validated by injecting events like transient connection establishment failure, abnormal disconnection due to transient network error and abnormal disconnection event due to ground peer restart occurs. The delivery guarantees QoSs have been successfully validated also in deployment scenarios involving PJ.14-02-04 multilink A/G network prototypes.

For what concerns security characteristic validation objectives, almost all the security controls related to message screening, overload protection, point to point mutual



authentication and certificate revocation status check, point to point authorization, and end to end integrity, authenticity and encryption have been validated.

- **Performance Framework KPAs (Key Performance Areas) assessment:** No validation targets were allocated to PJ.17-01 and no ATM solutions involved the solution in a coordinated KPAs assessment. Although a more complete assessment should be done in coordination with both technological solutions dealing with SWIM services and concerned ATM solutions, taking into account the SESAR 2020 performance framework, an impact assessment on KPAs (safety, security, capacity, global interoperability, etc.) was provided by the solution itself in the TRL6 TVALP. Based on the impact assessment only security and global interoperability KPAs have been addressed (direct impact) during technical validation activities.

The solution demonstrated that it contributes positively to the global interoperability by designing and validating in collaboration with EU members innovative and open standards based solution for the integration of the Aircraft into the SWIM “network”. The KPA was addressed by planning and executing validation exercises involving software prototypes (application/service, Air/Ground SWM infrastructure and Network layers) from different solution members.

For what concerns the security KPA, being a prioritized solution, security risk assessment activities defined in SecRAM 2.0 have been carried out. Design and validation activities carried out by this solution addressed more the “Implementation measures” focus area (refer to abovementioned security validation objectives). “Impact Measures” is not faced because it does not concern technical validation activities and it cannot be carried out in isolation by this solution. “Effectiveness Measures” (e.g. “Supply-chain Security aspects addressed”) concerns more industrialization phase.

- **High level Economic Appraisal:** In the TRL6 TVALR a high-level economic appraisal analysis is provided. It has been carried out by applying a bottom-up approach (technological solution), limiting the analysis to the enabling functions provided by the solution and recording assumptions and limitations. The high level economic appraisal analysis is based on reference scenarios defined in the ED-151 §4.1 and the solution scenario(s) consists in deploying the Purple Profile infrastructure and using it as enabler for consuming and providing uplink and downlink (Purple Profile enabled SWIM) AIS and MET services part of the reference scenarios/services. The “delta” introduced by this solution consists in using as “Data link infrastructure” (ED-151 §5) the Purple Profile infrastructure with recorded assumptions and limitations.
- **SESAR and FAA Air-Ground SWIM comparison:** In the final technical specification, a high-level comparison between SESAR (Purple Profile) and FAA (Aircraft Access to SWIM - AATs) Air-Ground SWIM is provided. The comparison is not expected to be exhaustive and complete: its purpose is to provide initial considerations that should be further assessed in a wide context from operational and technical perspectives. The comparison is provided from different perspectives: Operational, Technical, and Deployment.



## 6 Recommendations and Additional activities

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Following recommendations for the next maturity phase have been envisaged:

- Non-validated requirements (i.e. requirements still “in progress” and consolidated in the TRL6 TS Appendix G) should be addressed.
- Industrialization of Identity Management requirements covered by SWIM-SUPT-03a should be addressed.
- Modelling of infrastructure services by Technological Solutions in Wave 2 should be enhanced based on recommendation from PJ19.
- To discuss/refine at EU and/or ICAO level “SESAR and FAA Air-Ground SWIM comparison” developed by this solution.
- Performance (KPA, and technical measures like latency, TVALP §4.3.1) assessment should be done in a real-life technical and operational deployment (including deployment options illustrated in the deployment views in TS §4.2.3). Time-behaviour performance requirements should be refined and specified accordingly.
- Safety KPA should be addressed when identifying and designing Purple Profile enabled SWIM services. In particular:
  - it is expected from the operational solutions using Purple Profile enabled SWIM services to perform the adequate safety assessment and derive the necessary safety-related and/or performance-related (e.g. reliability/availability) requirements;
  - based on these requirements, the operational solutions are expected to choose the right Purple Profile interface binding option such as to respond to the QoS level that is adequate to the requirements.
  - Some of those safety-related or reliability/availability requirements (e.g. acceptable frequency of interruption) should be input to the standardization process.
- Security KPA (and risk assessment) should be completed by complementing what this solution defined with other aspects that were out of scope of this solution. In particular, the overall security management should be complete by addressing applicable but transferred security controls, additional supporting assets, and security related deployment and operational aspects out of scope of this technological solution.
- To complete the initial CBA putting together application/services, Purple Profile and communication networks.
- Taking into account performance and reliability results, the “single Ground SWIM Node” deployment option is not recommended. If mandated by specific deployment, multiple



replicas should be available. This may raise the needs/opportunities to design an AMQP based protocol to be used to synchronize federated Ground SWIM Nodes replicas.

- Consider real deployment, and address global interfaces to external systems, such as Network Operations Centre (NOC), Security Operations Centre (SOC), safety based recording, etc.
- A human factor analysis against a global operational use concept and an airworthiness evaluation of crew human performance impacts when operating over Purple Profile on-board is required.
- A stakeholder willing to deploy the Purple Profile for advisory A/G information sharing should consider an airworthiness evaluation as required by EASA AMC 20-25.



## 7 Actors impacted by the SESAR Solution

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The solution concerns all the roles and actors linked to the SWIM service to be provided/consumed over the Air/Ground SWIM infrastructure. The completeness and correctness of the list of impacted roles/actors depend on which services will be designed and operated over the Air/ground SWIM infrastructure.

However, as bottom-up activity, and in accordance with reference scenarios and services analysed in the high level economic appraisal, the following EATMA stakeholders (and related capabilities configuration) have been considered impacted by this solution:

- **ANSP** (Air Navigation Service Provider):
  - Civil AIS Service Provider (National AIM Capability Configuration).
  - Civil MET Service Provider (Aerodrome ATM-MET, Local Aerodrome ATM-MET, and ATM-MET Capabilities Configuration).
- **AU** (Airspace User):
  - Civil Flight Operations Centre (Civil Flight Operations Centre Capability Configuration).
  - Civil Scheduled Aviation (Civil Aircraft Capability Configuration).
- **AO** (Airport Operator):
  - Civil APT operator (Aerodrome ATM-MET Capability Configuration).
- **NM** (Network Manager):
  - Regional AIM Capability Configuration.



## 8 Impact on Aircraft System

The Air/Ground SWIM is a set of Aircraft and Ground functions that allow Aircraft SWIM Enabled applications to interact with Ground SWIM Enabled applications via provisioning and consumption of SWIM Services. At technical view level, the component that provides/realizes/deploys such functions is the SWIM Node that is further specialized as follow:

- The Ground Purple Profile SWIM Node covering ground side functions of the Air/Ground SWIM for advisory information sharing (SYS EN SWIM-INFR-06b).
- The Air Purple Profile SWIM Node covering aircraft side functions of the Air/Ground SWIM for advisory information sharing (SYS EN SWIM-INFR-06c).

Aircraft aiming at consuming or providing SWIM services are impacted by the architecture and requirements defined by this solution. Furthermore, this solution provides also deployment options concerning the integration of the Purple Profile capabilities with the avionics.

Avionics architectural considerations in the technical viewpoint address avionics specificities and provide the technical aspects governing avionics architectural choices. In the deployment viewpoint, avionics installation options (minimum impact to certified avionics' equipment) are described targeting minor avionics impacts and assuming EFB level2 installation compliance.

Limiting to the SWIM infrastructure layer without addressing application and network layers (out of scope of this solution), the impact on the aircraft system can be summarized as follows:

- The solution provides technical specification addressing also air side SWIM technical infrastructure for Air-Ground Advisory Information Sharing (Air Purple Profile SWIM Node).
- The Air Purple Profile SWIM Node is part of an on-board information system, and thus belongs to the Airline Information Service Domain (AISD). As consequences to this classification, integration of an Air Purple Profile SWIM Node with avionics systems must respect the data domains segregation, and thus already approved (e.g.: qualified) data interfaces between aircraft data domains.
- As the Air Purple Profile SWIM Node belongs to the Airline Information Service Domain (AISD), an insertion with minimum impact to certified avionics' equipment should be allocated to AISD avionics systems. Thus, integration targeting minor avionics impacts, should potentially be mapped onto the actual avionics systems:
  - **NSS:** ARINC 821 Network Server System, for Part 25 aircraft type supporting it, qualified against the aircraft's type certification. Core NSS equipment is the Network server unit (NSU) which can provide Air Purple Profile SWIM Node needed processing capability, memory, avionics interface with ACD, and with an IP Router.
  - **EFB:** ARINC 828 Electronic Flight Bag System (EFB) supporting a wide variety of aircraft type, providing that its installation is qualified against EASA AMC 20-25 "Airworthiness and operational consideration for Electronic Flight Bags (EFBs)". Core EFB equipment is based on a pair of EFBPU which can provide Air Purple Profile



SWIM Node needed processing capability, memory, along with an AID providing avionics interface with ACD and with an IP Router.

Assuming EFB level2 installation compliance (ADIF capable), there are several options for installing the Air Purple Profile SWIM Node on the EFB system: allocation to the EFBPU, allocation to the NSU, or allocation mixed between EFBPU and NSU.





## 9 Impact on Ground Systems

As introduced in §8, the Ground Purple Profile SWIM Node concerns ground side functions of the Air/Ground SWIM for advisory information sharing. The technical and deployment viewpoints (design and requirements) defined in this solution covers also the Ground Purple Profile SWIM Node.

In addition to the Ground Purple Profile SWIM Node, the Purple Profile introduces also changes concerning design and specification of so called “Purple Profile Enabled SWIM Services” and “Purple Profile Enabled SWIM Applications”. The Purple Profile introduces “Service bindings” (interface requirements) constraining (technical interoperability) the technical interface definition of SWIM services intended to be exposed and consumed over the Purple Profile.

For both Ground Purple Profile SWIM Node and Purple Profile Enabled SWIM Services/Applications, several technical and deployment options are addressed and each of them has different impact on the concerned ground systems.

The identification of the ground systems impacted by this solution is driven by the concerned EATMA stakeholders and further elaborated in the High-level Economic Appraisal. In particular the impacted ground systems are identified by mapping candidate Purple Profile Enabled SWIM services (AIS and MET services in ED-151) to stakeholder/capability configuration/technical system.

The reference scenarios assessed in the High-level Economic Appraisal concern following services:

- AIS Services:
  - Uplink of (D-)NOTAM (“Aeronautical Update Service” in ED-151).
- MET Services:
  - Uplink of MET information. Due to the scope of this solution (limited to enabling advisory information sharing) only following uplink MET services are applicable (selected in accordance with Pilot Decision Support classifications defined in ED-151 §7.1):
    - Weather planning decision services (WPDSs) and applicable MET products/information illustrated in ED-151 §7.4 and §7.5.
    - Weather near-term decision services (WNDSs) and applicable MET products/information illustrated in ED-151 §7.4 and §7.6.
  - Downlink of aircraft MET observations for improving weather forecast like (Aircraft Observation and Reports in ED-151 §7.4 and §7.9).

In accordance with the High-level Economic Appraisal, the impacted stakeholders/capability configurations are those already introduced in §7.



## 10 Regulatory Framework Considerations

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Following regulation considerations have been identified:

- Security management encompassing regulations and standards related to the use of PKI based solutions in security controls specified in this solution.
- Applicable avionics regulations (e.g. EASA AMC 20-25) and industrial report for avionics architecture supporting SESAR/NextGen concepts (e.g. ARINC 660B) should be updated/defined in accordance with Air/Ground SWIM activities.
- As for all the SWIM related activities proper (SWIM) governance has to be put in place.

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# 11 Standardization Framework Considerations

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Following standardisation needs have been identified:

- Purple Profile for advisory A/G information sharing should be standardized according to ICAO roadmap (ASBU B2-SWIM “Enabling Airborne Participation in Collaborative ATM through SWIM”), and industrialization and deployments phases.
- Although what is provided by the solution has been validated as technically feasible, in order to move in operation Purple Profile enabled SWIM services and infrastructure, different technical aspects should be standardized:
  - Purple Profile Enabled SWIM services. This encompasses identification and technical design (link to this solution) of SWIM services provided and consumed by the aircraft.
  - Security management encompassing standards related to the use of PKI based solutions in security controls specified in this solution.



## 12 Solution Data pack

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The Data pack for this Solution includes the following documents:

- PJ.17-01 SWIM TI Purple Profile for A/G Advisory Information Sharing - Technical Specification TRL6 (D2.2.615, Dissemination Level CO, edition 00.02.00, December 2019): This document provides architectural viewpoints description and requirements specification covering functional, non-functional and interface requirements concerning the Purple Profile technical systems (Ground Purple Profile and Air Purple Profile).
- PJ.17-01 SWIM TI Purple Profile for A/G Advisory Information Sharing - Technical Validation Report TRL6 (D2.2.640, Dissemination Level CO, edition 00.02.00, January 2020): This document provides the consolidated technical validation results from PJ.17-01 TRL6 prototyping and technical validation activities. Based on the analysis of the results and the conclusions, recommendation for next maturity phase, regulation and standardisation initiatives are provided.



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