



Solution PJ.17-01 scope, results and recommendation

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SESAR2020 W1 PJ.17 Open Day, 17th – 18th February 2020
Leonardo Rome, Italy



Founding Members

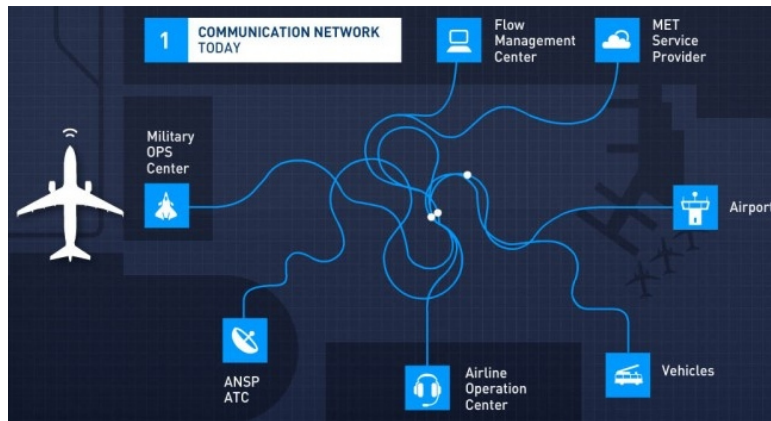


Outline (1h including Q&A)



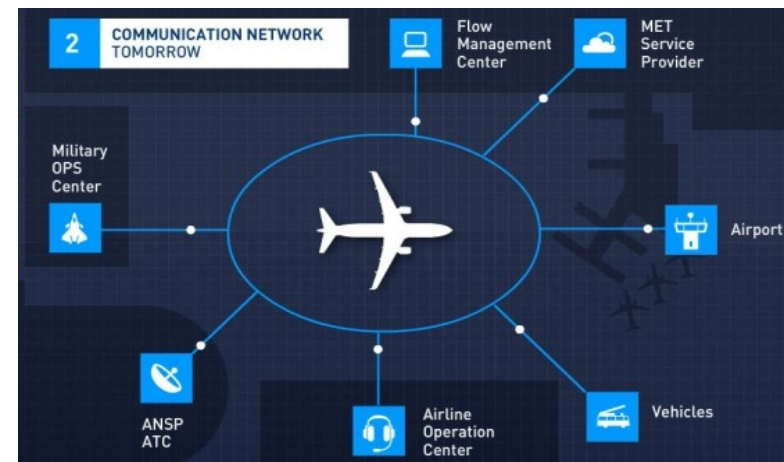
- Air/Ground SWIM advisory Information Sharing: Why & When & What
- SWIM-TI Purple Profile For Air/Ground Advisory Information Sharing design overview
- SWIM-TI Purple Profile For Air/Ground Advisory Information Sharing validation activities
- (additional slides) SWIM Benefits & characteristics

Air/Ground SWIM advisory Information Sharing: Why?



- The ICAO Global Air Navigation Plan (Doc 9750) introduces **ASBU B2-SWIM** “Enabling Airborne Participation in Collaborative ATM through SWIM” which considers the aircraft to be a fully connected information node in SWIM (taking into account overall SWIM benefits), enabling full participation in collaborative ATM processes with exchange of data, including meteorology.
- ICAO Doc 9750 plans to start with non-safety critical exchanges supported by commercial data links:
 - Non-safety critical (or advisory) information is defined as supplemental information that is not necessary for command and control of an aircraft.

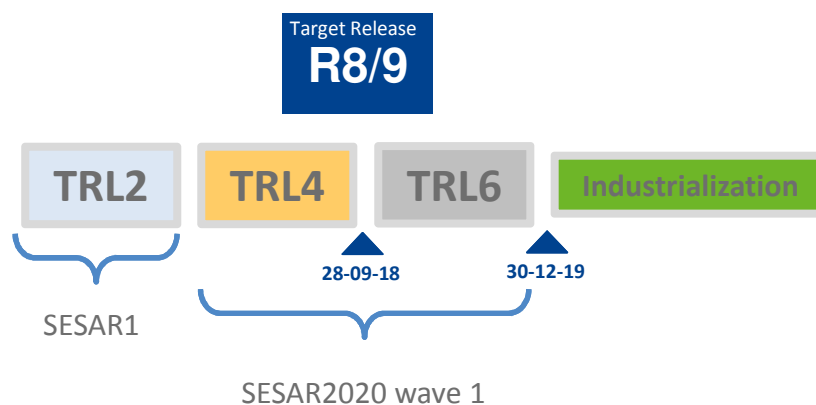
- Ground-based systems, air traffic managers and flight crews will all benefit of this timely **bi-directional** information exchange expected to contribute to increase predictability, flexibility and efficiency.
- Flight crews may benefit of **SWIM enabled uplink** information exchange in improving 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).



Air/Ground SWIM advisory Information Sharing: When?



PJ.17-01 TRLs and target releases:



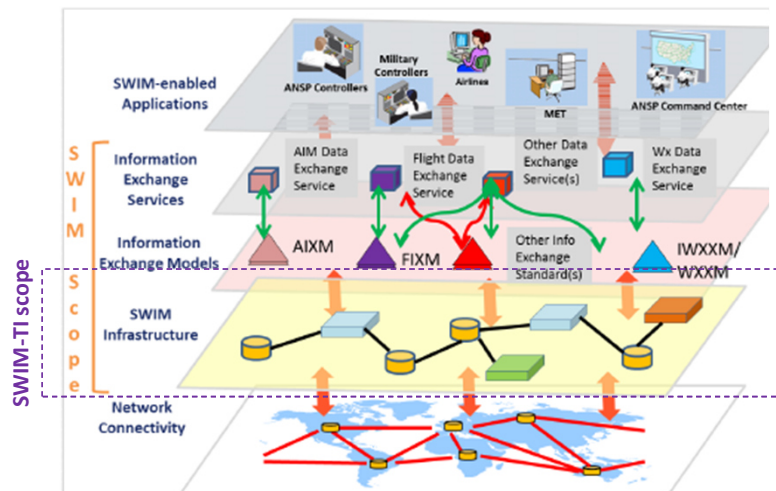
Operational Improvement Steps:

- (current) Benefits start date (IOC): 31/12/2027
- (current) Full benefit date (FOC): 31/12/2033

Air/Ground SWIM advisory Information Sharing: What?



- (ICAO Doc 10039) *SWIM (System Wide Information Management)* consists of standards, infrastructure and governance enabling the management of ATM information and its exchange between qualified parties via interoperable services.
- A service can be described using various perspectives or aspects including business aspect, operational aspect (e.g. what the service is about) and the solution aspect.



- PJ.17-01 contributes to the solution aspect of the Air/Ground SWIM service design (or *SWIM-enabled services*) and in particular to the technical interoperability.
- PJ.17-01 explored a standard based, reliable and secure Air/Ground SWIM infrastructure solution building on top of results from SESAR 1. The solution aims at supporting 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.
- Concrete examples of uplink and downlink information exchange are described in the *EUROCAE ED-151 - Operational Services and Environment Definition (OSED) for Aeronautical Information Services (AIS) and Meteorological (MET) Data Link Services*.

SWIM-TI Purple Profile For Air/Ground Advisory

Information Sharing design overview:

technical use cases driven



Per use case configurable Security characteristics (e.g. confidentiality, integrity) and Messaging QoS characteristics (e.g. delivery guarantees, ordering, etc.)



EUROCAE ED-151 - Operational Services and Environment Definition (OSED) for Aeronautical Information Services (AIS) and Meteorological (MET) Data Link Services, December 2007.

Data link mode	MEP/MEP Family
Broadcast	Publish/Subscribe Push (PSPUSH-MEP)
Demand	Request/Response (FDRR-MEP)
	Request/Multi-Response (FDRMR-MEP)
Contract	Request/Response (FDRR-MEP) composed with Publish/Subscribe (PS*-MEP)

UC ID	UC Title	Aircraft role	Ground-based system role	MEP Family	Brief description
PPUC-01a	Aircraft initiated Request/Response information exchange	Consumer	Provider	Request/Response	An aircraft consumes a Request/Response SWIM service provided by a ground-based system (FDRR-MEP).
PPUC-01b	Aircraft initiated Request/Multi-Response information exchange	Consumer	Provider	Request/Response	An aircraft consumes a Request/Response SWIM service provided by a ground-based system (FDRMR-MEP).
PPUC-02	Ground-based system provided Publish/Subscribe information exchange	Consumer	Provider	Publish/Subscribe	An aircraft consumes a Publish/Subscribe SWIM service provided by a ground-based system (PS*-MEP).
PPUC-03a	Ground-based system initiated Request/Response information exchange	Provider	Consumer	Request/Response	A ground-based system consumes a Request/Response SWIM service provided by an aircraft (FDRR-MEP).
PPUC-03b	Ground-based system initiated Request/Multi-Response information exchange	Provider	Consumer	Request/Response	A ground-based system consumes a Request/Response SWIM service provided by an aircraft (FDRMR-MEP).
PPUC-04	Aircraft provided Publish/Subscribe information exchange	Provider	Consumer	Publish/Subscribe	A ground-based system consumes a Publish/Subscribe SWIM service provided by an aircraft (PS*-MEP).

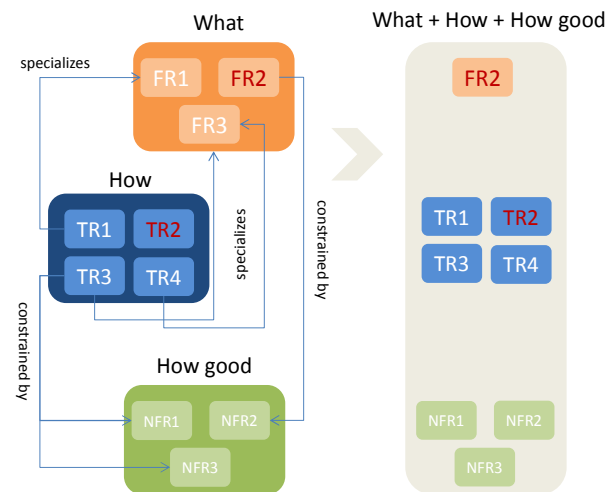
SWIM-TI Purple Profile For Air/Ground Advisory Information Sharing design overview: standard based architecture description



- In order to describe the Purple Profile architecture in a structured manner, the ISO/IEC/IEEE 42010:2011 standard has been adopted.
 - different actors (i.e. “stakeholders” in ISO/IEC/IEEE 42010:2011), concerns, architecture viewpoints and architecture views have been identified and described.
 - The viewpoints are based on the “what”, “how”, “how good” and “where”.

Functional Viewpoint which addresses the “what” without dealing with the “where” or “how” aspects of the SWIM-TI. It mainly addresses the concern about what the Purple Profile technical systems shall/should/could do.

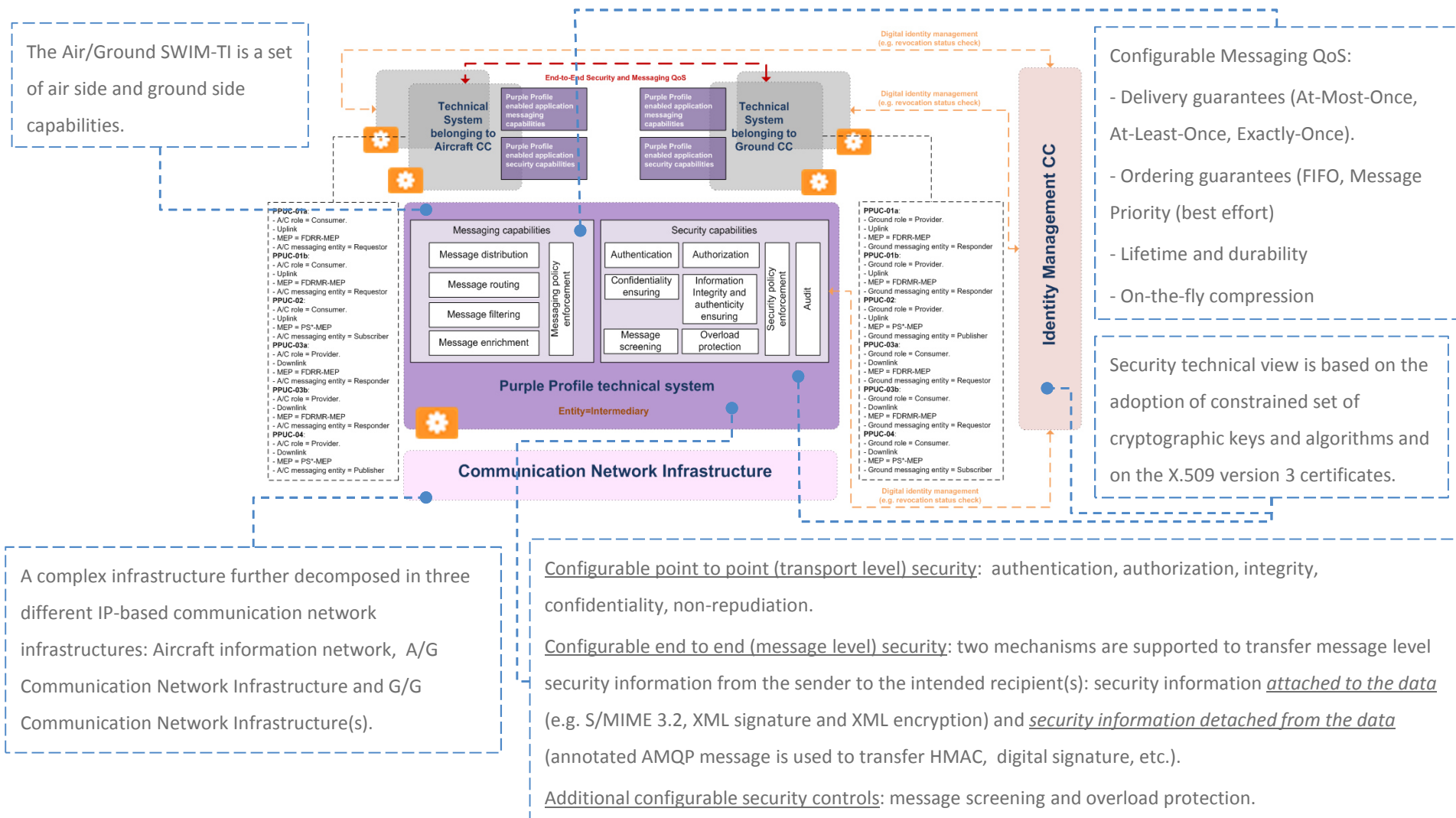
Technical Viewpoint which complements and specializes the “what” aspect addressing the “how” and “how good” but without dealing with the “where”. It provides the technical view according to technical architecture and technical interoperability needs (“how”) and SWIM-TI’s NFRs (“how good”).



EATMA Viewpoint which provides the EATMA architecture view according to EATMA model and EATMA concerns. It mainly put together elements from functional and technical views.

Deployment Viewpoint which mainly addresses the concern about how to deploy the Purple Profile (“what” and “how”) . It provides deployment options addressing the “where” in terms of architecture technical and integration options. PP design does not impose/restrict the deployment options and the list of deployment options is not supposed to be complete and exhaustive.

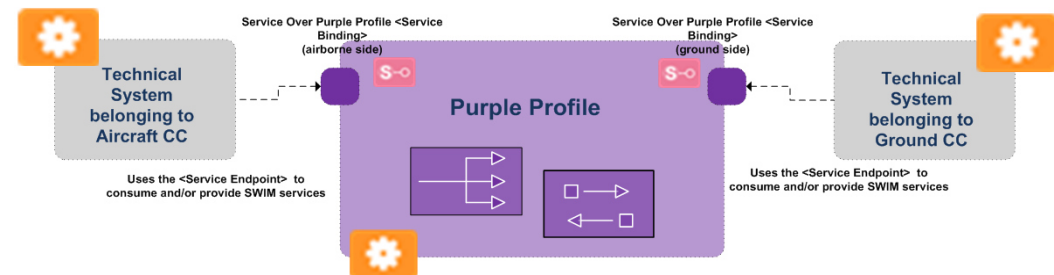
SWIM-TI Purple Profile For Air/Ground Advisory Information Sharing design overview: architecture “helicopter” view



SWIM-TI Purple Profile For Air/Ground Advisory Information Sharing design overview: Purple Profile enabled SWIM service



- A *Purple Profile enabled SWIM service* is instantiated over the infrastructure according to its technical design that mainly consists of:
 - Pair of aircraft and ground «Service Binding» used to consume/provide the service (traced to technical use cases).
 - Service specific artefacts describing the «contract» field of the selected «Service Binding» pair (message distribution and routing, QoSs, security controls, etc.)
 - Resources allocation and configuration concerning interface bindings (e.g. including message topics and subscription handling for Publish/Subscribe services).



Binding section	Binding sub-section	Definition
Protocol stack	Stacking	Request/Response Messaging Entities Purple Profile Messaging functionalities over AMQP 1.0 core over TLS {1.2 1.3} in the amaps form over TCP over {IPv4 IPv6}.
	Message structure& format	...
		...
...	...	...
Contract	Addressing	The binding does not constrain nor standardise the AMQP 1.0 core addressing scheme(s). Addressing scheme has to be documented together with non-opaque addressing for request and response message queues.
	Messaging resources	Message queues lifecycle is managed via administrative interfaces. The instantiation of this binding requires the creation and configuration of message queues.
	Messaging Policies	Messaging policies are managed via administrative interfaces. The instantiation of this binding requires the applicable messaging policies defined by the Purple Profile are documented and configured. Routing policies are mandatory to enable federation.
	Security Policies	Security policies are managed via administrative interfaces. The instantiation of this binding requires the security policies defined by the Purple Profile are documented and configured.
	QoSs	The instantiation of this binding requires that the applicable QoSs are documented and configured.
	CoS	The instantiation of this binding requires that the applicable CoS is documented and configured.
	Application-data	Although it is opaque for the binding, in order to enabled end to end interoperability the physical information model (e.g. JSON schema, XSDs, etc.) has to be documented.
	Application properties	The binding can use these properties for filtering and routing purposes. However, even if not used by the binding, in order to enabled end to end interoperability any application properties have to be documented.

SWIM-TI Purple Profile For Air/Ground Advisory Information Sharing validation activities: Plan & objectives



- PJ.17-01 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 validation activities focus was on the technical feasibility
- TRL6 validation activities focus was on non-functional characteristics including:
 - performance (time behaviour, ordering guarantees, on-the-fly compression).
 - security controls including 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.
 - reliability efficiency (delivery guarantees).
- Furthermore, in TRL6, also the integration with Future communication infrastructure (FCI) P14.02 multilink prototypes (e.g. AeroMACS, SATCOM) was planned.

SWIM-TI Purple Profile For Air/Ground Advisory Information Sharing validation activities:

Exercises



PJ.17-01 Exercises and dates:

- **TRL4 EXE1** (Leonardo, Frequentis, Leonardo GmbH): Uplink and downlink advisory information (weather, aeronautical) exchange in a scenario involving different Purple Profile SWIM Node prototypes, aircraft and ground Purple Profile enabled SWIM services (**TRL4 - 2Q2018**)
- **TRL4 EXE2** (Indra): Ground test application to communicate with several simulated aircrafts through Ground SWIM Node using SATCOM emulator (**TRL4 - 2Q2018**)
- **TRL4 EXE3** (Thales Air Systems, Thales Avionics SAS, Eurocontrol): Technical Validation of capabilities and robustness of the A/G SWIM Segment supporting interoperable communication between a/c and Ground SWIM Enabled Apps (**TRL4 - 2Q2018**)
- **TRL6 EXE1** (Leonardo, Frequentis, Leonardo GmbH, NLR): Evolution of EXE1, as defined in TRL4, according to applicable TRL6 validation objectives (**3Q2019**)
- **TRL6 EXE2** (Indra): Evolution of EXE2, as defined in TRL4, according to applicable TRL6 validation objectives (**3Q2019**)
- **TRL6 EXE3** (Thales Air Systems, Thales Avionics SAS, Eurocontrol): Evolution of EXE3, as defined in TRL4, according to applicable TRL6 validation objectives (**3Q2019**)
- **TRL6 EXE4** (Leonardo, Indra): EXE including a sub-set of TRL6 EXE1, EXE2 and EXE4 aiming at addressing SWIM-TI level technical interoperability (**3Q2019**)

SWIM-TI Purple Profile For Air/Ground Advisory Information Sharing validation activities: TRL6 EXE1.0001



Purple-profile enabled
NARSIM, The NLR ATM
Research
Simulator(@Marknesse)

Leonardo GmbH MET Provider
(and Consumer) (@Neuss)



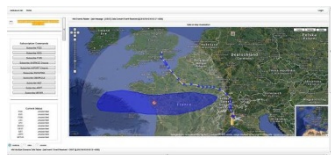
Leonardo Cockpit +EFB
Simulator equipped with
SWIM Aircraft Access
Point (@Turin)



Frequentis ePIB (Electronic Preflight
Information Bulletin) Service (@Wien)



Leonardo SWIM Viewer
(@Naples)



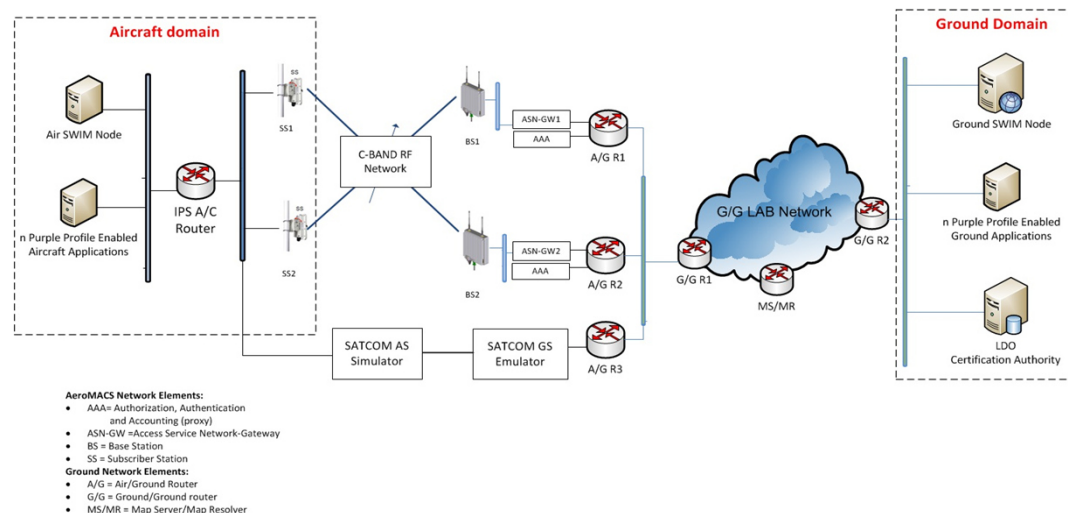
Leonardo Lab equipped with SWIM
Ground SWIM Node and SWIM
Certification Authority (@Rome)



SWIM-TI Purple Profile For Air/Ground Advisory Information Sharing validation activities: TRL6 EXE1.0002 (Leonardo)



- Reliability and security technical scenarios demonstrating:
 - Per-SWIM service QoSs like delivery guarantees, message priority based ordering guarantees, etc.
 - Point-to-point and end-to-end security (authentication, authorization, integrity, authenticity, non-repudiation)
 - Proper composition of Purple Profile level and Network level Class of services.
 - PJ14.02.04 FCI prototype (HON Aircraft Router integrating LDO AeroMACS and INDRA SATCOM links).
 - Both IPv4 and IPv6 based (only IPv6 when using FCI prototype).
 - Multilink transparent to Purple Profile SWIM Nodes.
 - Use of network level class of services (all the IPv4/IPv6 packets exchanged by two peers are marked with the CoS selected at TCP/IP connection establishment phase).



SWIM-TI Purple Profile For Air/Ground Advisory Information Sharing validation activities: TRL6 EXE2 (INDRA)



- Main Objectives
 - Performance.
 - Emphasis on non-nominal cases and time-behavior
 - Exhaustive tests on the latter (up to 500 aircrafts)
 - Reliability
 - Ensure delivery of messages on network/connection failures.
 - Security
 - Integration with ICARO
- Key results
 - No doubt about technical feasibility of the solution.
 - Coverage of objectives was higher than anticipated.
 - Identified key aspects of the specification that were fixed before delivery.

SWIM-TI Purple Profile For Air/Ground Advisory Information

Sharing validation activities:

TRL6 EXE3 (Thales Air Systems, Thales Avionics SAS, Eurocontrol)



- Main Objectives
 - Performance
 - Reliability
 - Security

- Key results
 - Technical feasibility of the solution has been validated.
 - System load testing did not reach the required performance figures
 - the global system performance is closely depending on deployment choices that directly impact how the load is distributed within the system's segments.

SWIM-TI Purple Profile For Air/Ground Advisory Information Sharing validation activities: TRL6 EXE4 (Leonardo, INDRA)



- The technical scenarios involve following prototypes:
 - Application layer:
 - LDO Emulated aircraft and ground SWIM enabled applications.
 - INDRA Emulated ground SWIM enabled applications.
 - INDRA data provider tool integrated with ICARO.
 - SWIM-TI layer:
 - LDO Aircraft and Ground SWIM Nodes.
 - INDRA Ground SWIM Node.
 - Network layer (IPv6):
 - PJ14.02.04 FCI prototype (HON Aircraft Router integrating LDO AeroMACS and INDRA SATCOM links).
 - Certification authority/PKI:
 - LDO CA
- The technical interoperability scenarios have been executed over following deployment:
 - INDRA Purple Profile enabled ground applications connected to INDRA Ground SWIM Node.
 - LDO Air SWIM Node connected to INDRA Ground SWIM Node.
 - LDO Purple Profile enabled aircraft applications connected to LDO Air SWIM Node.

SWIM-TI Purple Profile For Air/Ground Advisory Information Sharing validation activities:

Results



- Technical feasibility of the key elements concerning technical architecture, messaging capabilities and interface requirements has been successfully validated.
- Performance efficiency validation objectives (time behaviour, ordering guarantees, on-the-fly compression) have been validated reporting only partial results for time behaviour objectives.
- Almost all the security characteristic validation objectives 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.
- Reliability efficiency validation objectives (delivery guarantees) have been successfully validated. Validation objectives include 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.
- 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.
- Some EXEs have been executed on a V&VI integrated with P14.02 multilink prototypes (FCI).

SWIM-TI Purple Profile For Air/Ground Advisory Information Sharing validation activities:

Recommendations for next phases



- Performance requirements (e.g. technical measures like latency) assessment should be done in a real-life technical and operational deployment (including deployment options illustrated in the deployment views). Time-behaviour performance requirements should be refined and specified accordingly.
- Security KPA (including risk assessment) should be refined by complementing what has been 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.
- Safety KPA should be addressed when identifying and designing Purple Profile enabled SWIM services.
- 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.
- Consider real deployment, and address global interfaces to external systems, such as Network Operations Centre (NOC), Security Operations Centre (SOC), safety based recording, etc.
- To complete the initial CBA putting together application/services, Purple Profile and communication networks.
- To discuss/refine at EU and/or ICAO level “SESAR and FAA Air-Ground SWIM comparison” developed in PJ.17-01.

SWIM-TI Purple Profile For Air/Ground Advisory Information Sharing validation activities: Regulation and standardization recommendations



- Security management encompassing regulations and standards related to the use of PKI based solutions in security controls specified in this solution.
- 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.
- Purple Profile Enabled SWIM services encompassing the identification, safety assessment and technical design (link to this solution) of SWIM services provided and consumed by the aircraft.
- 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.

Solution members



THALES



Q&A



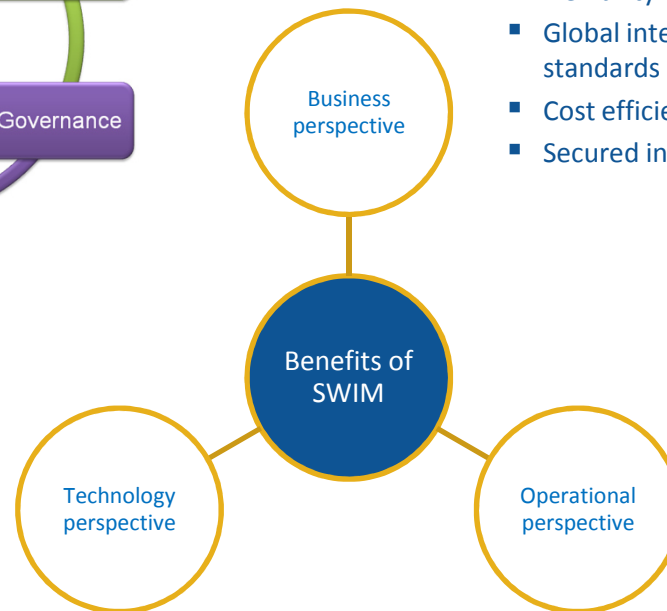
Additional supporting slides

SWIM Benefits & characteristics



- Re-use of code, rapid development
- Re-use of services
- Common standards
- Collaborative environment

- Agility in future evolution
- Flexibility in global uptake
- Global interoperability, common methods and standards
- Cost efficiency by service oriented architecture
- Secured information

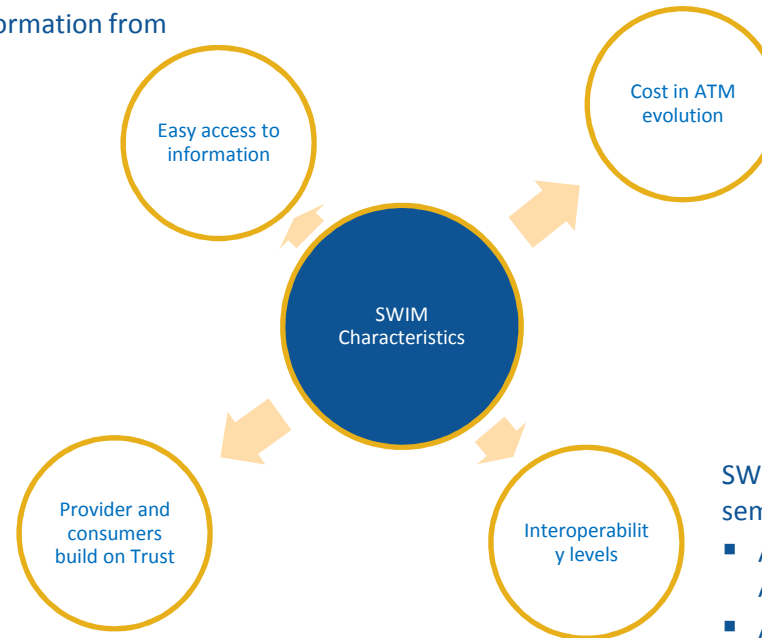


- Enables ASBUs (XMAN, A-CDM, FF-ICE, TBO, ..)
- The right information at the right time (filtering, alerting, visualization)

SWIM Benefits & characteristics



- Multiple ATM stakeholders
- Offer and consume ATM information from each other
- Easy to connect



- Cost proportional to required performance level
- Future changes shall be faster and cheaper

- All involved parties can be trusted (authorized entities only)
- Exchange mechanism can be trusted (secured, reliable, on-time)
- No abuse of information (adequate access control)

SWIM scope covers mainly (is not limited to) syntactical, semantic and technical interoperability levels:

- ATM information model (the standard definition of all ATM information),
- ATM services model (the logical breakdown of required information services and their behavioural patterns),
- Technical infrastructure (SWIM Technical Infrastructure (SWIM-TI) in SESAR).



Solution PJ.17-01 scope, results and recommendation

Thank you very much for your attention!



This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 730195



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