



PJ14 EECNS COM Open Day

PJ14.2.2 Future SATCOM Data Link

23 October 2019

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Founding Members



EUROPEAN UNION



EUROCONTROL

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Evolution of SESAR 2020 SATCOM-Related Solutions

SESAR Phase 1

15.2.4 FCI & ML
15.2.5 SATCOM Class B
15.2.6 SATCOM Class A

2010-2016

SESAR Phase 2 – Wave 1

14.2.2 SATCOM Service

14.2.4 FCI & ML

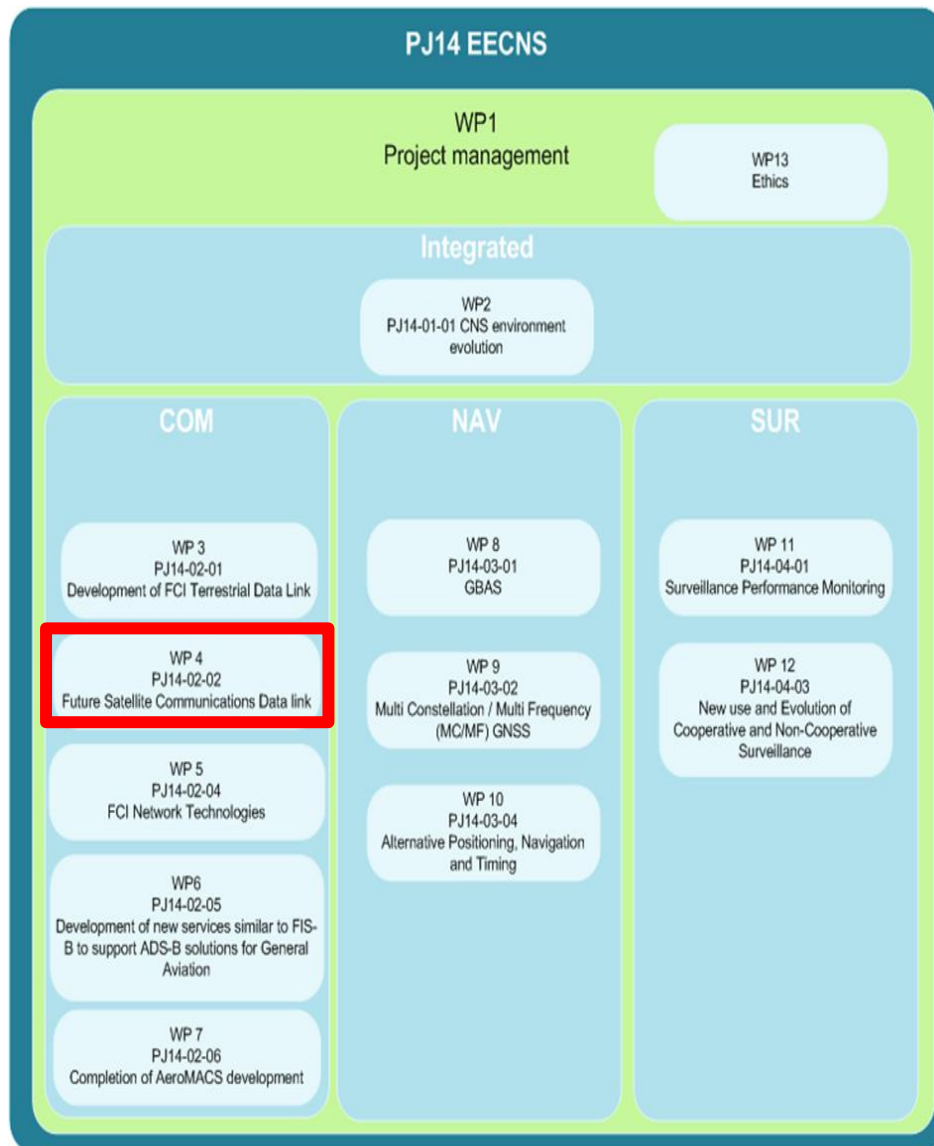
2017-2019

SESAR Phase 2 – Wave 2

Solution 107 Future
Satellite Communications
Datalink
Solution 77 FCI Services

2020-2022

Wave 1: PJ14 and PJ14.2.2



- PJ 14.02.02 solution that is part of the future CNS system for ATM.
- **PJ 14.02.02 Future Satellite Communications datalink** is focused on the near and long satellite datalink technologies for both continental and oceanic regions. It will also include digital voice as an element of the Future Communications Infrastructure (FCI).

Wave 1 (2017-2019): PJ 14-02-02 Future Satellite Communications Data link



Solution PJ 14-02-02: Future Satellite Communications Datalink

Development of future Long Term satellite datalink technologies (Class A), starting from incremental Class B SATCOM enhancements, for both the continental and remote/oceanic airspace volumes.

Main Objectives:

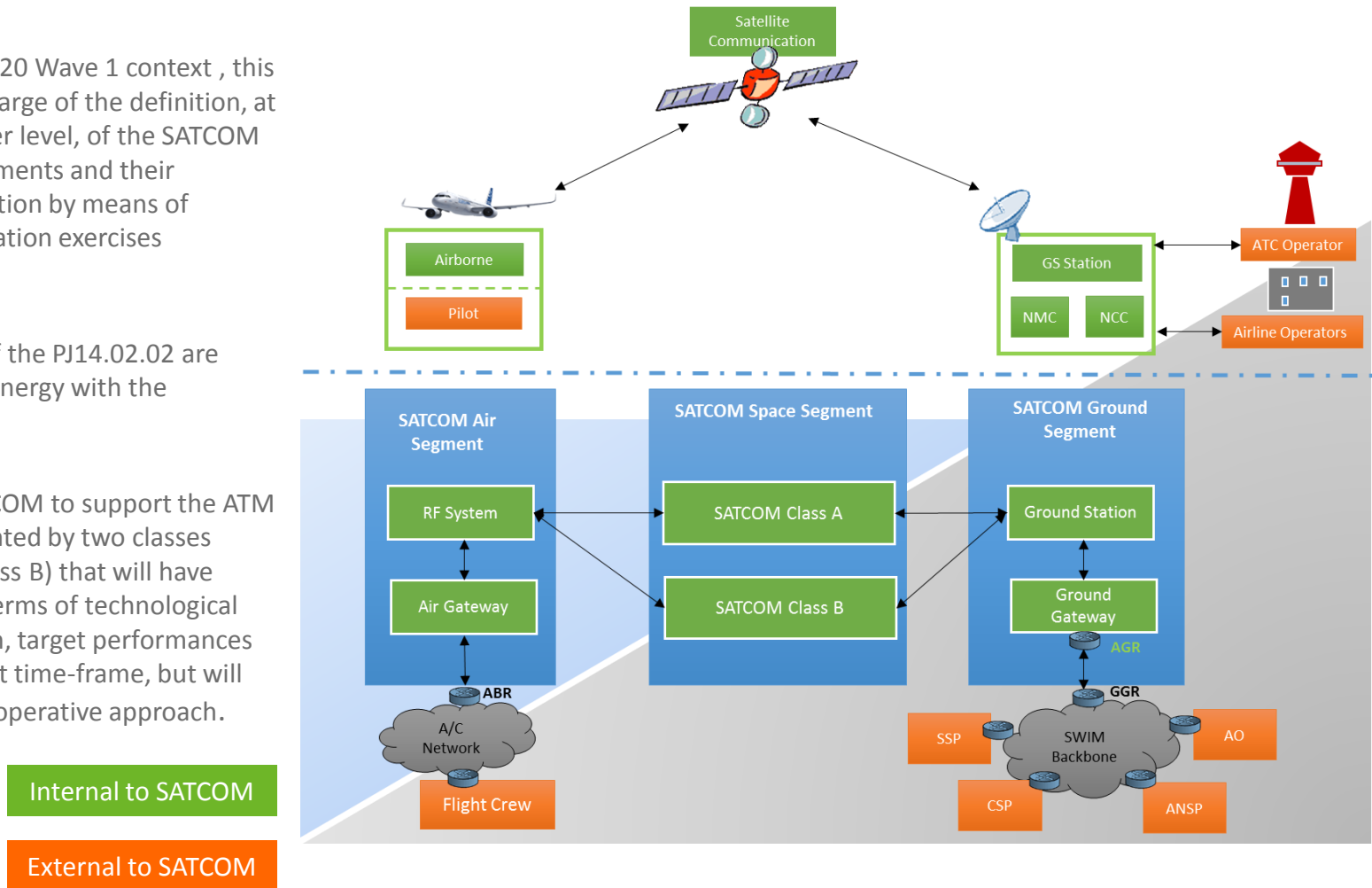
- Compliance with **ATN Baseline 2 requirements** (especially real time sharing of 4D trajectories)
- Development of **technical specifications and validation procedures** for Long Term (Class A) SATCOM for ATM integrated in the FCI (IPv6 and ATN/IPS with multilink policy), taking into account a seamless transition from the baseline and considering the intermediate step of the i4D based on the ESA Iris Precursor solution (Class B).
- **Technical validation of satellite air-ground datalink** for Long Term SATCOM integrated in the FCI (ATN Baseline 3, ATN/IPS, multilink)
- **Standardization at the global level** of the proposed solution for Long Term SATCOM. This notably includes the reuse and consolidation of the ESA Iris Programme prototypes where possible.

SESAR PJ 14.02.02 Solution overview

PJ.14 - EECNS

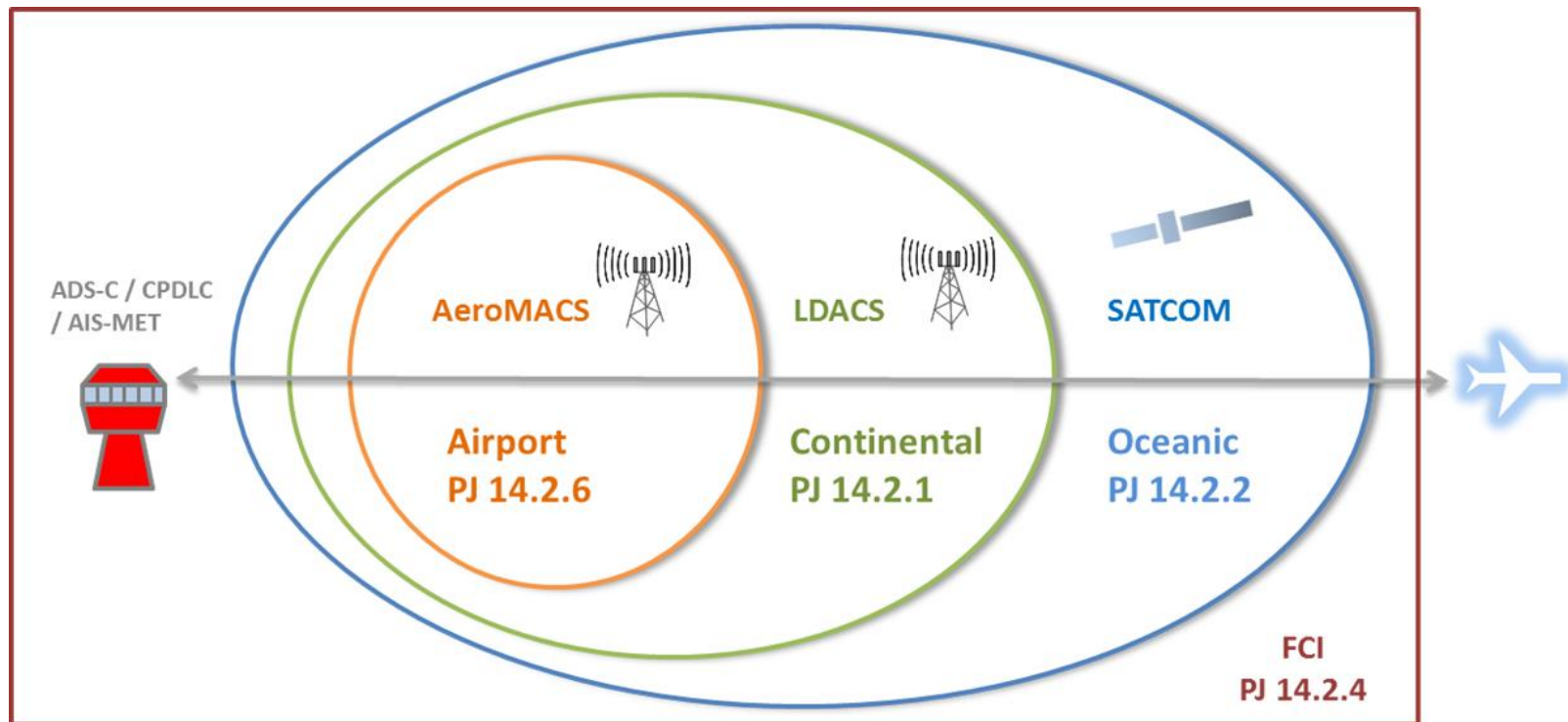


- In the SESAR 2020 Wave 1 context , this solution is in charge of the definition, at mission and user level, of the SATCOM Service requirements and their technical validation by means of dedicated validation exercises execution.
- The activities of the PJ14.02.02 are performed in synergy with the PJ14.02.04
- The future SATCOM to support the ATM will be represented by two classes (Class A and Class B) that will have differences in terms of technological implementation, target performances and deployment time-frame, but will have the same operative approach.



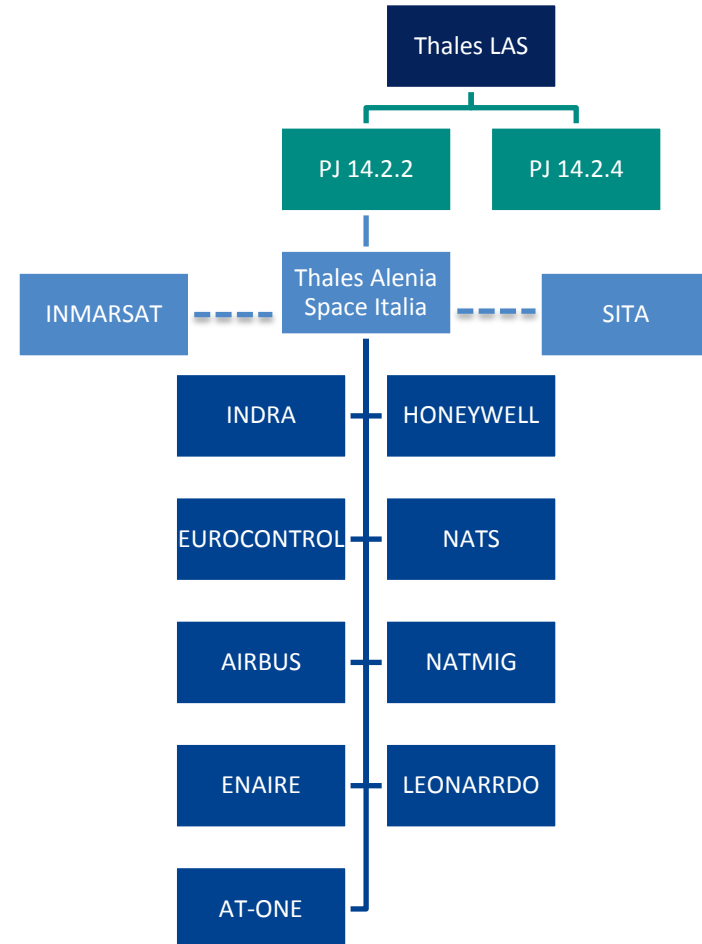
PJ 14-02-02: Relationship within the Overall FCI

Scope of the Wave 1 Solutions which together encompass PJ14-02-04, the European Future Communications Infrastructure (FCI)

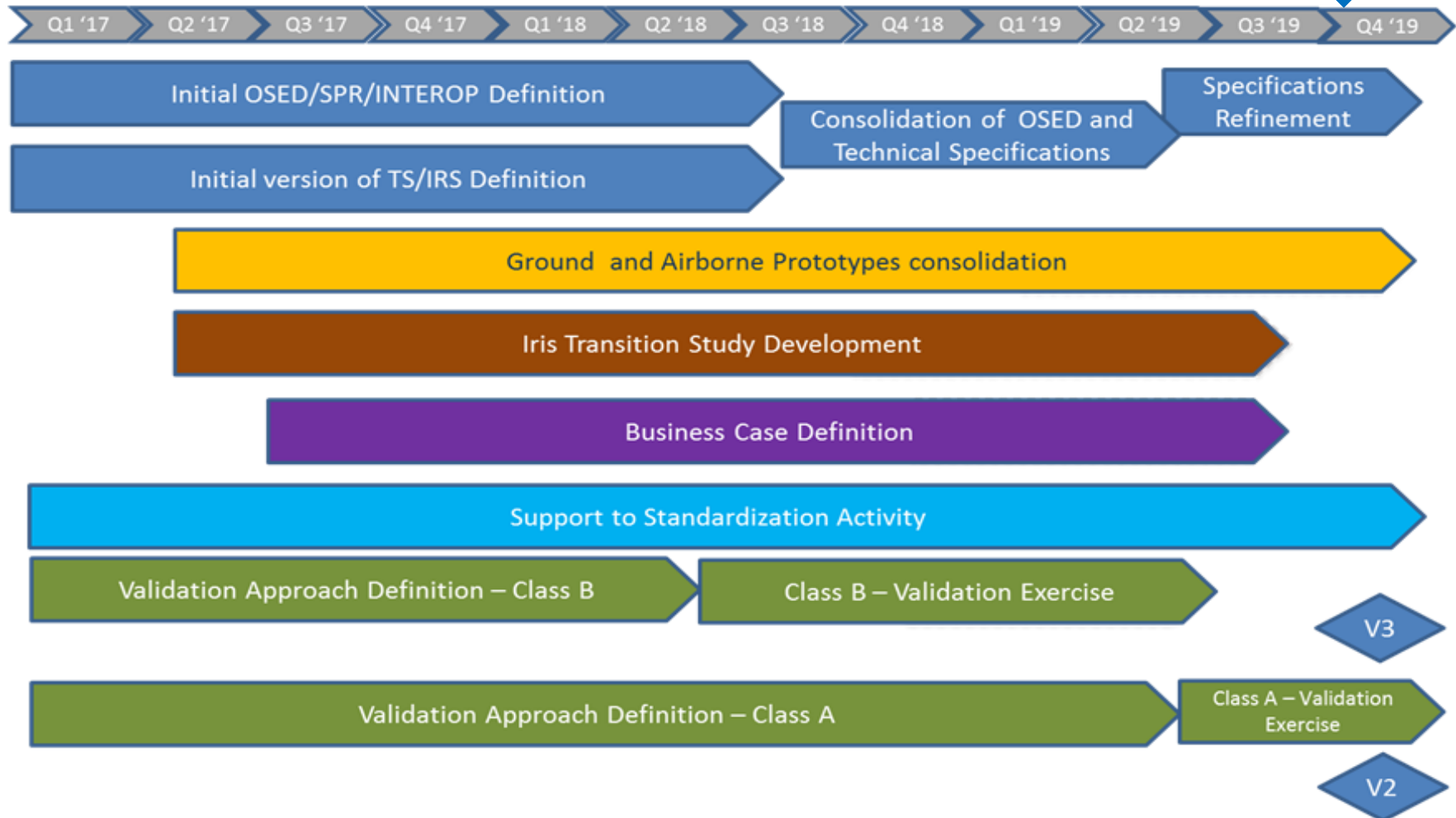


Solution PJ14.02.02: Consortium

PJ.14 - EECNS



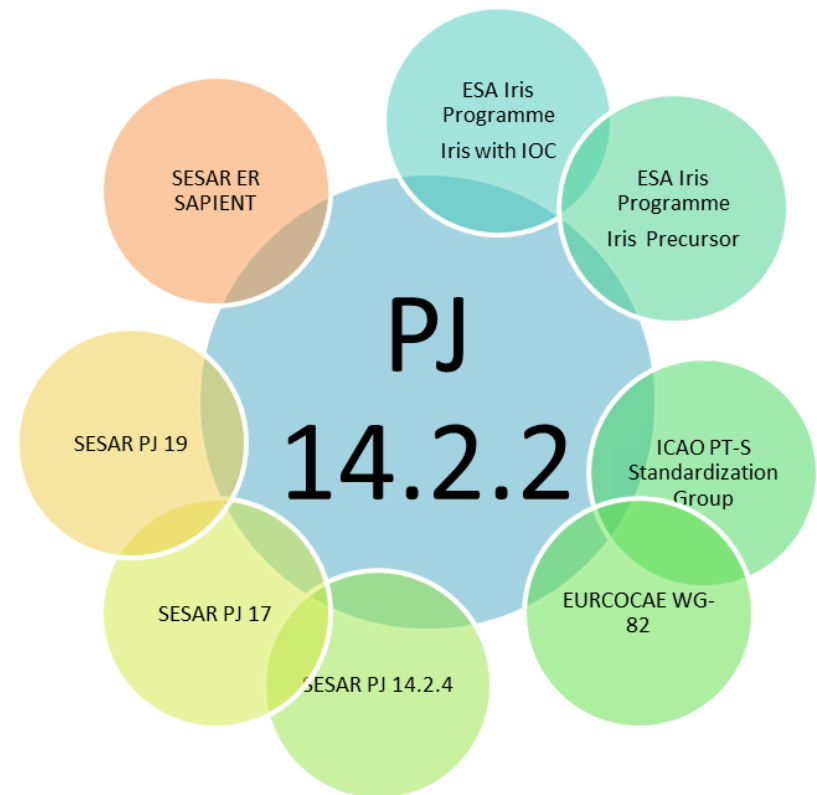
PJ14.2.2 – High Level Planning (major tasks)



PJ14.2.2: External Interactions

Relationships among SESAR 2020 PJ 14.2.2 and other projects, such as

- ESA Iris programmes,
- SESAR ER SAPIENT,
- Other solutions within the SESAR 2020 PJ14 and other PJs



PJ14.2.2 – Current Status - Synthesis

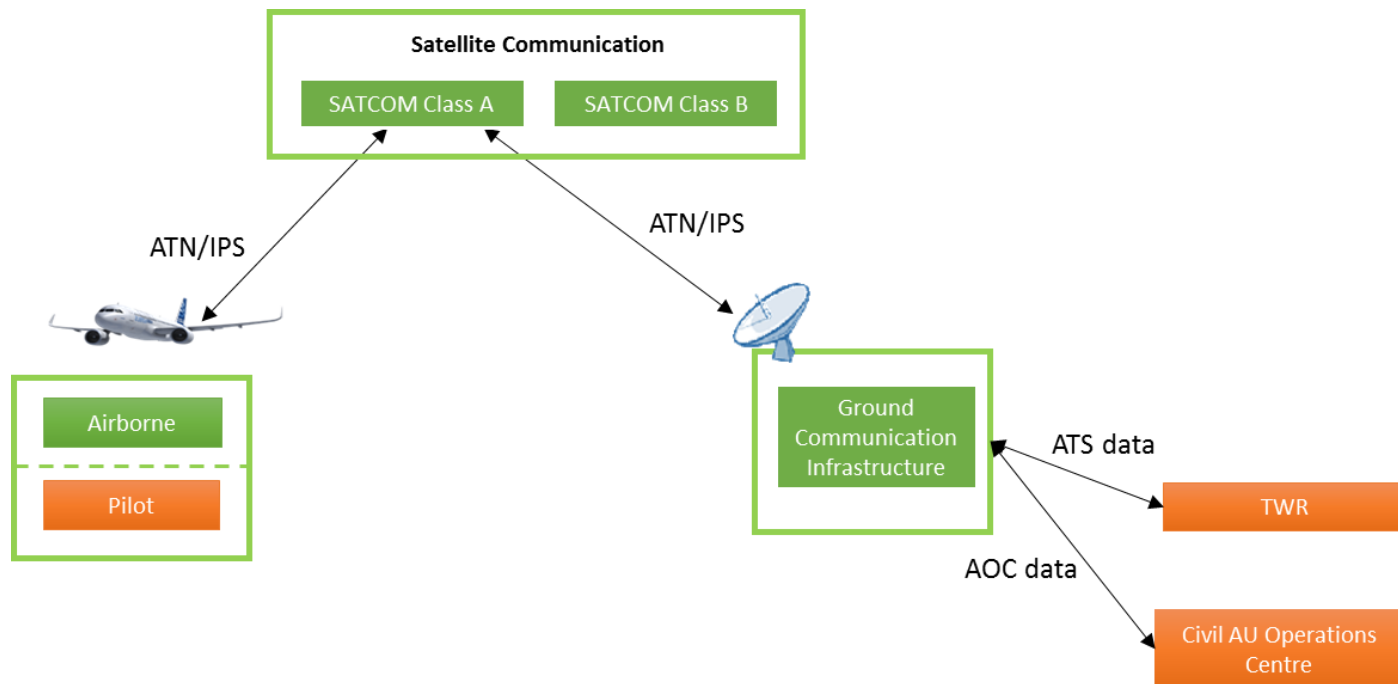


- SATCOM Class A and Class B **Data packs delivered**
- SATCOM V2 (Class A) and V3 (Class B) **Maturity Gates** preparation ongoing (5 November)
- SATCOM Service **Specification tasks concluded**
 - SATCOM SPR (Safety & Performance Requirements)
 - SATCOM INTEROP (Interoperability Requirements)
 - SATCOM TS/IRS (Technical Specification / Interface Requirement Specification)
 - SATCOM OSED (Operational Services and Environmental Definition)
- **Standardization Tasks**
 - Attendance and support to EUROCAE WG-82
 - Attendance and support to ICAO PT-S
- Technical **Validation Tasks concluded**
 - VE-01 – testing activities concluded, TVALP and TVALR finalised
 - VE-02 – testing activities concluded, TVALP and TVALR finalised
- **CBA Definition** Task Technical note available
- **Coordination with ESA/Iris Programme** on-going (periodic coordination webexes)

PJ14.2.2 – SATCOM Use Cases (1/4)

Reference Use Case #1: ATS/B3 over IPS, nominal user case

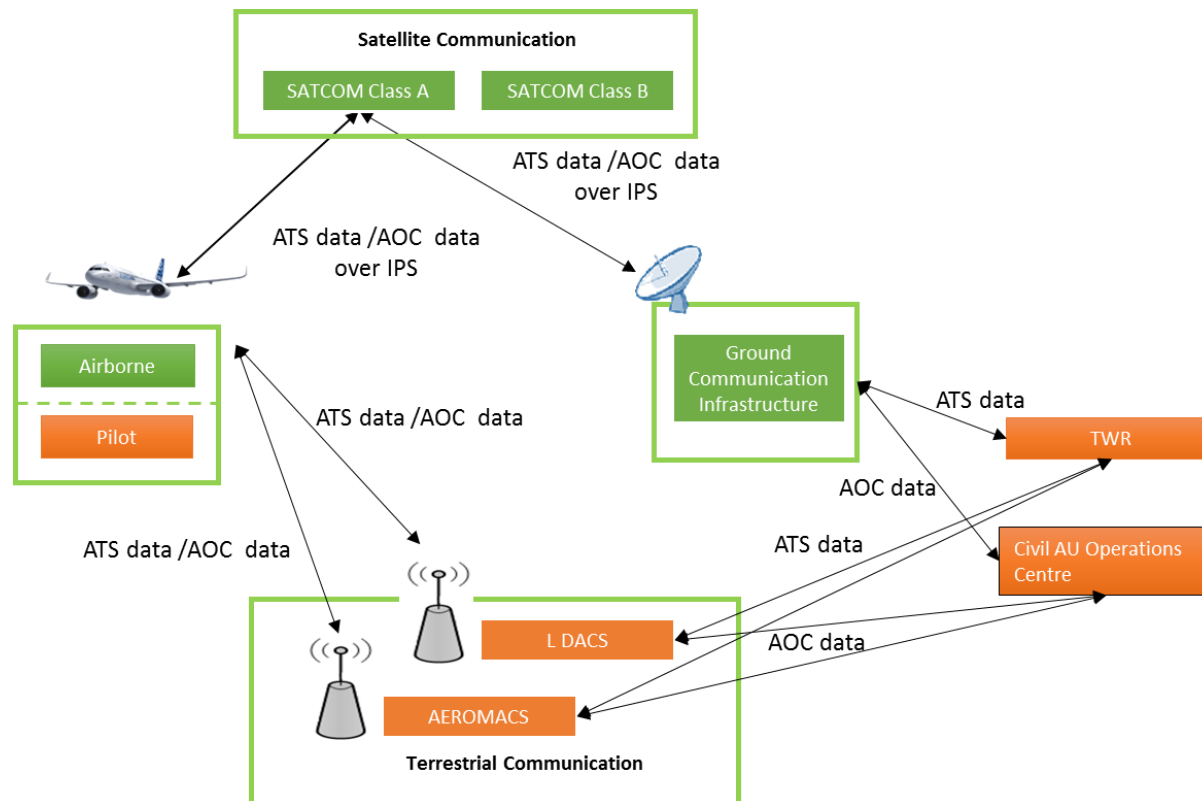
The case reports a nominal situation in which the A/C, during flight phase, i.e. the en-route, exchanges ATS B3 communications with TWR and Operation centre via SATCOM Terminal Class A, IPS domain.



PJ14.2.2 – SATCOM Use Cases (2/4)

Reference Use Case #2: Nominal Multilink user case

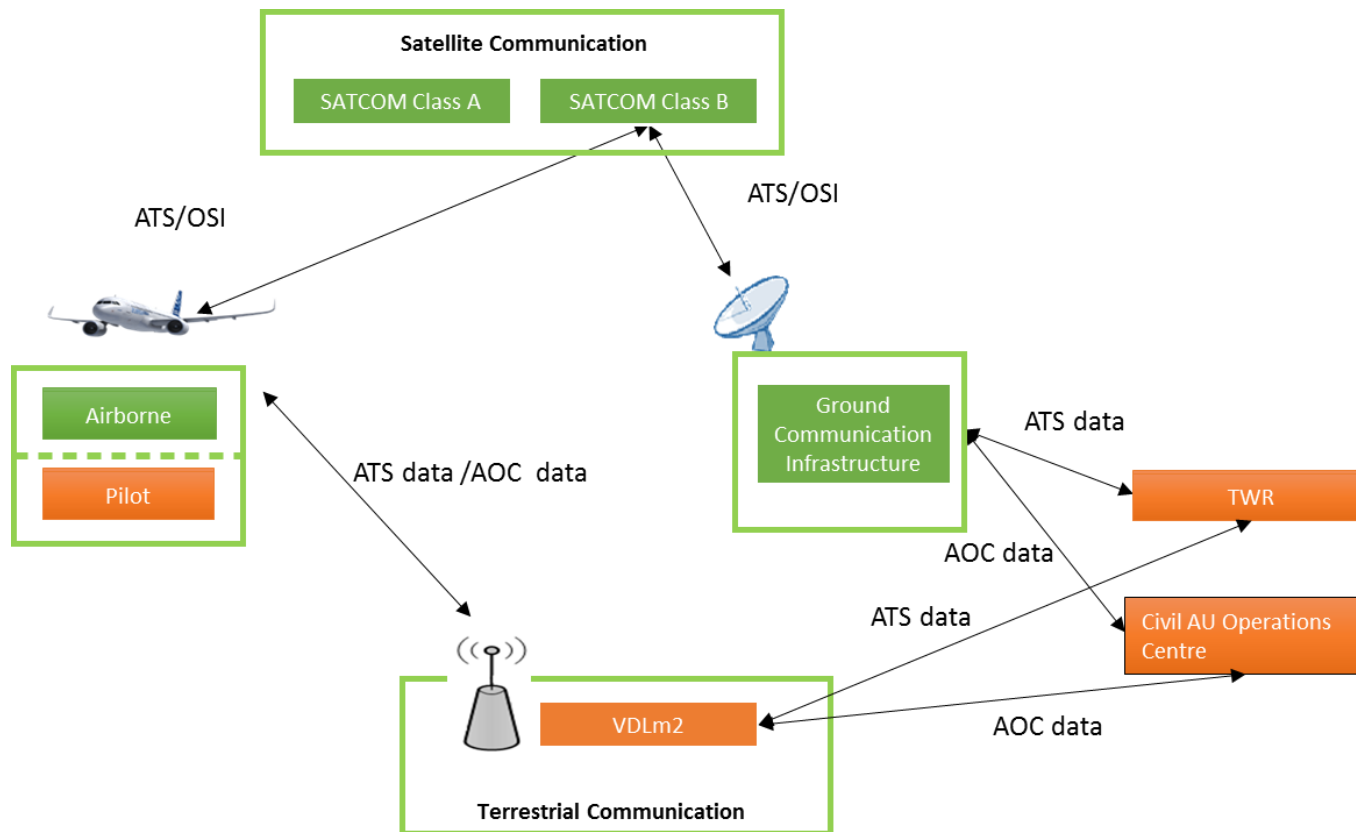
Nominal situation in which the A/C exchange communications with TWR and Operation centre via more than one DL, over IPS domain. It could potentially exchanges ATS communications via SATCOM Class A datalink and AOC via terrestrial one, or vice versa.



PJ14.2.2 – SATCOM Use Cases (3/4)

Reference Use Case #3: ATS/B2 over OSI, non-nominal Dual-Link use case

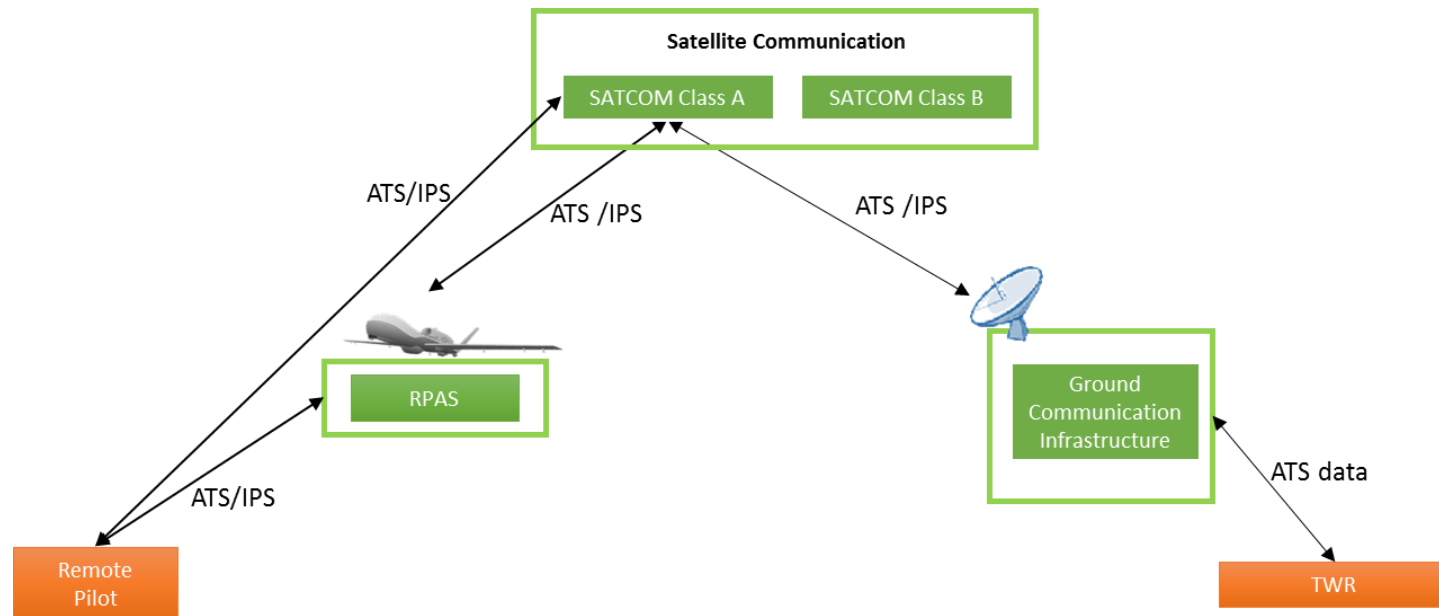
Non-nominal situation in which the A/C, during flight phase could not use the IPS communication for a fall-back. Then exchanges ATS B2 communications with TWR and Operation centre via SATCOM Class B or via Terrestrial Communication, based on the OSI domain.



PJ14.2.2 – SATCOM Use Cases (4/4)

Reference Use Case #4: RPAS nominal case via SATCOM Class A

The case reports a nominal situation in which the RPAS exchanges ATS over IPS communications with TWR via SATCOM Terminal Class A. The direct link between RPA and Remote Pilot in this provisional scenarios exchanges ATS/IPS messages and RPA relays that to the SATCOM link



SATCOM Initial Service Maturity



- **SESAR 1 Achieved Maturity Level (starting point):**
 - **SATCOM Class B - TRL 6**
 - **Successful flight trials.** On Feb 23, 2016, the Iris Precursor operated a first test flight between Toulouse and the Balearic Islands passing above Madrid, performing initial 4D flight path control and controller–pilot data link exchanges with the Maastricht Upper Area Control Center
 - **SATCOM Class A - TRL 4**
 - **Successful in-lab verification including prototypes**

PJ 14-02-02: Future SATCOM Technical Validation



Solution PJ 14-02-02 includes two Validation Exercises:

- EXE 01: SATCOM Class A - Iris FOC ATN/IPS Multilink
- EXE 02: SATCOM Class B - Iris IOC VDLM2 Dual-link

EXE-01, SATCOM Class A: Progress towards achievement of TRL 4 of a SATCOM Class A solution.

- Iris with Full Operational Capabilities (FOC)
- Definition and the assessment of Class of Service (CoS) and Quality of Service (QoS) classification schemes for the ATM applications exploiting SATCOM Class A
- Multilink capability in an ATN/IPS environment

EXE-02, SATCOM Class B: Confirm the achievement of TRL 6 of the SATCOM Class B solution

- Based on Iris Initial Operation Capability (IOC) SATCOM in a dual-link environment (VDLM2)
- This validation exercise aims at checking behaviour of the global transmission chain from the Aircraft to the ATC centre in a dual-link context, i.e. uplink and downlink routing operations in a dual-link environment.

VAL-EXE-01

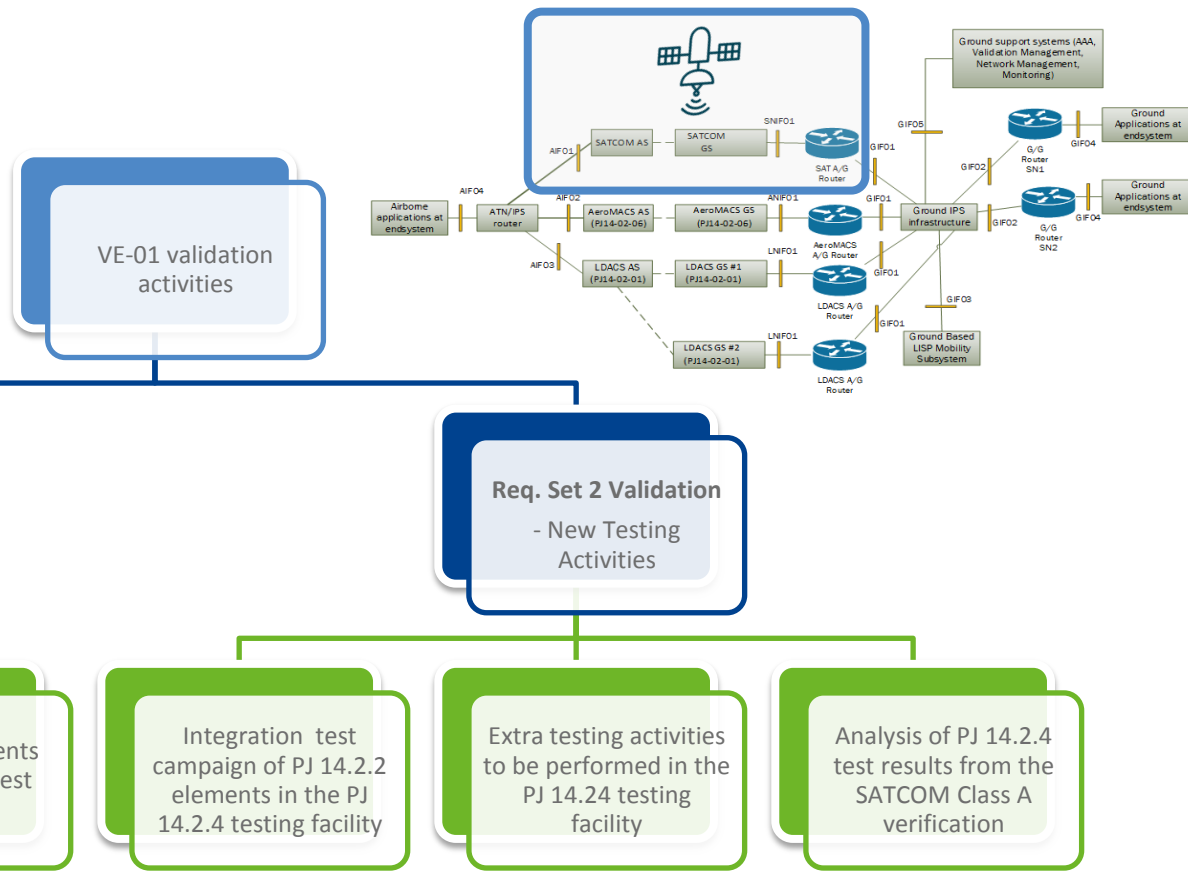
SATCOM Class A

PJ 14-02-02: EXE-01, SATCOM Class A Methodology

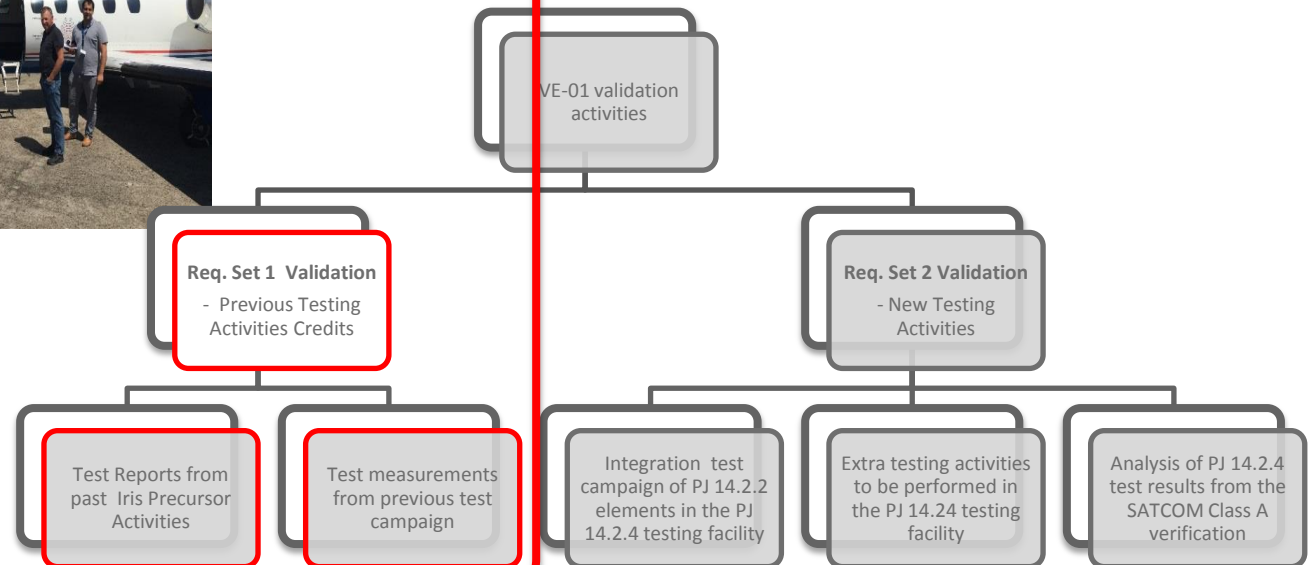
PJ.14 - EECNS



Two main technical validation areas:

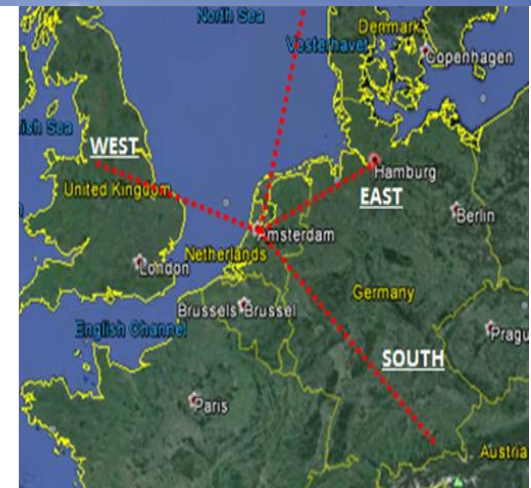
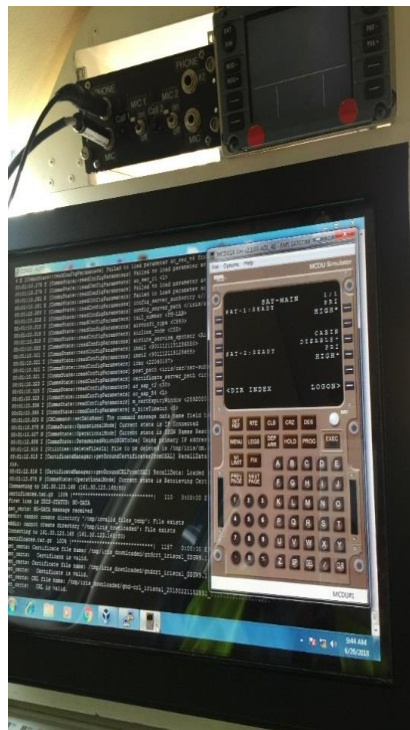
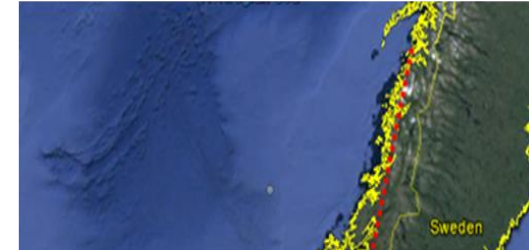


Req. Set 1 Validation: Previous Testing Activities Credits



Req. Set 1 Validation: Iris Precursor Flight Trials in connection with PJ 14.2.2

- Iris Precursor (2014 - 2018) made performance measurements on the bench and in flight.



Iris: Routes Flown

Flight	Date	Route	Duration
1	28 th June 2018	East	1:40
2	29 th June	South	1:30
3	2 nd July	West	1:30
4	3 rd July	South	2:41
5	3 rd July	North	3:23
Total			10:44 hrs

PJ.14 - EECNS

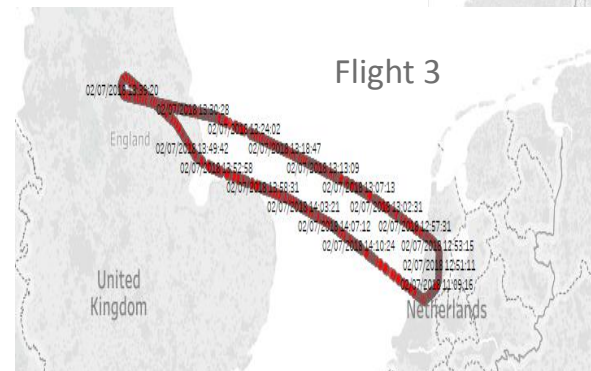


Flight 1

Flight 2



Flight 4/5



Flight 3

TVALP-010 Scope



TVALP-010 covers two lower level objectives

- TVALP-010-A – SB-Safety and VDLm2 Performance Comparison
- TVALP-010-B – Dual-link Concepts Assessment

The exercise was based on an analysis of real flight test data collected from two campaigns performed in Europe during 2018:

	Iris Precursor Flight Trials	VDLm2 Flight Trials
Test aircraft	PH-LAB NLR's Cessna Citation research aircraft	N757HW Honeywell's Boeing 757 flying test bed
Airborne router	Airbus' Iris ATSU prototype	Honeywell's CMU Mk2+ with -523 software
Airborne radio	Honeywell's Aspire 400 prototype	Honeywell's VDR products (RTA-44D, RTA-50D)
Air-ground link	Inmarsat's Enhanced SB-Safety service running over Inmarsat's operational BGAN network.	Operational VDLm2 network
Ground-ground infrastructure	SITA operational ATN	ARINC and SITA operational ATN
Applications	<u>ATN-B2</u> : ADS-C periodic reports + CPDLC ("i4D" FMS simulated by Airbus' ANETO A tool) <u>ACARS</u> : Several ACARS free-text messages sent during each flight from ANETO A to the SITA's ACARS FEP.	<u>ATN-B1</u> (PM-CPDLC)

TVALP-010 Methodology



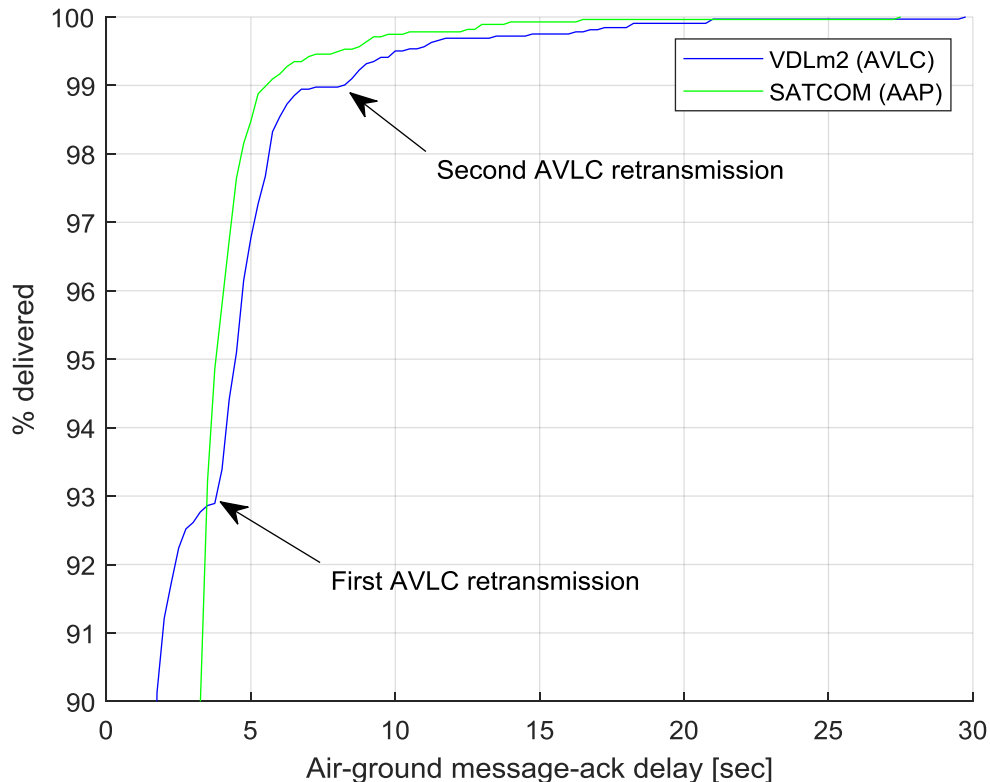
To compare VDLm2 and SATCOM and to assess potential performance improvements for different dual-link concepts, the following data were used:

- Message-acknowledgement round-trip time at Inmarsat SB-Safety service AAP layer
- Message-acknowledgement round-trip time at VDLm2 AVLC layer

these protocol layers are:

- Well comparable, because they represent boundaries of the SATCOM and VDLm2 air-ground links respectively.
- Applicable also for the future IPS service.

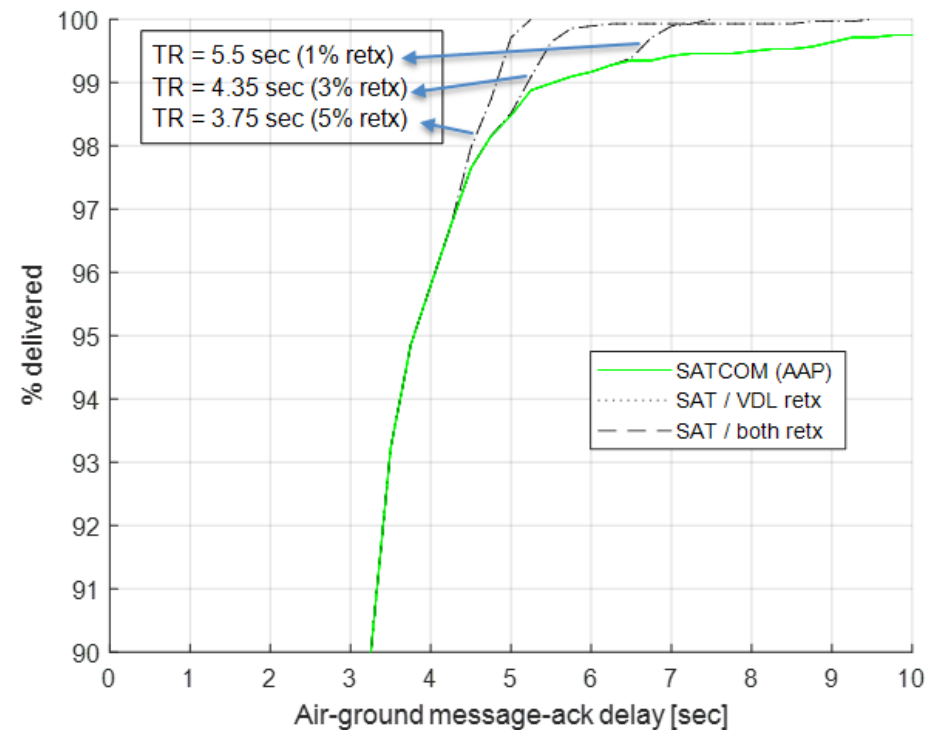
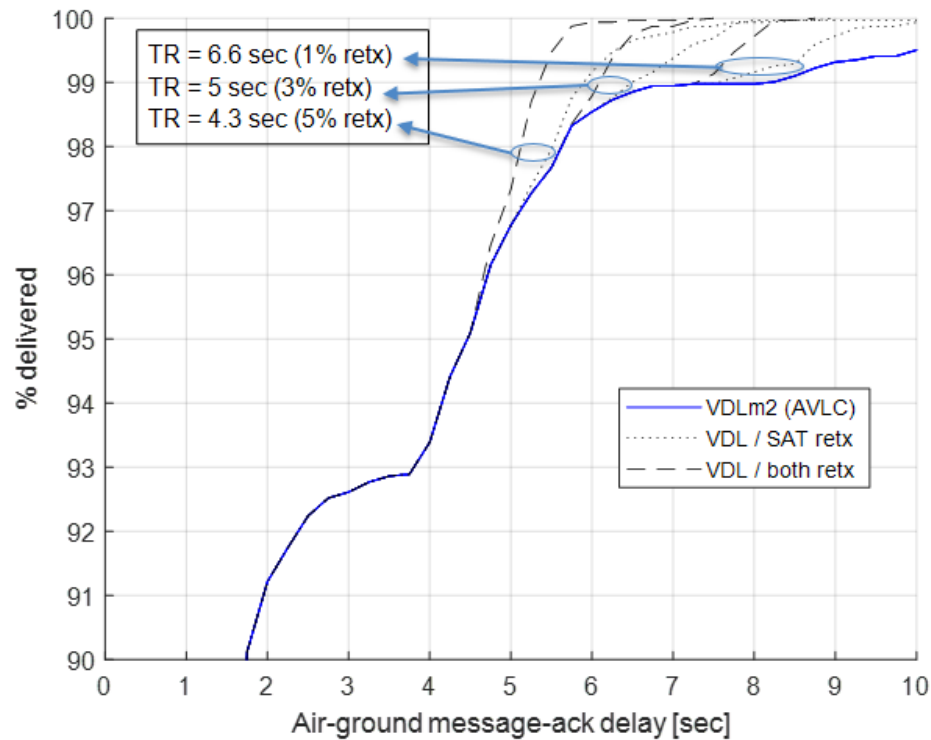
TVALP-010 Results – VDLm2 – SATCOM comparison



% delivered	Round trip time [sec]	
	SATCOM (AAP)	VDLm2 (AVLC)
50	2	1.1
90	3.2	1.7
95	3.7	4.4
99	5.5	8
99.5	7.9	9.9
99.9 (note 1)	13.8	18

Note 1: Roughly 2,700 measurements were available for each VDLm2 and SATCOM. More data would be needed to fully confirm the 99.9% performance.

TVALP-010 Results – Retransmission on secondary or both



TVALP-010 Conclusions



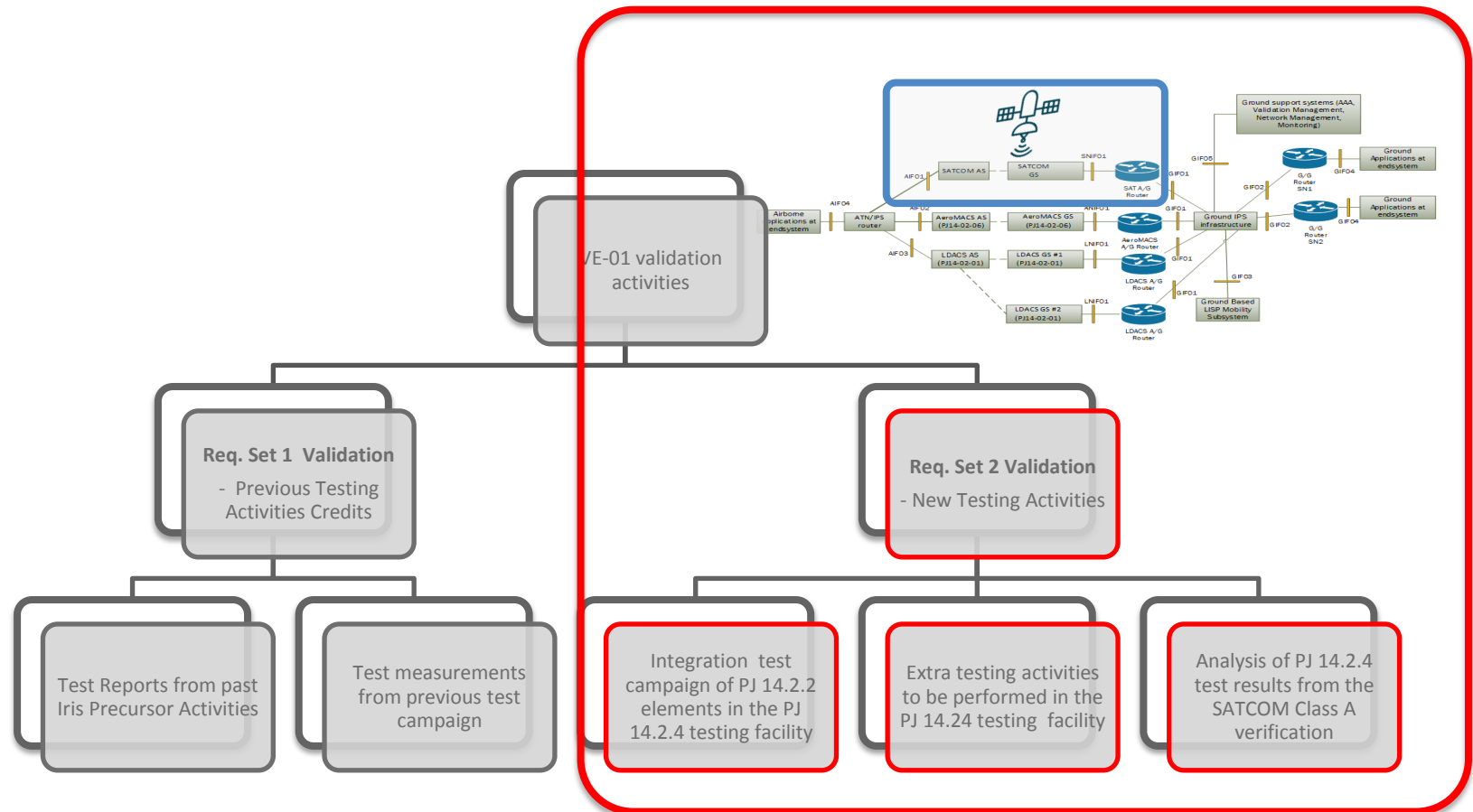
From RCP and RSP perspective, the **SB-Safety SATCOM latency performance is at least comparable to that of VDLm2** → SB-Safety can complement VDLm2 in the continental airspace as an enabler for the B1 and B2 datalink applications.

Substantial latency performance improvements are achievable with the parallel transmission over VDLm2 and SATCOM → this concept should be further considered in the IPS research, development and standardization work.

The dual link concepts using retransmission over alternate (secondary) or both links may reduce the latency at the tails of the statistical distribution (i.e. around 99% and above). The retransmission only on the secondary link rather than on both links seems to be more technically sound. This concept may be taken forward under IPS, if the 99.9% (or e.g. 99% or 99.5%) performance proves to be critical for some existing or future applications and services.

Req. Set 2 Validation: New Testing Activities in cooperation with PJ14.2.4

PJ.14 - EECNS

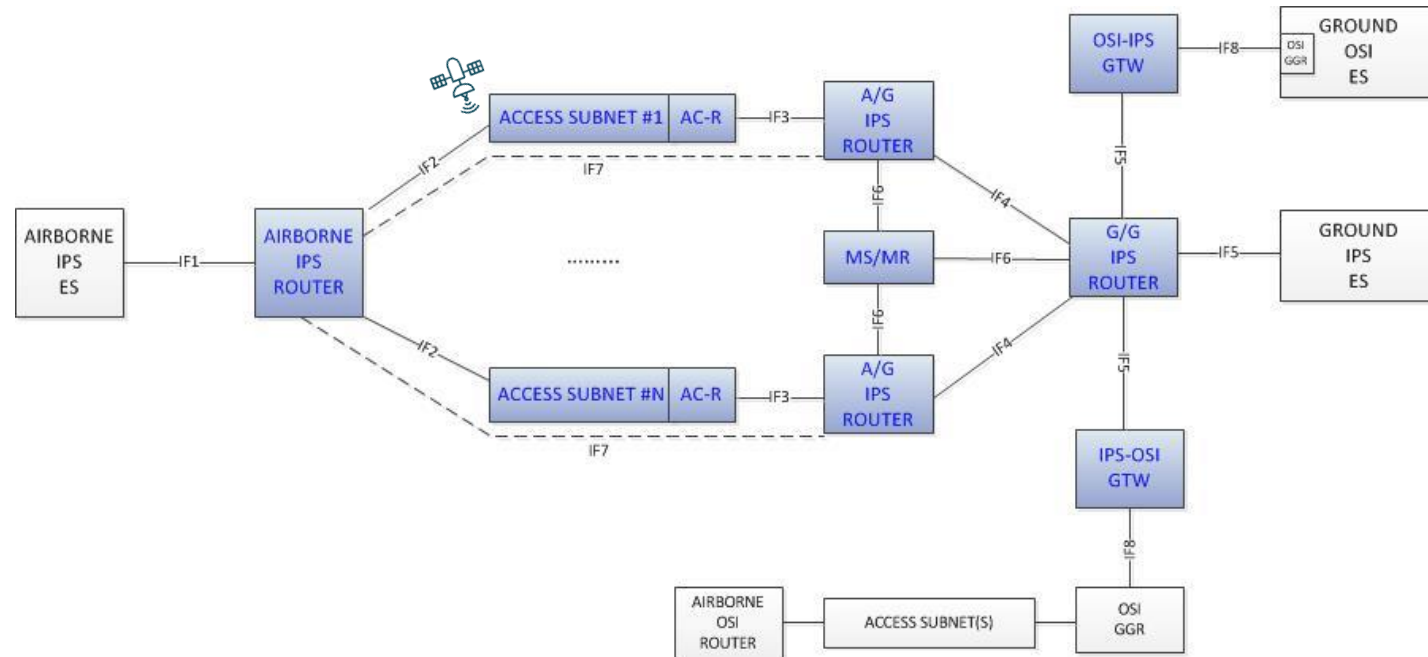


TVALP-020 Methodology

PJ.14 - EECNS



(EXE-PJ14.2.2-TRL4-)TVALP-020 Functional block diagram and interfaces



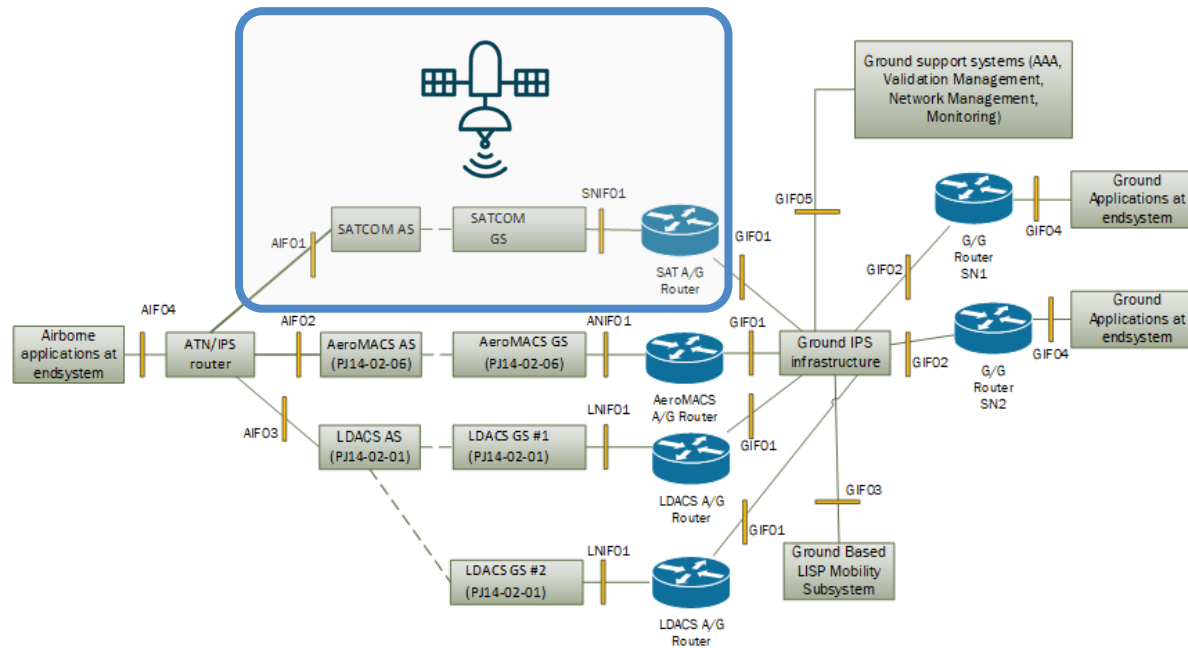
- IF7 (based on OSPF), IF3 and IF2 are temporary implementations since they are not currently formally defined

TVALP-020 Methodology

PJ.14 - EECNS



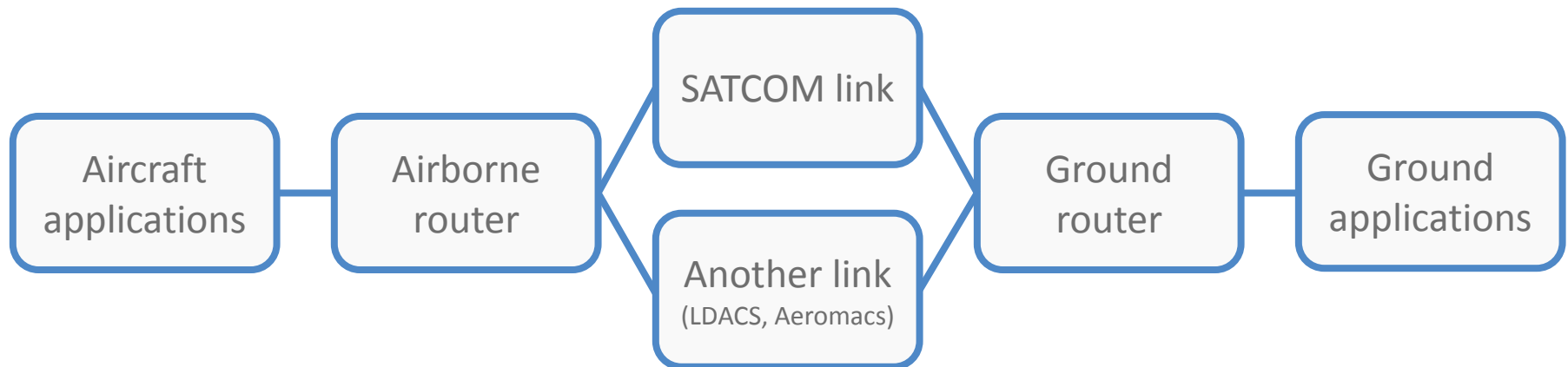
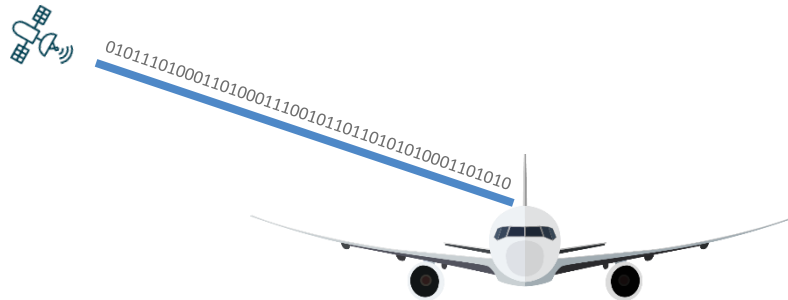
Testbed



- PJ14.2.4 testbed includes a simulated SATCOM link as part of their multilink testbed
- Specific SATCOM validation tests were performed

TVALP-020 Methodology

Validation scenario example



TVALP-020 Results

Validate SATCOM Integration	Messages exchanged, IF2 ok	✓
Validate ATN applications integration and Data exchange between aircraft and ground systems through SATCOM	ATN application traffic is sent through SATCOM	✓
Validate integration between A-R and A/G-R (IF7) through SATCOM	IF7 (OSPF) ok, multilink ok	✓
Mobile network support for unicast connectionless and connection-oriented communications through SATCOM	UDPAvgUDPmaxTCPavgTCPmax Air->Gnd862 ms878 ms1.29 s2.97 s Gnd->Air279 ms288 ms1.05 s2.66 s	✓
Simulate communication and temporary link loss (due to banking)	Ok, but temporary Gnd->Air packet losses if ground is unaware of SATCOM down	✓
Aircraft location announcement performance and functionality	Endpoint ID messages received and routes installed/removed	✓

TVALP-020 Conclusions



TVALP-020 conclusions and recommendations

- **SATCOM Class A** datalink is **able to support** the **multilink** functionality expected from ATN/IPS subnetworks
- The **detection** that the **SATCOM** radio link is **down** (e.g. due to banking) is expected to be relatively **fast on the airborne side** since the terminal will stop receiving the satellite signal
- 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 7** (between airborne router and air-ground router) should carry information, through each link, about the **status of all links**

VAL-EXE-02

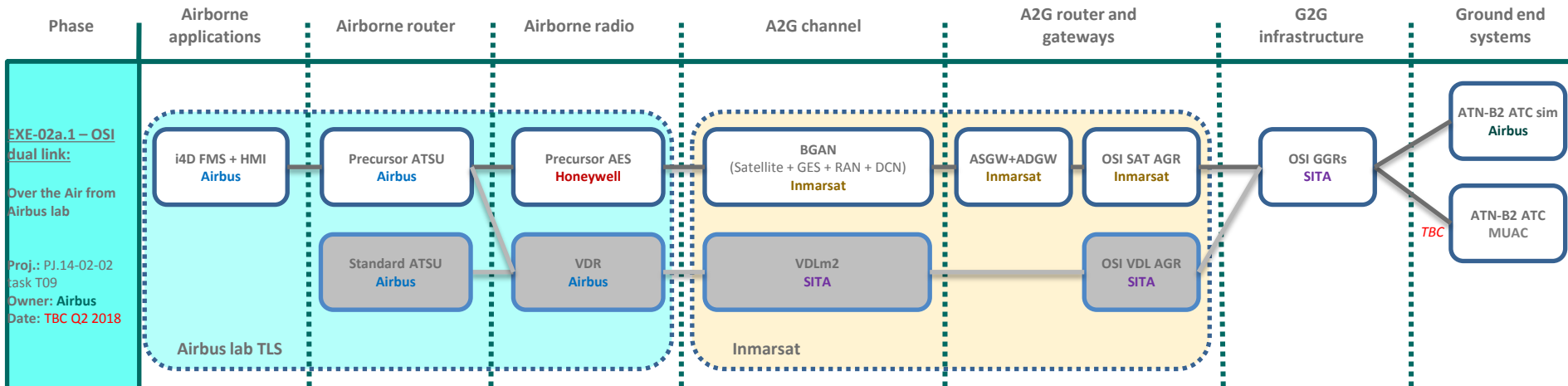
SATCOM Class B

VAL-EXE-02 Test Bed Scheme

PJ.14 - EECNS

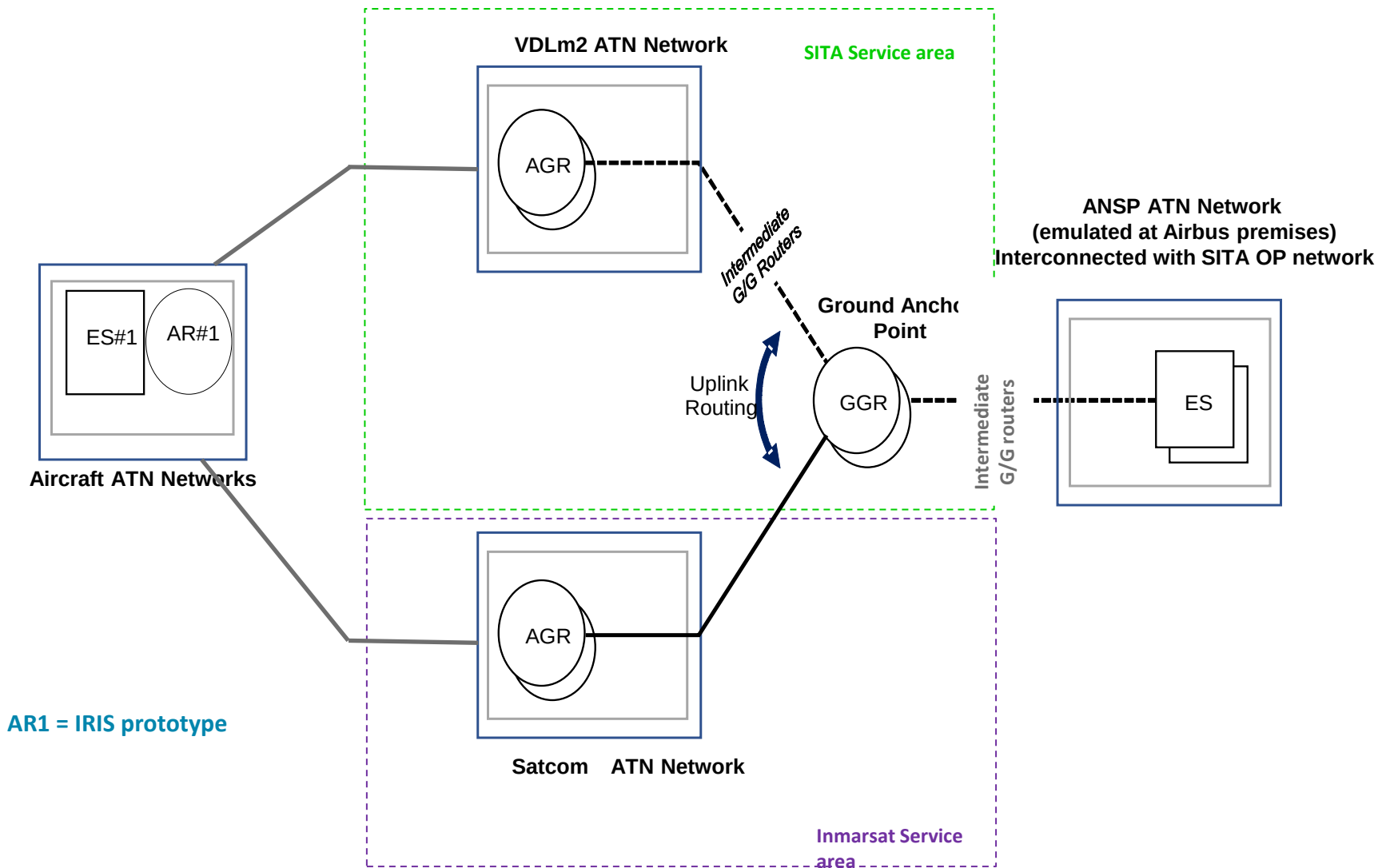


Airbus Test Bed Environment



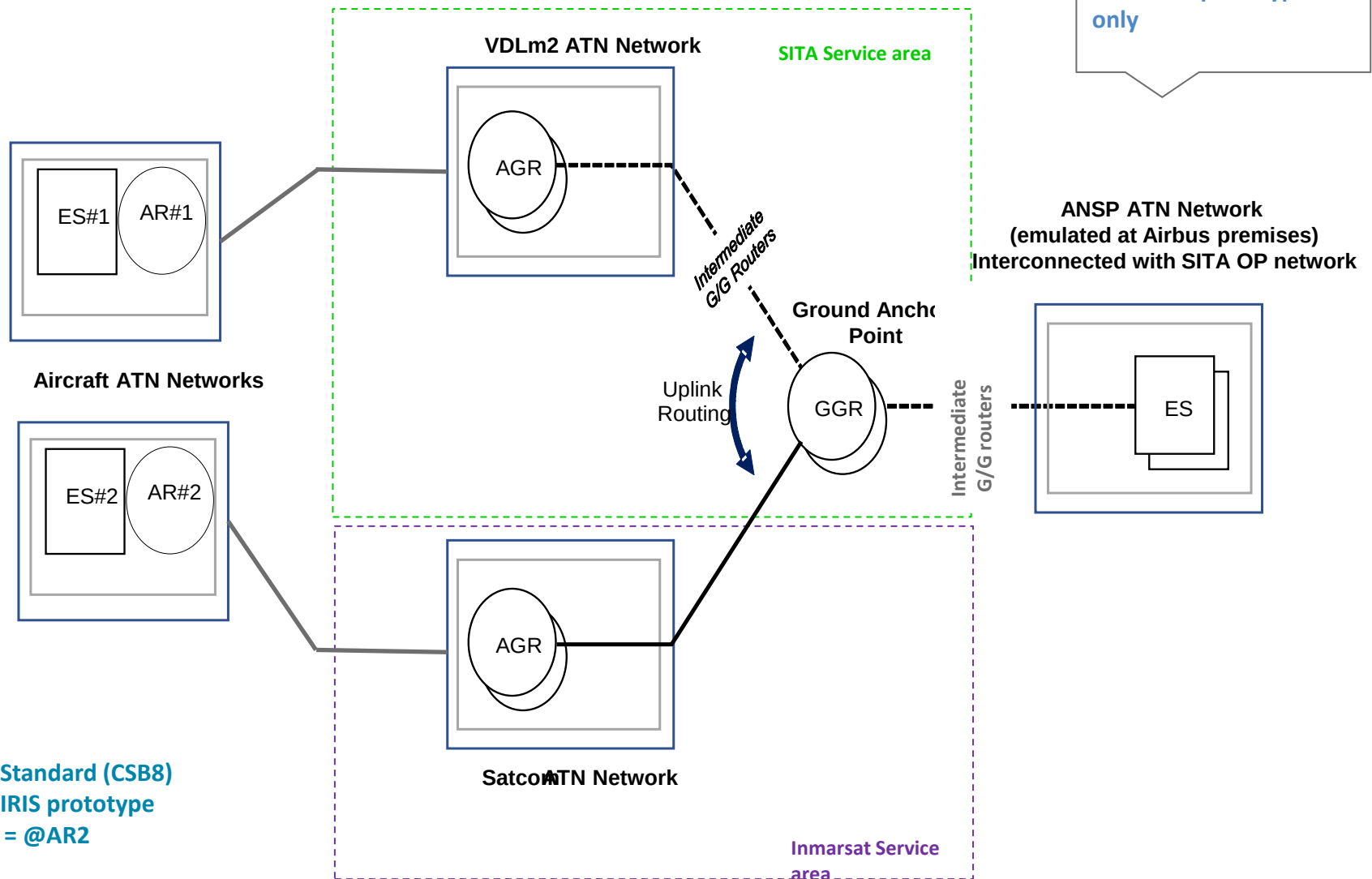


PJ14.2.2 T9: Test Architecture 1 (Airbus)

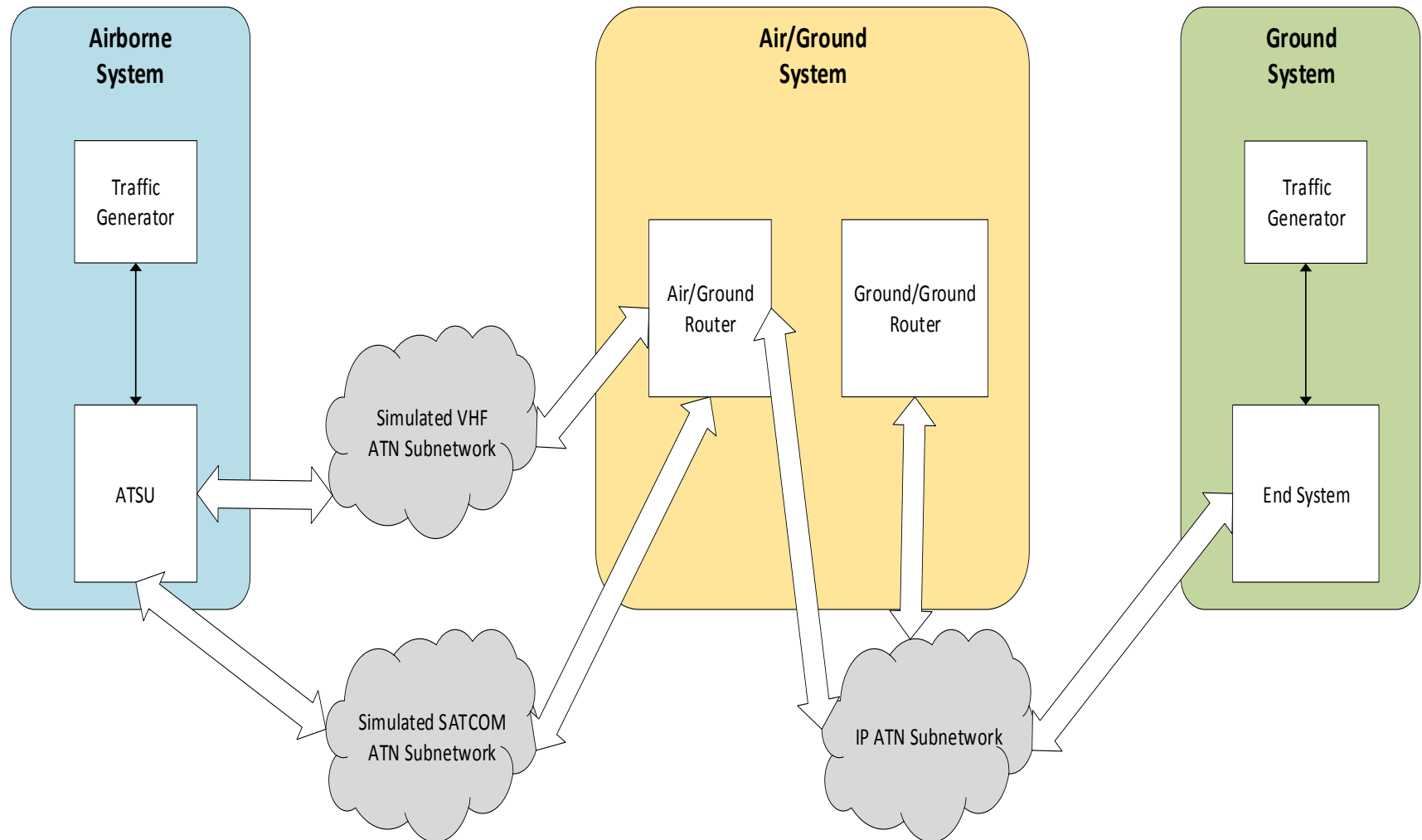


PJ14.2.2 T9: Test Architecture 2 (Airbus)

used for specific tests
non achievable with
ATSU IRIS prototype
only



PJ14.2.2 T9: Test Architecture 3 (Airtel)



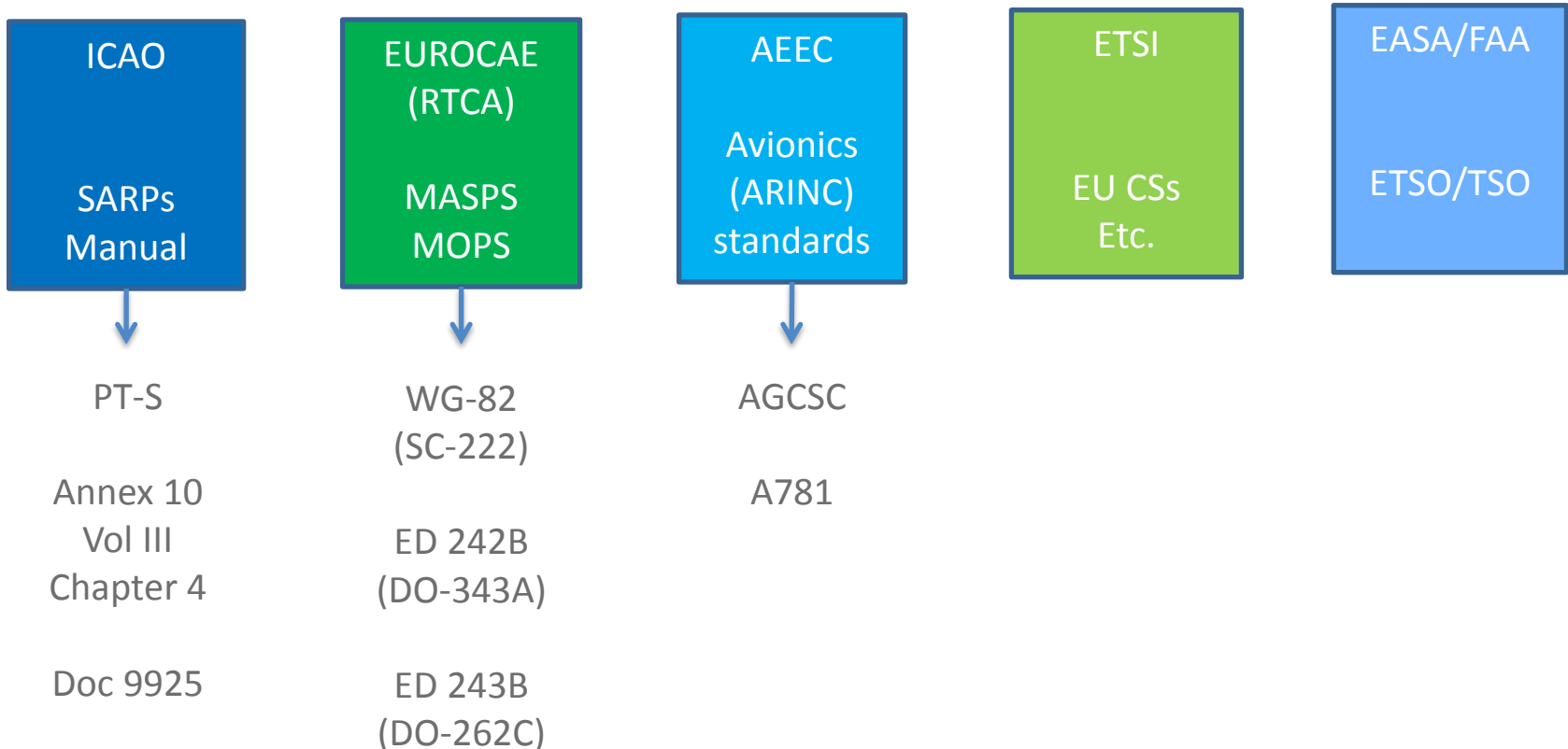
PJ14.2.2 T9 – Test results

VVO	VVO Test Coverage			Airtel Ex	Airbus Ex	Global Status
	Tests achieved	Tests not achieved	%			
#1	2	0	100	Passed		Passed
#2	5	6	46	Passed		Passed
#3	2		100	Passed		Passed
#4	4		100	Passed		Passed
#5	2		100	Passed		Passed
#6	2		100	Passed		Passed
#7	3	1	86	Passed		Passed
	3				Passed	
#8	3	1	86	Passed		Partially Passed
	3				Partially passed	

Standardisation and Dissemination Activities

PJ 14-02-02: Support to Standardization Efforts

As with any aviation communication system, development of performance requirements for all of the supporting technologies and enablers for Class A SATCOM (e.g. ATN/IPS) requires coordination with the Standards Development Organizations (SDOs).



Standardisation Activities - Status (1/2)



ICAO

Class B standardisation is progressing

- SARPs: Depending on SSP (INMARSAT and Iridium) support the target is to complete draft SARPS by October 2019 and targeting an applicability date of 2022.
- Manual: Work will start soon with a target of completion by end of 2020 / mid 2021

Class A standardisation

- Lack of clear requirements
- Has not started

Standardisation Activities - Status (2/2)



EUROCAE/RTCA:

Class B standardisation is complete for Inmarsat over ATN/OSI

- IPS will be considered in a future update
- Iridium is considered in RTCA

Class A standardisation

- Lack of clear requirements
- Has not started

PJ14.2.2 – Dissemination Activities



- Events - Groups
- Conferences
- Publications
- Others

Dates	Location	Event name	Description of solution planned activity	Solution Focal Point	Achieved
12-14/09/17		AEEC DLUF	Presentation of PJ14-02-02	ECTL	Yes
19-20/10/17		AEEC Mid Term	Presentation of PJ14-02-02	ECTL	Yes
2018					
Dates	Location	Event name	Description of solution planned activity	Solution Focal Point	Achieved
June	Cologne	EUROCAE-WG 82	present solution update	TAS-I and ECTL	yes
September	Brussels	AEEC DLUF	present solution update	ECTL	yes
September	Brussels	FCI-TF	present solution work and SATCOM update	TAS-I	yes
October	Brussels	CNS symposium	stand and presentation of SATCOM solution and Iris	Honeywell and INMARSATyes	yes
October	Niagara Falls, Canada	Ka and Broadband Communications Conference	presentation of SESAR PJ14.2.2 and Iris	TAS-I	yes
2019					
Dates	Location	Event name	Description of solution planned activity	Solution Focal Point	Achieved
March	Mardid	WAC	present solution work and SATCOM update	tbc HW, TAS-I and Inmarsat	yes
March	Brussels	FCI-TF	present solution work and SATCOM update	TAS-I	yes
April	Herdon, Virginia US	ICNS 2019	presentation of SESAR PJ14.2.2 and Iris	Inmarsat	yes
June	Webex	EUROCAE-WG 82	present solution update	TAS-I and ECTL	yes
September		AEEC DLUF	present solution work and SATCOM update	ECTL	yes
October	Brussels	PJ14 COM Open Day	Open Day for the SESAR 2020 PJ.14 EECNS communication solutions	TAS-I	yes
October	Brussels	FCI-TF	present solution work and SATCOM update	TAS-I	yes

Conclusions and Next Steps

Conclusions



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 – V2/TRL4
 - SATCOM Class B in dual-link mode - V3/TRL6
- Contribution to standardization at the global level
- Coordination with ESA/Iris Programme

Next steps



Maturity Gates (V2 and V3) planned on 5th November 2019

Wave 2 Solution#107 Future SATCOM Data Link to start in January 2020

- Objectives
 - 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



Presentation name

Presenter's contact data

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 [number]



Founding Members



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