# Iris Precursor Verification Report

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***Abstract***

This document provides the Verification report from Project 15.02.05 on the Iris Precursor system. It describes the results of verification exercises defined in 15.02.05-D02 and how they have been conducted. Iris Precursor integration and testing activities includes:

- Phase 1: Airborne systems Verification
- Phase 2: Laboratory SDU-ATSU Integration Verification
- Phase 3: Iris Precursor System Laboratory Test Verification
- Phase 4: Iris Precursor System Flight Test Verification

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| Rational for rejection |
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# Document History

| Edition | Date | Status | Author | Justification |
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| 00.00.01 | 06/01/2015 | Draft | Airbus | New Document |
| 01.00.00 | 13/01/2016 | Release | Airbus | First Released version<br>Partners comments taken into account.<br>Phase 1 and 2 completed<br>Phase 3 and 4 not started |
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# Intellectual Property Rights (foreground)

This deliverable consists of SJU foreground.

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# Executive summary

Iris is the European Space Agency's (ESA) program to develop a comprehensive satellite ATM system for SESAR based on a global communication standard.

As part of incrementally working towards the long-term Iris goals, the Iris Precursor service will provide air–ground communications for initial 4D flight path control by 2018.

This deliverable is part of "T2.4 – Coordination and preparation of V&V phases" activity.

The SESAR 15.2.5 project technical baseline is focused on:

- [SPR ATS] for Air Traffic Data Communication Services (Safety and Performance),
- [INTEROP ATS] for the Interoperability Requirements.

This document provides the Verification report from Project 15.02.05 on the Iris Precursor system. It describes the results of verification exercises defined in 15.02.05-D02 and how they have been conducted. Iris Precursor integration and testing activities includes:

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- Phase 4: Iris Precursor System Flight Test Verification

# 1 Introduction

## 1.1 Purpose of the document

This document provides the Verification report for Iris Precursor system. It describes the results of verification exercises defined in 15.02.05 - D02 and how they have been conducted.

## 1.2 Intended readership

This document is expected to be of primary interests for partners of the 15.02.05 Project, who will get from this report the factual data on the performance of the Iris Precursor system.

This document is also intended to serve as input for SATCOM Class B standards, and should hence be of interest to the organizations involved in these standardization groups, including notably the EUROCAE WG82 and the RTCA SC223.

## 1.3 Structure of the document

This document is structured as follows:

- Chapter 1 is an introduction describing the purpose of the document and the intended readership.
- Chapter 2 describes the context of the Verification. It includes a summary of the verification exercises.
- Chapter 3 defines the verification approach, describing how the verification exercises were implemented and where they have been performed (Suppliers or Airbus Laboratory, Flight Test).
- Chapter 4 gives a summary of the verification exercises results
- Chapter 5 provides the conclusions and recommendations
- Chapter 6 gives a summary of the verification activities performed on ATSU and SATCOM at supplier level
- Chapter 7 gives a summary of the verification activities performed at Airbus laboratory on ATSU and SDU integration
- Chapter 8 gives summary of the verification activities performed at Airbus laboratory on i4D testing and performance assessment
- Chapter 9 gives a summary of the verification activities performed during Flight test.
- Chapter 10 is a list of applicable and reference documents

## 1.4 Glossary of terms

**Aeronautical mobile-satellite (R) service (AMS(R)S):** An aeronautical mobile-satellite service reserved for communications relating to safety and regularity of flights, primarily along national or international civil air routes.

**SESAR Programme:** The programme which defines the Research and Development activities and Projects for the SJU.

**SJU Work Programme**: The programme which addresses all activities of the SESAR Joint Undertaking.

**ATSU (Air Traffic Services Unit)** is the main component of Airbus ATIMS (Air Traffic and Information Management. System) – in this document the term ATSU refers to this airborne communication unit installed on Airbus aircraft family.

**Unicast:** the one-to-one transmission of data packets to one specified destination

**Multicast:** the one-to-many transmission of data packets to interested destinations

**Broadcast:** the one-to-all transmission of data packets to all possible destinations

**Communication protocol:** A set of rules defining how network entities interact with each other, including both syntactic and semantic definitions

**Layered protocol:** A class of communication protocols that is sub-divided into separate layers, each of which performs distinct functions.

**Protocol stack:** A specific instance of a layered protocol that defines the communication protocol.

> The satellite communication system developed within the Iris Programme supports several protocols in parallel, each with its own terminology. The ISO-OSI reference protocol stack terminology is used for describing these protocols.

**Physical Layer:** The physical layer defines the Satellite Communication System waveform, including modulation and coding.

**Link Layer:** The link layer defines the media access method (often referred to as MAC - Media access control) as well as framing, formatting and error control (often referred to as LLC - logical link control).

**Network Layer:** The network layer defines the format of end-to-end data packets, as well as routing of packets within the network

**Transport layer:** The transport layer defines end-to-end functionalities such as reliable/unreliable data transport, flow and congestion control.

> The transport layer operates end-to-end, and is implemented only in the end systems. Therefore, it has no direct impact on the Satellite Communication system. However, the mechanisms of the transport layer have to be carried, in the form of overhead on network layer packets and additional packets.

**Ground Segment (GS):** The collection of all entities in the System located on ground.

**User Terminal (also called Airborne Earth Station - AES):** The avionics onboard the aircraft that implements the communication protocol and provides the interface to other on-board elements via an on-board network.

**Air Navigation Service Provider (ANSP):** a body that manages flight traffic on behalf of a company, region or country.

**Transaction:** The basic unit of interaction between peer parties used for operational, safety and performance assessments. An interaction includes one or more operational messages that are transmitted using the same communication medium from one party to the other. It also includes related message activities, i.e. message identification, message composition, and message recognition.

**Connection Establishment Delay:** Connection establishment delay, as defined in ISO 8348, includes a component, attributable to the called subnetwork (SN) service user, which is the time between the SN-CONNECT indication and the SN-CONNECT response. This user component is due to actions outside the boundaries of the satellite subnetwork and is therefore excluded from the AMS(R)S specifications.

**Data Transfer Delay requirements** are set by the need to assure that data link messages are delivered through the communications system in a timely manner. The measured transfer delay characteristics of a subnetwork and its elements are normally characterized by data which, plotted as a histogram, appear as an probability distribution having a biased offset (latency) from the zero value. The DO-270 expresses three different values of transfer delay the latency, the mean value (transit delay) and the 95th-percentile value. These values are the minimum necessary to combine properly the delay data of individual elements, systems and subnetworks for aggregated delay values (e.g., for "end-through-end" delays). (RTCA DO-270).

**Data Transfer Latency** of the AMS(R)S System is defined under conditions of no user traffic loading other than the test block itself; however, normal system management traffic and protocol overhead traffic are expected to be present, due to management entities internal to the subnetwork. Thus,

latency is the minimum delay that can be expected within the system, and accounts for the relatively fixed delay components such as propagation delay, component transmission speeds, and latent buffering.[RTCA DO-270 Section 2.2.5.1.4]

**Data Transit Delay:** in packet data system, the elapsed time between a request to transmit an assembled data packet and an indication at the receiving end that the corresponding packet has been received and is ready to be used.

**Validation:** the process which demonstrates the conformance of the system to the user needs

*Note: The SATCOM system is only verified against the SRD requirements to transport messages from the aircraft antenna to the attachment point of the GES within the defined coverage and within the defined performance parameters. To validate that this SATCOM service is suitable to support operational application, additional activities are needed, including the procedures and the HMI in the ATS Units and in the cockpit. Validation therefore requires the contribution of multiple actors. The end result of the validation is a safety assessment submitted respectively by the aircraft operator or by the ATSP to their competent authorities. The Communication Service Provider (CSP) is not legally responsible for this latter process.*
*Note: In this document validation has to be understood in the Airbus definition. The document is written in this way to better reflect the activity at the project level. It is clear that for SJU it represents another level of verification but the project members have chosen to proceed this way in order to ease the definition of the activities to be performed during the project.*

**Verification:** the process which demonstrates the conformance of the SATCOM system to applicable requirements

## 1.5 Acronyms and Terminology

| Acronym | Definition |
|---|---|
| **ACARS** | Aircraft Communications Addressing and Reporting System |
| **ACSP** | Aeronautical Communications Service Provider |
| **AES** | Aeronautical Earth Station |
| **AGW** | Air-Ground Gateway |
| **AMS(R)S** | Aeronautical Mobile Satellite (Route) Service |
| **AMU** | Audio Management Unit |
| **ATC** | Air Traffic Control |
| **ATM** | Air Traffic Management |
| **ATN** | Aeronautical Telecommunication Network |
| **ATS** | Air Traffic Services |
| **ATSP** | Air Traffic Service Provider |
| **ATSU** | Air Traffic Services Unit |
| **BGAN** | Broadband Global Area Network |
| **BITE** | Build In Test Equipment |

| Acronym | Definition |
|---|---|
| **BOP** | Bit Oriented Protocol |
| **CMC** | Central Maintenance Computer |
| **CMU** | Communication Management Unit |
| **CMS** | Central Management System |
| **CNS** | Communication Navigation Surveillance |
| **CSP** | Communication Service Provider |
| **CWP** | Controller Working Position |
| **DSP** | Data Service Provider |
| **E-ATMS** | European Air Traffic Management System |
| **ECAM** | Electronic Centralised Aircraft Monitoring |
| **E-OCVM** | European Operational Concept Validation Methodology |
| **EUROCAE** | European Organisation for Civil Aviation Equipment |
| **EUT** | Equipment Under Test |
| **FANS** | Future Air Navigation System |
| **FIB** | Functional Integration Bench |
| **FMS** | Flight Management System |
| **FTR** | Flight Test Request |
| **FWC** | Flight Warning Computer |
| **FWS** | Flight Warning System |
| **GGW** | Ground-Ground Gateway |
| **HMI** | Human Machine Interface |
| **HSDU** | High Speed Data Unit |
| **i4D** | Initial 4D (Trajectory Management) |
| **ICD** | Interface Control Document |
| **IDRP** | Inter Domain Routing Protocol |
| **ISM** | In-Service Monitoring |
| **LGCIU** | Landing Gear Control Interface Unit |

| Acronym | Definition |
|---|---|
| **LR** | Long Range |
| **LTR** | Laboratory Test Request |
| **MCDU** | Multifunction Control Display Unit |
| **OSED** | Operational Service and Environment Definition |
| **OSI** | Open System Interconnection |
| **PDU** | Protocol Data Unit |
| **PIR** | Project Initiation Report |
| **PTS** | Purchaser Technical Specification |
| **RTCA** | Radio Technical Commission for Aeronautics |
| **SA** | Single Aisle |
| **SARPs** | Standards and Recommended Practices |
| **SBB** | SwiftBroadband (aeronautical derivative of the BGAN service) |
| **SDM** | System Definition Manual |
| **SDU** | Satellite Data Unit |
| **SESAR** | Single European Skies ATM Research |
| **SIB** | System Integration Bench |
| **SID** | System Interface Document |
| **SJU** | SESAR Joint Undertaking |
| **SPR** | Safety and Performance Requirements |
| **SRD** | System Requirements Document |
| **SUT** | System Under Test |
| **SVS** | Shared Virtual Sky |
| **TAD** | Technical Architecture Description |
| **TS** | Technical Specification |
| **UT** | User Terminal |
| **VDL** | VHF DataLink |
| **VVO** | Verification and Validation Objectives |

# 2 Context of the Verification

Project 15.02.05 is a technological project dealing with the addition of SATCOM system as a new communication mean that can be used over ATN network. Iris Precursor system is envisaged as a complementary solution supporting i4D and aeronautical data sharing.

The objective of the verification phase was thus to perform real evaluation of the Iris Precursor system, using prototypes in laboratory environment and Flight trials.

The corresponding Verification Plan / Strategy is documented in the document 15.02.0-D02.

## 2.1 System Overview

Iris Precursor system is composed basically of two main airborne equipment, SATCOM and ATSU (highlighted in Figure below). The SATCOM is providing SBB connection through SBB Inmarsat I-4 satellite constellation while the ATSU is providing the ATN connectivity.

Under 15.02.05 project both system prototypes will be available to perform verification exercises.

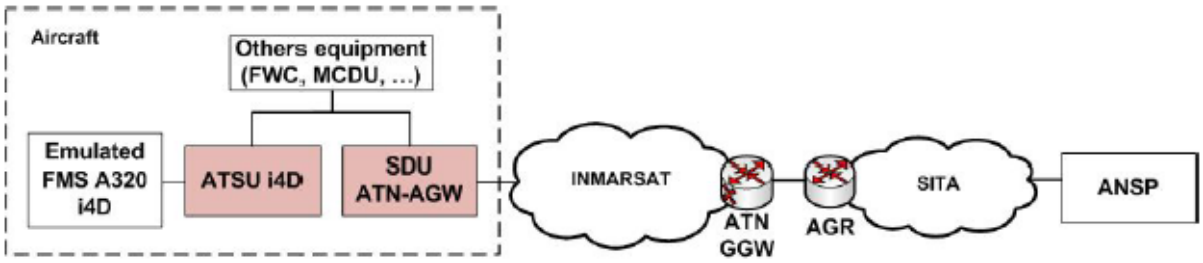


Figure 1: Iris Precursor System Overview

The Iris Precursor SATCOM prototype is based on the existing and certified MCS-7200 mod C developed by Honeywell. In the frame of this project, Honeywell will develop a specific software module implementing the ATN Airborne Datalink Gateway (ATN-ADGW) that is the counterpart of the ATN Ground Datalink Gateway (ATN-GGW). This modification is limited to software and adaptation of existing SATCOM module. No hardware modification needed.

The Iris Precursor ATSU prototype is based on:

- Last ATSU FANS B+ product (CSB8.3) for the hostplatform, Router (ATN capability over SATCOM) and Hardware
- Last ATSU SESAR prototype i4D capable (ATSU std3) for ATC applications. The application is a reuse without any modification

The adaptation is done on hostplatform for the SATCOM interface and on the router to add ATN capability over SATCOM.

The definition of the interface between SATCOM and ATSU has been addressed in 15.02.05 – D04.

## 2.2 Summary of Verification Exercise/s

### 2.2.1 Summary of Verification Objectives

Iris Precursor Verification Objectives have been defined with the SESAR 15.02.05 partners and are listed in the attached Excel file:

15.02.05 - Iris Precursor Verification

### 2.2.2 Choice of methods and techniques

Refer to the Verification Plan (15.02.05 - D02)

# 3 Conduct of Verification Exercises

## 3.1 Verification Exercises Preparation

The main activities for the Verification Exercises preparation were:

- The definition of verification strategy and plan, the identification of the verification objectives, and the determination of the required test infrastructures. These points were addressed within 15.02.05 Task x, and their resolution was documented in the deliverable 15.02.05-D02
- The ATSU prototype #1 development, within 15.02.05-Task 12. A second version of the prototype was completed in 15.02.05 Task 13
- The SATCOM Honeywell prototype #1 development, within 15.02.05-Task 10. A second version of the prototype was completed in 15.02.05 Task 11
- The test procedures for the laboratory testing phase 2 and Phase 3.1 and for Flight tests scenarios. This was respectively achieved within 15.02.05 Tasks 14, 15, 18 and 20, and the results are documented in this deliverable.

## 3.2 Verification Exercises Execution

The SESAR 15.02.05 tests were organized in 4 main phases:

| Verification phase | WP15.2.5 WBS | Contributor | Coordination activities |
|---|---|---|---|
| Phase 1.1: ATSU equipment verification | T012 and T013 ATSU System development | **Airbus**: To develop ATSU according to system specifications | |
| Phase 1.2: SATCOM equipment verification | T010 and T011 SATCOM System development | **Honeywell**: To develop SATCOM (ATN/OSI GW) according to system specifications | **Integration with Aero Safety Ground infrastructure (ESA Iris Precursor project)** |
| Phase 2.1: ATSU-SDU integration verification<br>Phase 2.2: Airborne integration verification with ATN-AGW | T014 Laboratory test request<br>T015 Laboratory test procedure<br>T016 Laboratory test | **Airbus**: To run the laboratory tests | **Integration with Aero Safety Ground infrastructure (ESA Iris Precursor project)** |
| Phase 3.1: Iris Precursor system verification (lab test), including the end-to-end ATN data link chain, which includes the satellite communication medium and the full data link chain at ANSPs | T017 Laboratory test request<br>T018 Laboratory test procedure<br>T019 Laboratory test | **Airbus: To run the laboratory tests**<br>**Honeywell: for test support and anomalies analysis**<br>**MUAC: for test support (ground side) and i4D test scenarios** | **Inmarsat (ESA Iris Precursor project), ACSP, ANSP** |
| Phase 4.1: Iris Precursor system verification (flight test) | T020.1 Flight test request<br>T021 Flight test | **Airbus: To run the flight tests**<br>**Honeywell: for test support and** | **Inmarsat (ESA Iris Precursor project), ACSP, ANSP** |

| | | | |
|---|---|---|---|
| | | **anomalies analysis**<br>**MUAC: for test support (ground side) and support for flight test scenarios** | |

Table 1 below indicates the dates of execution and analysis of these Verification Exercises

| Exercise ID | Exercise Title | Actual Exercise execution start date | Actual Exercise execution end date | Actual Exercise start analysis date | Actual Exercise end date |
|---|---|---|---|---|---|
| Phase 1.1 | Airborne systems development: ATSU equipment Verification | 05/02/2015 | 19/06/2015 | 22/06/2015 | 20/09/2015 |
| Phase 1.2 | Airborne systems development: SATCOM equipment Verification | 05/10/2014 | 12/10/2015 | 22/06/2015 | 09/10/2015 |
| Phase 2.1 | ATSU-SDU Integration Verification | 22/06/2015 | 23/10/2015 | 16/10/2015 | 15/12/2015 |
| Phase 2.2 | Airborne Integration verification with ATN-AGW | 12/10/2015 | 06/11/2015 | 19/10/2015 | 15/12/2015 |
| Phase 3.1 | Iris Precursor System Verification (Laboratory) | 8/12/2015 | 31/01/2016 | 18/01/2016 | 21/03/2016 |
| Phase 4.1 | Iris Precursor System Verification (Flight Test) | 15/02/2016 | 30/03/2016 | 23/02/2016 | 30/04/2016 |

Table 1: Verification Exercises execution/analysis dates

The following diagram (Figure 2) is summarizing all the Verification activities performed in the frame of SESAR 15.2.5 project. It gathers the date the activities were performed, which stakeholders that were contributing and also the test configuration that was used (Figure 3).

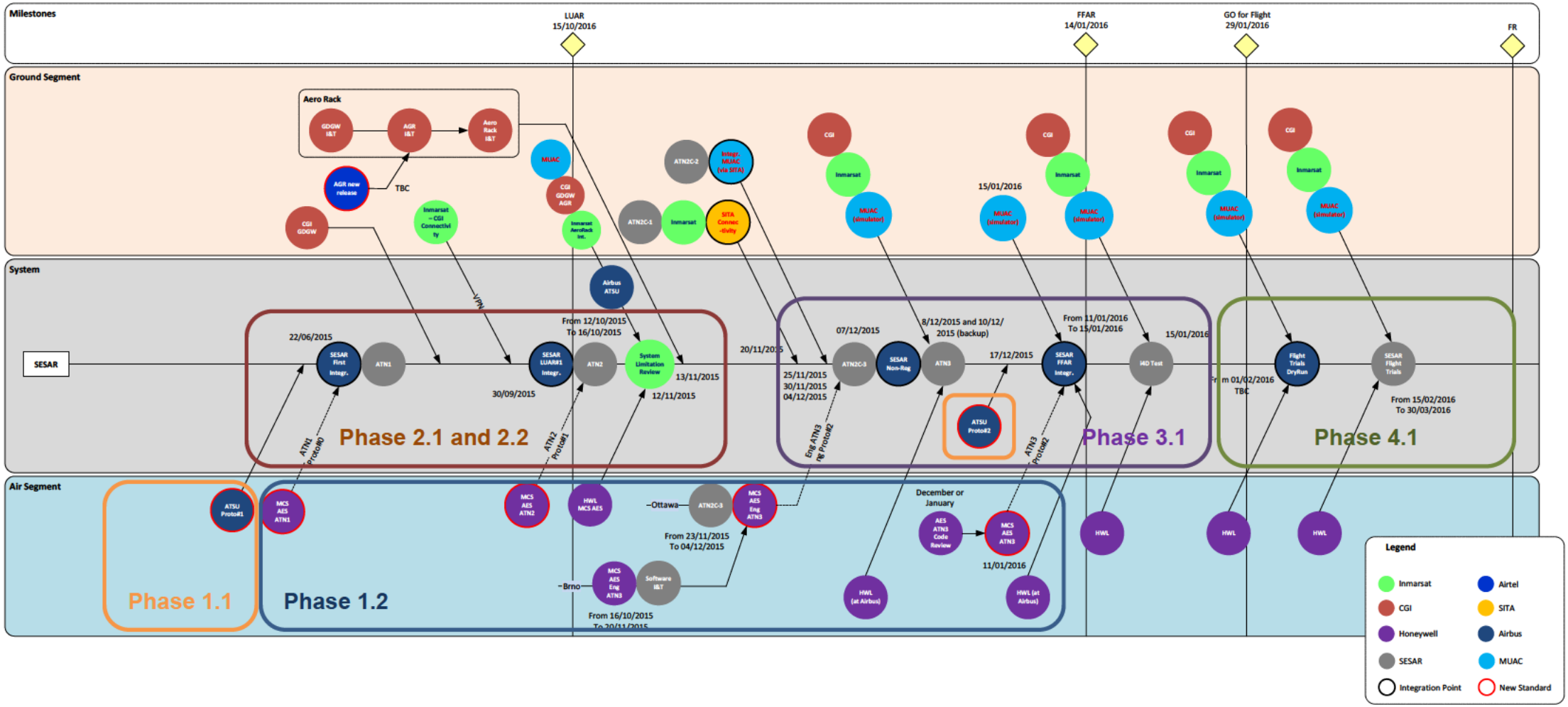


Figure 2: Verification Exercise Sequence and ESA - SESAR contributor

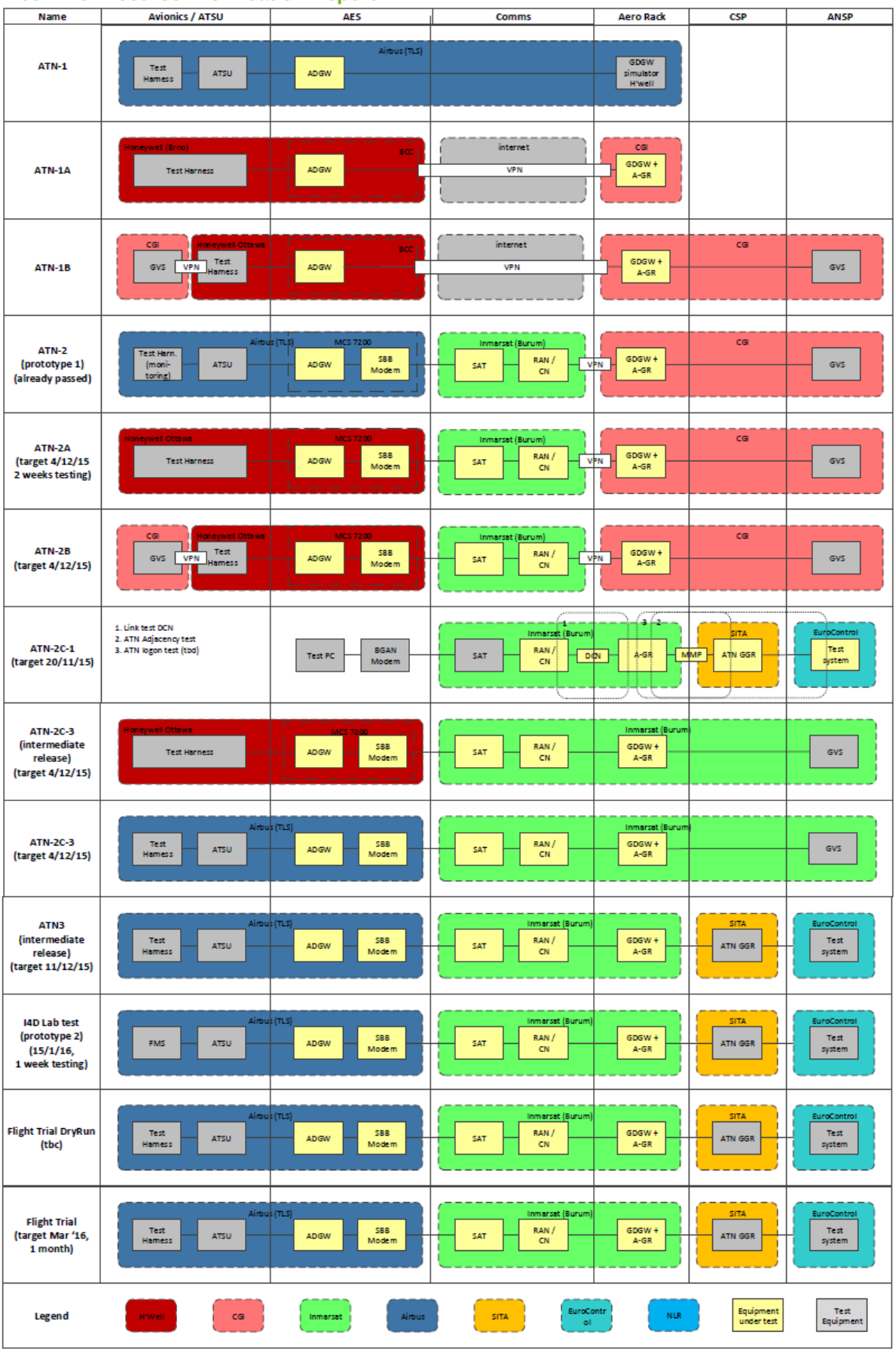


Figure 3: Iris Precursor Test Configurations

## 3.3 Deviations from the Planned Activities

### 3.3.1 Deviations with Respect to the Verification Strategy

N/A

### 3.3.2 Deviations with Respect to the Verification Plan

Compared to the Verification Plan [D02] some deviations have arisen along the project course. The following deviations are listed hereunder:

- It was agreed that validation activities defined in D02 are in fact verification activities in the eye of SJU. To ease the reading, this document will only refer to verification exercise
- It was planned that the modification will be performed on SDU and HSDU equipment. It was finally decided that the modification will be only made on HSDU equipment as Honeywell is proprietary of this product.
- Due to the directly above deviation, Airbus laboratory and Airbus Aircraft adaptation were necessary. It was basically wiring modification.
- Delay on component delivery led the project to decide to split SATCOM prototype #1 in two prototypes (proto#0 and proto#1). See details in section 6.2.2
- VPN establishment for Phase 2.2 test configuration was made between Inmarsat and CGI due to Airbus difficulties to setup properly the VPN configuration (Airbus security constraints)
- MUAC is the only ANSP to actively participate in Phase 3 and 4 testing.

*Note: It is worth to note that none of these deviations are impacting the VVO defined in the frame of the SESAR Iris Precursor project.*

# 4 Verification exercises Results

## 4.1 Summary of Verification Exercises Results

The Table 2 below is synthesizing all the test results in regard to Verification Objective and for all the Verification phases of the 15.02.05 project.

Different VVO status in the sixth column are depicted:

- Passed means the test has been successfully completed
- Partially Passed means that not all test procedures were successful and minor limitation noticed and reported in comment column
- Not completed means test procedures were not all performed
- Failed means the test was not successful

| Phase 1.1: ATSU equipment verification | | | | | | |
|---|---|---|---|---|---|---|
| **High Level VVO Id** | **High Level VVO** | **Specification requirement** | **VVO Id** | **VVO** | **VVO Status** | **Comment** |
| OBJ-15.02.05-VS-ATSU_VVO-0001 | Verify the compliance of the ATSU with the PTS. | A.AR.COM607R.07 | 6110 | Verify the SAT Dispatcher determines Join/Leave event information from BDS SSATATNSBB/1 parameter and forwards them to the ATN router. | Passed | |
| | | A.AR.COM608R.07 | 6111 | Verify the SAT Dispatcher generates a Leave event as soon as the satcom subnetwork is detected in an inop state. | Passed | |
| | | A.AR.COM609R.07 | 6112 | Verify the Convergence Layer forwards data between CLNP layer and SAT Dispatcher. | Passed | |
| | | A.AR.COM610R.07 | 6113 | Verify the CL SNDCF layer only transmits data to SAT Dispatcher if the ARINC 429 WB V3 protocol has been successfully established with the SDU. | Passed | |
| | | A.AR.COM146R.01 | 6114 | Verify the ARF Router only sends blocks to SDU when:<br>- BDS parameter SNOTSATLINK/1 is reset (link available)<br>- or BDS parameter SSATACARSLEG/1 is set<br>- or BDS parameter SSATACARSSBB/1 is set | Passed | |
| | | A.AR.ATN032R.01 | 6115 | Verify the ATN airborne correctly implements the 'ATN_Comm' boolean. This bolean will be set to:<br>- '1' if the FIB comprises at least one route received via an IDRP connection established with an a/g router over the Satcom subnetwork | Passed | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | - '0' otherwise | | |
| | | A.AR.COM611R.07 | 6116 | Verify that upon valid status word (label 270) recovery from SDU, the ARF router re-initializes the version of the ARINC 429 WB protocol (version 1 or 3) used before the label gets invalid. | Passed | |
| | | A.AR.COM612R.07<br>A.AR.COM614R.07 | 6117 | Verify the ARF Router requests a switching from the version 1 to the version 3 of the ARINC 429 WB protocol only the first time it received a BDS parameter SSATBOPMODE/1 valid and set to 1. | Passed | |
| | | A.AR.COM455R.01 | 6118 | Verify the ARF Router uses the I/F4' interface to convey through 429 WB V3 protocol:<br>- Control exchanges with the SDU<br>- ACARS and ATN uplink /downlink data exchanges with the SDU (exclusively and simultaneously) | Passed | |
| | | A.AR.COM616R.02<br>A.AR.COM617R.02 | 6119 | Verify that when using IF4' to send (respectively receive) data to (from) the SDU, the ARF Router adds (removes) a header encapsulating data within the ARINC 429 BOP frames.<br>Note: This header will be composed of one single byte including:<br>- 3 first MSB (most significant bits) describing the Protocol ID, set to '5'<br>- 5 last LSB (least significant bits) describing the Version, set to '0' | Passed | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | A.AR.COM456R.01 | 61110 | Verify that at initialization, the ARF Router registers to I/F 4', i.e. it communicates to AGCM-PROTO-WB-V3 the list of GFIs allowed for this interface :<br>- GFI list= '5' and 'E' hex for SDU | Passed | |
| | | A.AR.COM457R.01 | 61111 | Verify the ARF Router completes 429 WB V3 protocol initialization prior to sending any file request to the SDU. | Passed | |
| | | A.AR.COM613R.07 | 61112 | Verify that if the ARINC 429 WB V3 protocol is used for ATSU/SDU interface and if the ARF Router is informed of an ALO V1 or an ALR V1 receipt from SDU, the ARF Router requires a new ARINC 429 WB V3 initialization sequence (ALO/ALR exchange).<br>Note : Receipt of ALO and ALR V1 will be reported to ARF Router by the AGCM-PROTO WB V3 module:<br>- Receipt of ALO V1 should only be reported to the ARF Router after the version 3 of the protocol has been successfully established.<br>- Receipt of an ALR V1 should only be reported to the ARF router during the initialization sequence of the version 3 of the protocol. | Passed | |
| | | A.AR.COM615R.07 | 61113 | Verify the ARF Router checks that a GFI corresponds to a message allowed at the time it is received. | Passed | |
| SYSM IF INF GESTION SOURCE V3 I2 | Verify ISM logs defined for the new interface between ATSU and SDU are correctly recorded. | | 61114 | Verify the ARF router correctly records all ATN downlinks intented to the SDU as ISM logs. | Passed | |
| | | | 61115 | Verify the ARF Router correctly records all ATN uplinks received from the SDU as ISM | Passed | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | logs. | | |
| | | | 61116 | Verify the ARF Router correctly records all signals exchanged between the SAT dispatcher and the ATN stack as ISM logs. | Passed | |
| | | | 61117 | Verify the ARF router correctly records all switches of A429 protocol version (switch from version 1 to version 3) as ISM logs. | Passed | |
| AGCM PROTO WB V3 I01 V02 | Verify the compliance of the AGCM PROTO WB V3 module with the PTS. | A.W3.GEN002R.01 | 61118 | Verify the ARINC 429 Williamsburg version 3 protocol between the ATSU and the SDU is interrupted upon refresh default of SDU status word. | Passed | |
| | | A.W3.GEN018R.01 | 61119 | Verify that when it received an initialisation request from the SDU (apart from start phase and phase of protocol re-activation upon status label recovery) and this request includes a switch request of protocol version, the AGCM PROTO WB V3 module forwards this initialisation request to the ARF Router. | Passed | |
| | | A.W3.GEN017R.01 | 61120 | Verify that when the SDU answered to the ALO sent by the ATSU with a ALR including a different protocol version number, the AGCM PROTO WB V3 module forwards that switch request of protocol version to the ARF Router. | Passed | |
| | | A.W3.GEN006R.02 | 61121 | Verify that when it received a switch request of protocol version from the SDU whereas a message is being received, the AGCM PROTO WB V3 module discards that partially received message. | Passed | |
| | | A.W3.GEN008R.01 | 61122 | Verify the AGCM PROTO WB V3 module discards a message which has been received but not yet transmitted to the upper layer when it received a switch request of protocol version from the SDU. | Passed | |

| Phase 1.2: SATCOM equipment verification | | | | | | |
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| **High Level VVO Id** | **High Level VVO** | **Specification requirement** [SES] section number: DOORS ID | **VVO Id** | **VVO** | **VVO Status** | **Comment** |
| OBJ-15.02.05-VS-SDU_VVO-0001 | Verify the compliance of the SDU with the PTS. | **3.1.1:** All<br>**3.1.4:** SES-65, SES-80 | 6120 | Verify that the scope of the AES changes complies with SES. Particularly verify that:<br>- AES can establish and maintain the SBB link (the SBB stack and modem are not impacted)<br>- The following AES interfaces were not *adversaly* (note 2) impacted: LGCIU, FWC, CMC, HPP, Data Loader, MCDU, AMU, ADIRS (see [PTS] REQ-SATCOM_IrisPrec-023) | Passed | |
| | | **3.1.2:** All | 6121 | *Verify that reconfiguration of the AES between Precursor and Normal mode works correctly.* | Passed | It is done by HSDU dataloading |
| | | **3.1.3:** SES-43 | 6122 | Verify, that after power on in Precursor mode the AES automatically establishes the ATN/OSI air/ground subnetwork link over SBB | Passed | |

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| | | **3.1.3:** SES-45, SES-48, SES-49, SES-42<br>**3.3.1:** SES-51<br>**3.4.6:** SES-103 | 6123 | Verify, that AES correctly generates Join and Leave events to the ATSU:<br>- Join and leave annunciation format in line with ICD<br>- Timing in line with SES | Passed | |
| | | **3.1.4.3:** SES-68, SES-69, SES-70<br>**3.3.1:** SES-51 | 6124 | Verify, that AES correctly reports abnormal status to the ATSU:<br>- Failure reporting detected by BITE is unchanged (note 1)<br>- Link unavailability is correctly reported per ICD | Passed | |
| | | **3.1.4.4:** SES-54, SES-56, SES-46 | 6125 | Verify that:<br>- Logon failure is correctly reported on the AES test interface.<br>- in case of logon failure the logon attempt is always automatically repeated | Passed | |
| | | **3.1.4.5:** SES-71 | 6126 | Verify the automatic recovery procedure in case of loss of the air/ground link. | Passed | |
| | | **3.2.3:** All | 6127 | Verify, that the specified AES parameters can be monitored from a test controller during AES runtime, when the test controller is connected.<br><br>***Note:*** *The test controller is expected to be connected during lab trials, but not in the test aircraft.* | Passed | The monitoring is implemented and has been validated during Honeywell "factory tests" but I's not really used at Airbus lab or test aircraft. |
| | | **3.2.4:** All | 6128 | Verify that:<br>- AES can operate without test controller being connected.<br>- Specified data and events are correctly logged in the HSU non-volatile memory<br>- The logged data can be downloaded after the test for offline analysis | Passed | |

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| | | **3.3.1:** SES-51<br>**3.3.3.2:** SES-118 | 6129 | Verify that labels 172, 270, 271 and 377 are correctly reported to ATSU. | Passed | SES-118 removed because it is covered in ICD |
| | | **3.3.1:** SES-51 | 6130 | Verify that:<br>- BOPv3 session is correctly established between ATSU and AES<br>- Data are correctly exchanged over BOPv3 between ATSU and ATN-AGW.<br>- The BOPv3 timers, labels and frame format are correctly implemented<br><br>***Note:*** *In fact with the current solution there is additional "hop" between BOPv3 end system in the AES and the ATN-AGW. This is the serial bus between CP card and Channel Card inside HSU. This is expected to be covered by one end-to-end link test, where BOPv3 is established, followed by exchange of some test data patterns.* | Passed | |
| | | **3.3.3.2:** SES-123 | 6131 | Verify the correct encapsulation of ATN/OSI packets in BOPv3 FDUs. | Passed | |
| | | **3.3.3.4:** All<br>**3.4.1:** SES-52<br>**3.4.2:** SES-112 | 6132 | Verify, that BOPv3 data are correctly forwarded by the SDU to the HSU.<br><br>***Note:*** *In principle this is covered by the end-to-end tests, but this test can be performed at the SDU black-box level and because SDU would be under Thales responsibility, the test is desirable. It also validates assumption used in the [SES] timing analysis.* | N/A | Architecture change. HSDU is now embedding Iris function. No modification done on SDU side |
| | | **3.4.4:** SES-102 | 6133 | Verify the AES logon duration under representative scenarios. | Passed | |

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| | | **3.4.5:** SES-101 | 6134 | Verify that the delay of the aircraft position reported towards the ground in the signaling generated by ATN-AGW complies with the specification. | Passed | Despite the position timing requirement was not relevant for 15.2.5, it was tested and appears to be within proposed limits |

| Phase 2.1: ATSU-SDU integration verification | | | | | | | |
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| **High Level VVO Id** | **High Level VVO** | **Specification requirement ID** | **Specification requirement** | **VVO Id** | **VVO** | **VVO Status** | **Comment** |
| OBJ-15.02.05-VS-ATSU_SDU-VVO-0001 | Verify the compliance of the SATCOM-ATSU interfaces with the SID. | ATN_AGW-SID-0001 | ATN services | 6211 | Check that ATSU and SDU exchange correctly (i.e. without any retry or rejection) messages (e.g. CNLP packets or ISH PDUs) in both direction.<br>Expected results: 'SATCOM subnetwork acces' functional block operates as described in the ATSU-SDU SID<br>ATSU is ready for notification phase (check on MCDU)<br>Airbus lab: perform test and collect logs (ATSU & SATCOM)<br>Equipment suppliers (ATSU & SATCOM): perform analysis on logs and check if results are as expected | Partially Passed | ATSU Open issue:<br>- ATSU IRIS ISH frames retransmissions at [ES-IS] layer level (DMD 815) |
| | | ATN_AGW-SID-0002 | WB v3 | | | | |
| | | ATN_AGW-SID-0009 | GFI | | | | |
| | | ATN_AGW-SID-0035 | Header | | | | |
| | | ATN_AGW-SID-0036 | Header | | | | |
| | | ATN_AGW-SID-0010 | Label 304 | | | | |
| | | ATN_AGW-SID-0011 | Label 307 | | | | |
| | | ATN_AGW-SID-0017 | Label 172 | 6212 | Check that the label 172 transmitted by SDU is correctly managed by ATSU<br>Expected results: ATSU switches to ARINC 429 WB V3 upon reception of the label 172 bit 18 set to 1.<br>Airbus lab: perform test and collect logs (ATSU & SATCOM)<br>Equipment suppliers (ATSU & SATCOM): perform analysis on logs and check if results are as expected | Failed | One issue reported:<br>- ATSU IRIS Williamsburg V3 ATSU Negotiation with SATCOM robustness (DMD 813) |
| | | ATN_AGW-SID-0003 | ATSU to ground packets | 6213 | Check messages exchange to the ground:<br>Check that the ATSU (resp. SDU) forwards messages encapsulated within data packets (e.g.: CLNP packets or ISH PDUs) to the SDU (resp. ATSU) for transmission and reception over an emulated SBB service. | Not completed | Phase 2.1: no AAP layer emulation. |
| | | ATN_AGW-SID-0031 | Ground to ATSU packets | | | | |

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| | | | | | Expected results:<br>- ATSU exchange CLNP and ES-IS packets (ISH, IDRP open) correctly encapsulated by AAP with the emulated ground (laptop).<br>- In the other way, the AAP packets are unencapsulated and the CLNP and ISH packets are sent to the ATSU.<br>Airbus lab: perform test and collect logs (ATSU & SATCOM)<br>Equipment suppliers (ATSU & SATCOM): perform analysis on logs and check if results are as expected | | |
| | | ATN_AGW-SID-0012 | Join | 6214 | Check ATSU behavior when a join event is sent by the SDU<br>Expected results: when the SDU issues a "join event" to the ATSU to indicate the availability of a communication path the ATSU starts to establish a route (by sending an ISH PDU) (ARINC 429 Label 271)- .<br>- 'SATCOM subnetwork management' functional block operates as described in the ATSU-SDU SID | Passed | Sending messages is not possible after 'Leave' event (traffic stopped); but ATSU does not explicitly discard routes.<br>One issue reported:<br>- ATSU IRIS Loss of connectivity (ATN service) partially taken into account (DMD 814) |
| | | ATN_AGW-SID-0029 | Label 271 | | | | |
| | | ATN_AGW-SID-0030 | Bit 28 | | | | |
| | | ATN_AGW-SID-0013 | Leave | 6215 | Check ATSU behavior when a leave event is sent by the SDU<br>Expected results: when the SDU issues a "leave event" to the ATSU to indicate that a previously available communication path over SATCOM is no longer available the ATSU discards the route that was established (ARINC 429 Label 271).<br>- 'SATCOM subnetwork management' functional block operates as described in the ATSU-SDU SID | Partially Passed | Sending messages is not possible after 'Leave' event (traffic stopped); but ATSU does not explicitly discard routes.<br>One issue still open:<br>- ATSU IRIS IDRP questionable traffic (DMD 816) |
| | | ATN_AGW-SID-0029 | Label 271 | | | | |
| | | ATN_AGW-SID-0030 | Bit 28 | | | | |
| | | ATN_AGW-SID-0025 | Label 270 from ATSU | 6216 | Check ATSU (resp. SDU) behavior based on label 270 content | Partially Passed | ATN loss is not reported at operation level |

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| | | ATN_AGW-SID-0026 | Label 270 from SDU | | Expected results: the ATSU transmit data packets (downlink) to the SDU and in the other way SDU to the ATSU (uplink) only when datalink is reported as available and ATSU reported as active (ARINC 429 Label 270).<br>- 'SATCOM subnetwork management' and 'SATCOM status' functional blocks operate as described in the ATSU-SDU SID | | whereas data packets are no more transmitted to SATCOM. |
| | | ATN_AGW-SID-0018 | Label 270 | | | | |
| | | ATN_AGW-SID-0019 | Label 270 from SDU | | | | |
| | | ATN_AGW-SID-0020 | Label 270 from ATSU | | | | |
| | | ATN_AGW-SID-0023 | Label 270 bits from SDU | | | | |
| | | ATN_AGW-SID-0024 | Label 270 bits from ATSU | | | | |
| OBJ-15.02.05-VS-ATSU_SDU-VVO-0002 | Verify the compliance of the SATCOM-ATSU behaviour with the PTS SATCOM. | REQ-SATCOM_IrisPrec-027 | SDU labels | 6217 | Check that logs are available and sufficient to troubleshoot problems in phase 3&4<br>Check that logs are available in real time on maintenance port (on-line)<br>Check that logs can be retrieved through a maintenance port (off-line)<br>Expected results: SDU logs are consistent with laboratory test scenario, at least for: join/leave events, messages content, keepalive exchanges with the ground - including timestamping | Partially Passed | SATCOM logs do not contain PDP context information. |
| | | REQ-SATCOM_IrisPrec-029 | join/leave events | | | | |
| | | REQ-SATCOM_IrisPrec-031 | IP address | | | | |
| | | REQ-SATCOM_IrisPrec-032 | PDP context | | | | |
| | | REQ-SATCOM_IrisPrec-033 | Keepalive | | | | |
| | | REQ-SATCOM_IrisPrec-034 | Keepalive | | | | |
| | | REQ-SATCOM_IrisPrec-035 | Timeout | | | | |

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| | | REQ-SATCOM_IrisPrec-038 | Labels | | | | |
| | | REQ-SATCOM_IrisPrec-039 | Data packets | | | | |
| | | REQ-SATCOM_IrisPrec-043 | Internal param | | | | |
| | | REQ-SATCOM_IrisPrec-037 | Timestamp | | | | |
| | Overall non-regression test for SATCOM System | REQ-SATCOM_IrisPrec-023 | Interfaces | 6218 | Check that the IRIS precursor airborne SATCOM system behavior is correct on the interfaces that have not changed (non regression).<br>Interfaces non impacted:<br>- Voice services (tbc)<br>- MCDU HMI<br>- FWS (no spurious alert)<br>- CMC (no spurious fault)<br>- dataloading<br>Note: The SDU doesn't support ACARS traffic. | Passed | Phase 2.1: no real network connection.<br>Phase 2.2: Test successful |
| | Overall non-regression test for ATSU System | A.CO.COM168 R.01 | Interfaces | 6219 | Check that the IRIS precursor airborne ATSU system behavior is correct (non regression).<br>Interfaces non impacted:<br>- FWS (no spurious alert)<br>- CMC (no spurious fault)<br>- dataloading | Partially Passed | WARNING Verification (non regression): No spurious noticed.<br>BITE Verification (non regression): spurious observed (failures and interactivity).<br>Dataloading OK. |

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| | Overall robustness test for IRIS precursor airborne system | REQ-SATCOM_IrisPrec-010 REQ-SATCOM_IrisPrec-012 A.AR.COM611 R.07 A.AR.COM608 R.07 | | 62110 | Check ATSU and SATCOM system behavior when the following events occur:<br>- SATCOM system is restarted (loss of periodic labels)<br>- ATSU is restarted (loss of periodic labels)<br>- Label 270 transmitted by the SDU sent with SSM set to FT (Functional Test)<br>- Label 270 transmitted by the SDU sent with SSM set to FW (Failure Warning)<br>- Label 270 transmitted by the SDU sent with SSM set to NCD (No Computed Data)<br>Expected results:<br>- the air-ground communication is correctly recovered,<br>- the ATSU re-initializes the ARINC 429 WB version 3 protocol used before the label gets invalid and then re-establishes an ATN connection with the ground as soon as ATN capability has been advertised by the SDU (Label 271). | Partially Passed | No ATSU robustness to SATCOM labels loss or invalidity. |

| Phase 2.2: ATSU-SDU integration verification | | | | | | | |
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| **High Level VVO Id** | **High Level VVO** | **Specification requirement ID** | **Specification requirement** | **VVO Id** | **VVO** | **VVO Status** | **Comment** |
| | | ATN_AGW-SID-0001<br>ATN_AGW-SID-0003<br>ATN_AGW-SID-0031 | | 6221 | Check messages exchange to the ground:<br>Check that the ATSU (resp. SDU) forwards messages encapsulated within data packets (e.g.: CLNP packets or ISH PDUs) to the SDU (resp. ATSU) for transmission and reception with a ground ATN router via SBB services.<br>Expected results:<br>- ATSU exchange CLNP and ES-IS packets (ISH, IDRP open) correctly encapsulated by AAP with the emulated ground (laptop).<br>- In the other way, the AAP packets are unencapsulated and the CLNP and ISH packets are sent to the ATSU.<br>Airbus lab: perform test and collect logs (ATSU & SATCOM)<br>Equipment suppliers (ATSU & SATCOM): perform analysis on logs and check if results are as expected | Passed | |
| | | ATN_AGW-SID-0012 | | 6222 | Check ATSU behavior when a join event is sent by the SDU<br>Expected results: when the SDU issues a "join event" to the ATSU to indicate the availability of a communication path the ATSU starts to establish a route (by sending an ISH PDU) (ARINC 429 Label 271). | Passed | |
| | | ATN_AGW-SID-0013 | | 6223 | Check ATSU behavior when a leave event is sent by the SDU<br>Expected results: when the SDU issues a "leave event" to the ATSU to indicate that a previously available communication path over SATCOM is no longer available the ATSU discards the route that was | Passed | OVV passed with L2 configuration. |

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| | | | | | established (ARINC 429 Label 271). | | |
| | | ATN_AGW-SID-0028 | events filtering | 6224 | Check SATCOM system behavior when frequent "join/leave" events occur:<br>- Check AAP logoff with the ground<br>Expected results:<br>- The SATCOM filters overly frequent events and reports to ATSU a "join/leave" at most every 10 seconds | Not completed | Filtering mechanisms not implemented at SATCOM level. |
| OBJ-15.02.05-VS-ATSU_SDU-VVO-0002 | Verify the compliance of the SATCOM-ATSU behaviour with the PTS SATCOM. | REQ-SATCOM_IrisPrec-004<br>REQ-SATCOM_IrisPrec-010<br>REQ-SATCOM_IrisPrec-013 | ATN services Automatic establishment /re-establishment | 6225 | Check route initiation with the ground and dynamic behavior of leave/join events<br>Expected results:<br>- Check that the SDU manages automatically the connection to the ATN-GGW and reports datalink status to the ATSU.<br>- Check that ATSU (re)initiate a route with the ground after receiving a join event | Partially Passed | SATCOM manages automatically the connection to the ATN-GGW and reports datalink status to the ATSU, except ground initiated log-off and dynamic satellite management.<br>ATSU does not reinitiate a route with the ground after receiving join event: in case IDRP Hold timer is not expired regarding previously established route, it keeps alive a route. |
| OBJ-15.02.05-VS-ATSU_SDU-VVO-0004 | Verify the SDU provides ATN/OSI network services over SBB to the ATS and AOC applications through the link between the SDU ATN-AGW and the ATN-GGW. | | | | | | |

| Phase 3.1: Iris Precursor system validation (lab test) | | | | | | |
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| **High Level VVO Id** | **High Level VVO** | **Specification requirement** | **VVO Id** | **VVO** | **VVO Status** | **Comment** |
| OBJ-15.02.05-VS-Validation-P3-001 | Validate the datalink function by using ATN/OSI network services, with the i4D related CPDLC messages and ADS-C Contracts, over SBB to the ATS and AOC applications, by re-using i4D related operational scenarios (using the i4D CPDLC message set and all ADS-C Contracts) as used during i4D validation campaign, which was executed by the operational SESAR project P04.03 in cooperation | | P15.2.5-PH3-VVO-041-1 | Check that the pilot initiated CM logon procedure with the ATC ground center is achievable (DLIC). | Passed | |

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| | with P09.01. As such both the INTEROP [INTEROP ATS] and SPR [SPR ATS] are subject of these validations. | | | | | |
| | | | P15.2.5-PH3-VVO-042-1 | Check that the Initial 4D function offers the capability to perform controller initiated end to end CPDLC exchanges using the following list of messages:<br>UM including a RTA constraint:<br>- Loadable messages in the FMS: UM252 UM256<br><br>UM including a route clearance:<br>- Loadable messages in the FMS: UM266 UM268<br><br>Others messages can also be exchanged:<br>Standard clearances: UM338<br>Loadable message in the FMS: UM336<br>Uplink without answer messages: UM289<br><br><u>Note:</u> message numbering is compliant with version H of SPR. | Passed | 'No answer UMs' test performed only with THA FMS |
| | | | P15.2.5-PH3-VVO-043-1 | Check that the CPDLC connection can be terminated properly via the SATCOM/ATN network. | Passed | Termination use cases sampled |

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| | | | P15.2.5-PH3-VVO-045-1 | Check that loss of CPDLC connection due to the SATCOM/ATN network can be detected by both airborne and ANSP systems. | Passed | Loss detection by both sides functionally OK<br>Timing expiration measured consistent |
| | | | P15.2.5-PH3-VVO-046-1 | Check that all ADS-C contract acceptation/cancellation mechanisms operate correctly. | Passed | Not assessed in multiple connections configuration with real FMW (Honeywell or Thales).<br><br>Assessed only in multiple connections configuration with FMS simulated (ANETO A) |
| | | | P15.2.5-PH3-VVO-047-1 | Check the end to end good behavior and functionning of ADS-C Demand contract including “EPP” and “RTA reliable interval".<br>Note: EPP downlinks containing various number of waypoints will be tested, especially maximum number (ie 128 waypoints). | Passed | With real FMS (Thales):<br><br>Tested on December 10th: ATSU L1 + HSDU L2 configuration (report with 128 waypoints received on ground)<br><br>With simulated FMS:<br>Limit tested with 127 waypoints (vs. 128) frame |
| | | | P15.2.5-PH3-VVO-048-1 | Check the end to end good behavior and functionning of ADS-C On Event contract including “EPP”.<br>Note: EPP downlinks containing various number of waypoints will be tested, especially maximum number (ie 128 waypoints). | Passed | MUAC front end limitation |
| | | | P15.2.5-PH3-VVO- | Check the end to end good behavior and functionning of ADS-C Periodic contract including “EPP” and “RTA reliable interval”.<br>Note: EPP downlinks containing various | Passed | MUAC front end limitation |

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| | | | 049-1 | number of waypoints will be tested, especially maximum number (ie 128 waypoints). | | |
| | | | P15.2.5-PH3-VVO-050-1 | Check that loss of ADS-C connection due to the SATCOM/ATN network can be detected by both airborne and ANSP systems. | Passed | Periodic reports resuming and staking mechanisms questioned |
| | | | P15.2.5-PH3-VVO-051-1 | Check that the i4D function operates correctly when using several ADS-C contracts simultaneously. | Passed | |
| | | ATN_AGW-SID-0004 | P15.2.5-PH3-VVO-052-1 | Check that only uplink messages intended to the aircraft are well received on board. | Passed | N/A in MUAC/TESTEDYA interoperations configuration |
| OBJ-15.02.05-VS-Validation-P3-002 | Validate that all alerts and memos are well displayed on the ECAM through the FWS. | | P15.2.5-PH3-VVO-053-1 | Check that the ATC message warning mechanisms operate correctly. | Passed | Oral alerts warning mechanisms assessed through bit state monitoring |
| | | | P15.2.5-PH3-VVO-054-1 | Check the conformance of the communication status displayed to the crew and the real air/ground communication availibility. | Passed | |

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| OBJ-15.02.05-VS-Validation-P3-003 | Validate the network capacity and reliability (end to end performance demonstration ) satisfies the i4D needs. | | P15.2.5-PH3-VVO-055-1 | Check that for the following scenarios, ADS end to end transmissions comply with DT95% transaction time defined in ED228 RSP 160 (table 6-13):<br>- Transaction time between the moment an uplink periodic contract request is generated and the moment the first periodic report is recognized by the controller<br>- Transaction time between the moment a periodic report timeout / an ADS event is experienced on board and the moment the corresponding report is recognized by the controller<br><br>Note1: value required in ED228 for ADS end to end transmissions includes on board navigation data consolidation time which is not currently implemented. To check compliance with ED228, this value shall consequently be subtracted from ED 228 values:<br>- 60 sec for ADS Periodoc contract<br>- 45 sec for ADS Event contract<br><br>Note2: even if IRIS is based on version H of SPR, required performances will comply with ED228 which replaces version H of SPR and defines a more realistic performance requirement for i4D operations. | Partially Passed | Low distribution exposure DT95% with THA is 90s |

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| | | | P15.2.5-PH3-VVO-056-1 | Check that for the following scenarios, CPDLC end to end transmissions comply with TT95% transaction time defined in ED228 RCP 130 (table 5-14):<br>- Transmission by the controller of an UM and receipt by the controller of an operationnal response from the aircraft completing the transaction<br>- Transmission by the aircraft of pilot initiated downlink request and receipt on board of the operational response from the controller completing the transaction<br><br>Note1: even if IRIS is based on version H of SPR, required performances will comply with ED228 which replaces version H of SPR and defines a more realistic performance requirement for i4D operations. | Passed | Low distribution exposure<br>Operational issues |
| | | | P15.2.5-PH3-VVO-057-1 | Check that the Quality of Service of the Datalink connection via SATCOM/ATN network for a non-moving target is acceptable for supporting i4D function (network transition time, validity of data…). | Passed | Low distribution exposure<br>Periodic reports resuming and staking mechanisms questioned |
| | Satcom Spot Beam Handover transparency test for IRIS precursor airborne system | ATN_AGW-SID-0027 | P15.2.5-PH3-VVO-059-1 | Check that ATN connection is not impacted by SDU/GES handovers or RAN/Core Network failures. | Passed | GES handover not assessed (N/A)<br>RAN/Core Network failure not assessed (N/A) |

| Phase 4.1: Iris Precursor system validation (flight test) | | | | | | |
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| **High Level VVO Id** | **High Level VVO** | **Specification requirement** | **VVO Id** | **VVO** | **VVO Status** | **Comment** |

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| OBJ-15.02.05-VS-Validation-P3-001 | Validate the datalink function by using ATN/OSI network services, with the i4D related CPDLC messages and ADS-C Contracts, over SBB to the ATS and AOC applications, by re-using i4D related operational scenarios (using the i4D CPDLC message set and all ADS-C Contracts) as used during i4D validation campaign, which was executed by the operational SESAR project P04.03 in cooperation with P09.01. As such both the INTEROP [INTEROP | N.A. | | Check that the pilot initiated CM logon procedure with the ATC ground center is achievable (DLIC). | Passed | |

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| | ATS] and SPR [SPR ATS] are subject of these validations. | | | | | |
| | | N.A. | | Check that the CPDLC connection can be terminated properly via the SATCOM/ATN network and that is not possible to send further UM | Not completed | Flight Test was mainly focused on exchange of ADS-C reports. This VVO was considered as “optional”. |
| | | N.A. | | Check that loss of CPDLC connection due to the SATCOM/ATN network can be detected by both airborne and ANSP systems, and that the CPDLC connection is closed and it is not possible to send further UM. | Not completed | Flight Test was mainly focused on exchange of ADS-C reports. This VVO was considered as “optional”. |
| | | N.A. | | Check that all ADS-C contract acceptation/cancellation mechanisms operate correctly. | Passed | |
| | | N.A. | | Check the end to end good behavior and functionning of ADS-C Demand contract including “EPP” and “RTA reliable interval". Note: EPP downlinks containing various number of waypoints will be tested, especially maximum number (ie 128 waypoints). | Not completed | Only ADS-C On Event messages were exchanged. Integration in the flight test scenario of ADS-C Demand message exchanges was constraining. It was then decided to mainly focus on ADS-C On Event reports. |
| | | N.A. | | Check the end to end good behavior and functionning of ADS-C On Event contract including “EPP”. | Partially Passed (TBC) | NOK for ADS-C reports containing 128 waypoints. |

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|---|---|---|---|---|---|---|
| | | | | Note: EPP downlinks containing various number of waypoints will be tested, especially maximum number (ie 128 waypoints). | | OK for ADS-C reports containing 20 waypoints. |
| | | N.A. | | Check the end to end good behavior and functionning of ADS-C Periodic contract including “EPP” and “RTA reliable interval”.<br>Note: EPP downlinks containing various number of waypoints will be tested, especially maximum number (ie 128 waypoints). | Not completed | Only ADS-C On Event messages were exchanged. Periodic contracts are not correctly handled due to an issue at ground side, increasing transmission delay. Observed performances would not have been relevant. Moreover, ADS-C On Event contracts are considered as the most critical in terms of performance. |
| | | N.A. | | Check that loss of ADS-C connection due to the SATCOM/ATN network can be detected by both airborne and ANSP systems. | Not completed | This VVO was considered as “optional” and complicated to assess during the flight test. |
| | | N.A. | | Check that the i4D function operates correctly when using several ADS-C contracts simultaneously. | Partially passed (TBC) | NOK when using ADS-C reports containing 128 waypoints.<br>OK for ADS-C reports containing 20 waypoints. |
| OBJ-15.02.05-VS-Validation-P3-002 | Validate that all alerts and memos are well displayed on the ECAM through the FWS. | N.A. | | Check that the ATC message warning mechanisms operate co+rrectly.<br>Warning mechanisms in terms of timer expiration, loss of connection, etc. operate correctly according to current regulations (ED-110B) | Passed | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | N.A. | | Check the conformity of the communication status displayed to the crew and the real air/ground communication availibility.<br>On the ground side (ATS application) the communication status is displayed following different colour codes | Passed | |
| OBJ-15.02.05-VS-Validation-P4-002 | Validate the network capacity and reliability (end to end performance demonstration ) satisfies the i4D needs. | N.A. | | Check that for the following scenarios, ADS end to end transmissions comply with DT95% transaction time defined in ED228 RSP 160 (table 6-13):<br>- Transaction time between the moment an uplink periodic contract request is generated and the moment the first periodic report is recognized by the controller<br>- Transaction time between the moment a periodic report timeout / an ADS event is experienced on board and the moment the corresponding report is recognized by the controller<br><br>Note1: value required in ED228 for ADS end to end transmissions includes on board navigation data consolidation time which is not currently implemented. To check compliance with ED228, this value shall consequently be subtracted from ED 228 values:<br>- 60 sec for ADS Periodoc contract<br>- 45 sec for ADS Event contract<br><br>Note2: even if IRIS is based on version H of SPR, required performances will comply with ED228 which replaces version H of SPR and defines a more realistic performance requirement for i4D operations. | Passed (TBC) | NOK with ADS-C reports containing 128 waypoints.<br>OK for ADS-C reports containing 20 waypoints. |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | N.A. | | Check that for the following scenarios, CPDLC end to end transmissions comply with TT95% transaction time defined in ED228 RCP 130 (table 5-14):<br>- Transmission by the controller of an UM and receipt by the controller of an operationnal response from the aircraft completing the transaction<br>- Transmission by the aircraft of pilot initiated downlink request and receipt on board of the operational response from the controller completing the transaction<br><br>Note1: even if IRIS is based on version H of SPR, required performances will comply with ED228 which replaces version H of SPR and defines a more realistic performance requirement for i4D operations.<br>On the ground side, ADS-C implementations have to be compliant with RSP values (i.e., RSP 160) | Passed | |
| OBJ-15.02.05-VS-Validation-P4-001 | Validate the Iris Precursor system manage transparently all satellite/GES handovers. | | | Check that ATN connection is not impacted by SDU/GES handovers or RAN/Core Network failures. | Passed | |

Table 2: Summary of Verification Exercises Results

## 4.2 Analysis of Verification Exercises Results

IRIS Precursor Phase 2 objectives dealt with SATCOM-ATSU System integration verification:

- Phase 2.1: assessment of ATSU-HSU integration with one emulated SBB network regarding ATN OSI DATALINK transfer
- Phase 2.2: assessment of end to end network to provide ATN/OSI network services over SBB

Preliminary assessment of avionics integration was performed without AGGW on SATCOM side.

End to end network assessment was performed in a configuration not fully representative of final one with one VPN terrestrial link between INMARSAT and CGI Ground Gateway/Air-Ground Router, but with real SBB SATCOM services.

Laboratory test campaign enables to conclude ATSU and SATCOM L1 units provide basic capabilities with some issues regarding operations and robustness:

- Subject to VDL2 settings condition and nominal WB V3 negotiation, initial ATN connectivity establishment can be processed and maintained
- Loss of ATN services and ATN connectivity is partly managed (ATSU and SATCOM sides)
- WB V3 ATSU negotiation with SATCOM is not robust
- ATN layers traffic events require forward analysis (retransmissions, sequences, delays)
- Filtering of overly frequent join/leave events is not implemented (Function not mandatory with the current AAP parameter defined so no functional limitation induced)

As a consequence, possible inconsistency can occur between single actual SATCOM status, and ATC/NOTIFICATION availability status reported on MCDU pages.

Regarding non-regression testing:

- No FWS spurious alert event trigger observed
- ATSU dataloading performed without noticed regression (some loads with no signature present)
- Spurious BITE failures and spurious BITE interactive behaviour are noticed on ATIMS

IRIS Precursor Phase 3 purpose is to assess the end-to-end performances of the new SATCOM and new ATSU in an i4D capable environment, including the end-to-end ATN data link chain, which includes the satellite communication medium and the full data link chain at ANSPs.

Phase 3 tests campaign enables to conclude ATSU and SATCOM L2 units provide capabilities to perform ATN operations over SATCOM SBB:

- CMA Logon procedure
- CPDLC exchanges
- ADS-C contracts

Connectivity management is functionally satisfactory.
Network service enables to perform ATN operations.

End to end transmissions performances comply with Required Communication Performance nominal time for CPDLC operations (RCP 130 as per ED228) under tests campaign distribution exposure.
ADS-C End to end transmissions performances comply with Required Surveillance Performance nominal delivery time (RSP 160 as per ED228) under tests campaign distribution exposure but was not statistically demonstrated for both FMS configurations.

2 DMDs processed on previous ATSU IRIS CSBR8.3.3 are corrected:

- DMD 814 - **ATSU IRIS Loss of connectivity (ATN service) partially taken into account**
- DMD 815 - **ATSU IRIS ISH frames retransmissions at [ES-IS] layer level**

1 Anomaly processed on previous SATCOM IRIS L1 is corrected:

- Anomaly #1 - **Under constrained AES disconnection from ground (GGW), no leave event is generated; and AAP link is not actually restored**

Regarding phase 4, the Flight Test of the A330 was performed on February the 23th 2016.

During the first part of the flight, from Toulouse until crossing back the French border at Biarritz level, content of ADS-C reports was limited to 20 waypoints instead of 128 waypoints as initially requested.

ADS-C contracts with 128 waypoints were then established until the end of the flight but 128 waypoints reports cannot be forwarded to the ground.

The flight test allowed however the transmission of numerous ADS-C reports and CPDLC messages to the ground during the first part of the flight. These exchanges represent a good sample of data to assess performances.

Post flight analysis showed that the ATN link via SATCOM offered performances compliant with performance requirements for both ADS-C and CPDLC messages.
No major issue at ATSU or at SDU level has been noticed during the 1st part of the flight.

Satcom spotbeam handovers were transparent to the crew, no communication link disruption being observed.

The detailed analysis of the verification Exercises can be found in each verification exercise report from Section 6 to Section 9.

The following paragraph is reporting the problems observed during the different test phase.

### 4.2.1 Unexpected Behaviours/Results

During the verification exercises the following problems have been encountered:

This paragraph references ATSU issues recorded in SESAR database (ATSU_R&D Grefie database). ATSU IRIS stands for CSBR8.3.3.

- **ATSU IRIS Williamsburg V3 ATSU Negotiation with SATCOM robustness**
- **ATSU IRIS Loss of connectivity (ATN service) partially taken into account**
- **ATSU IRIS ISH frames retransmissions at [ES-IS] layer level**
- **ATSU IRIS IDRP questionable traffic**

On CSBR8.3.4, no other noticeable ATSU anomaly was noticed during the Phase 3 test campaign.

Regarding issues detected on CSBR8.3.3:

- The issue “ATSU IRIS Loss of connectivity (ATN service) partially taken into account” has been corrected and its correction validated.
- The issue “ATSU IRIS ISH frames retransmissions at [ES-IS] layer level” has not been observed anymore. This issue can then be considered as corrected.

“ATSU IRIS IDRP questionable traffic” issue has not been monitored or further investigated on CSB8.3.4 as it is linked to IDRP layer which has not been modified in the frame of the IRIS Precursor project. Moreover this issue has no operational impact.

Corrections have been implemented for “ATSU IRIS Williamsburg V3 ATSU Negotiation with SATCOM robustness” issue. Those corrections globally improved ATSU/SDU interface robustness but have not solved that issue. The limitation is then still encountered on CSBR8.3.4.

During the flight test, no ADS-C report containing 128 waypoints can be exchanged. This problem seems due to an anomaly at ground facilities followed by an ADS-C application freeze.

This paragraph references the SATCOM anomalies discovered during the Phase 2 test campaign. SATCOM IRIS anomalies are monitored at Honeywell level using SESAR 15.2.5 SW Problems Tracking file: problems are “JIRA task” referenced.

**Anomaly #1 (JIRA task IRISPREC-112, IRISPREC-137)**: Under constrained AES disconnection from ground (GGW), no leave event is generated and sent by SATCOM; and AAP link is not actually restored.
This anomaly has been corrected with the Prototype#2 used during Phase 3 test campaign.

An issue was encountered with MUAC frontend (DLFEP) when the sizes of the reports are larger than 16Kbits. This limitation enabled to perform most of the tests with a core size of EPPs (up to 64 waypoints), However, it caused some issues in the assessment of the performances of the SATCOM communications at the limit (some EPPs with 128 waypoint EPPs were exchanged, but only for a very limited number which does not allow statistical analysis). This anomaly is not specifically linked to the SATCOM communication, and will be corrected by MUAC in the frame of SESAR2020.

All the details could be found in section 6, 7, 8 and 9.

# 5 Conclusions and recommendations

## 5.1 Conclusions

Globally speaking the SESAR 15.02.05 project results are deemed satisfactory.

From prototype point of view a good level of maturity has been achieved throughout the project as there is no blocking anomaly and very few remaining open problem on both prototypes.

From performance perspectives, the compliance to RCP130 and RSP160 was demonstrated during tests performed in Phase 3 and 4. This level of performance is the expected one for ATN baseline 2 services defined in the ED228.

The conclusion of the SESAR 15.02.05 is that all the objectives set were fulfilled.

Please refer to section 6.1.4, 6.2.4 7.1.3, 8.1.4 and 9.1.4 for detailed conclusions for Phase 1, 2, 3 and 4.

## 5.2 Recommendations

At project level the following recommendations could be made:

- Test environment representativeness

  It has been experienced during the first phases of the project some difficulties regarding testing, either at supplier level or Airbus laboratory. The attention was really focused on prototype development but it was proved that we lacked test environment representativeness during early phases when we were testing only part of the whole chain.

- Statistical sample

  All the conclusions made on performances are based on a limited set of data that were collected during phase 3 and phase 4. The question remains regarding the representativeness, in a statistical way, of the RCP and RSP ED228 compliance.

- Flight Test

  The flight test was performed with a FMS simulator that were generating fixed EPP data. The level of confidence is high that a real FMS interfaced would not have degrade the measurement but it was not verified.

  It was not possible to exchange ADS-C report with 128 waypoints (that is the maximum allowed). At some time the limit would have to be tested in flight conditions.

  *Note: This last remark is only applicable to flight test because during phase 3 a large number of ADS-C report containing 128 waypoints were exchanged*

On a more global view, the verification exercises performed in SESAR 15.02.05 project had some limitations that temper the conclusions stated in the previous paragraph. Indeed, the project was attached to demonstrate that satellite communication using Iris Precursor service could support i4D exchanges and comply to associated performances. All the verification exercises were performed with the SATCOM as the only ATN communication means on-board, i.e. VHF was disabled for the sake of the testing objective. It is not realistic to imagine that Iris Precursor will be embedded on aircraft as a standalone solution, i.e. without VHF VDLm2 capability. So multilink problematic arise.

Plus, all the test were done with only one Iris Precursor user meaning that the network availability, capacity and load was not stressed out. To make an analogy with VDLm2, it is necessary to know when the Iris Precursor service will be overloaded, congested and what the timeframe is.

Global project recommendations would be then, to address particularly the verification exercise on multilink aspect and assess the Iris Precursor sustainability in time performing global simulation (including VDLm2 models) and/or Very Large scale Demonstrations.

That is why such area are proposed to be dealt with in SESAR 2020 project (PJ14.2.2).

Please refer to section 6.1.4, 6.2.4, 7.1.3, 8.1.4 and 9.1.4 for detailed recommendation for Phase 1, 2, 3 and 4.

# 6 Phase 1 - Verification Exercises reports

## 6.1 Phase 1.1 – ATSU Verification Exercise Report

### 6.1.1 Verification Exercise Scope

The Verification will be performed on all ATSU prototypes with the SDU prototype during the integration test (Phase 1) on the supplier test bench. The supplier will perform ATSU prototype verification on equipment bench with simulated interfaces and networks.

The verification exercise for Phase 2 is in accordance with [8]Iris Precursor Verification Strategy

### 6.1.2 Conduct of Verification Exercise

#### 6.1.2.1 Verification Exercise Preparation

First part of the tests were performed at Rockwell Collins premises as they are in charge of the router part of the ATSU and the rest of the tests were performed on EYY ATSU integration bench.

The following tools have been used for the tests (instrumentation/monitoring/recording/test setting):

- ANETO AIO (IRIS v1.0.0.4373) to simulate SATCOM unit and to interface ATSU

#### 6.1.2.2 Verification Exercise execution

- ATSU prototype #1 (CSB 8.3.3)
  - Router verification at Rockwell Collins
  - ATSU integration at Airbus on EYY equipment bench

Rockwell Collins Router verification were performed from 02/04/2015 to 05/06/2015. Some extended testing were run due to SATCOM delay.

EYY ATSU integration were performed from 01/01/2015 to 18/06/2015

- ATSU prototype #2 (CSB 8.3.4)
  - ATSU integration at Airbus on EYY equipment bench

EYY ATSU integration was performed from 14/12/2015 to 16/12/2015.

#### 6.1.2.3 Deviation from the planned activities

None

### 6.1.3 Verification exercise Results

#### 6.1.3.1 Summary of Verification exercise Results

Refer to section 4.1

#### 6.1.3.2 Analysis of Verification Exercise Results

All tests led by Rockwell Collins and EYY were passed, dealing with:

- Performance at start-up
- Software upload
- Operational functionalities
- Memory and CPU use

- Labels control (especially newly defined ones in the frame of IRIS)

System behaviour was judged satisfactory regarding all previous points.

Additional tests implying applicative exchanges were not achieved due to test tool limitations.

No blocking issue was however identified during this Verification Exercise.

#### 6.1.3.2.1 Unexpected Behaviours/Results

This section references open issues observed during the verification phase of ATSU CSB 8.3.3 standard:

- Some ISH frames are wrongly retransmitted (ATN issue)
- ATC ATN communication through SDU is possible only if VDLm2 link is established
- IDRP connection is established only after 2-3 minutes (interoperability issue between ANETO and ATSU)

During Verification phase of ATSU CSB8.3.4, a random software reset was also observed. This issue is also present on ATSU CSB8.3.3 but it was only perceptible after a test tool modification implemented between ATSU CSB8.3.3 and ATSU CSB8.3.4 deliveries. This issue does not prevent communication between ATSU and SDU and foreseen tests could be achieved without limitation.

### 6.1.4 Conclusions and recommendations

#### 6.1.4.1 Conclusions

On a first basis the verification exercise for Phase 1.1 is deemed satisfactory because all the objectives are fulfilled. Refer to section 4.1 for more details on the achievements of VVOs. But after Phase 2 verification exercise it can be noted that some behaviour or anomalies discovered could have been anticipated at equipment verification level, i.e. Phase 1.1. Use of real SATCOM if possible because Simulated environment lack of representativeness.

#### 6.1.4.2 Recommendations

Regarding the above conclusion the recommendation that follows is:

Due to the lack of representativity of the simulated environment, especially on the interface between ATSU and SATCOM, it is recommended to have a dedicated session with the real SATCOM.

Moreover, in the frame of this Verification phase, test tool maturity and representativeness is crucial and has to be assessed as early and as entirely as possible.

Proceeding as described will thus allow anticipating anomaly discovering.

## 6.2 Phase 1.2 – SATCOM Verification Exercise Report

### 6.2.1 Verification Exercise Scope

The Verification will be performed on all prototypes at SATCOM supplier facility with the supplier test bench. The supplier will perform SDU prototype verification on equipment bench with simulated interfaces and networks.

The verification exercise for Phase 2 is in accordance with [8] Iris Precursor Verification Strategy

### 6.2.2 Conduct of Verification Exercise

#### 6.2.2.1 Verification Exercise Preparation

When possible the verification exercise was performed in two steps :

- BCC test bench in Brno, Czech Republic

Partial test bench regarding MCS system. Only software test performed on the BCC

- MCS system test bench in Ottawa, Canada

  Complete system integration with possibility to perform real connection with satellite

#### 6.2.2.2 Verification Exercise execution

Two prototypes were planned to be produced in the frame of SESAR 15.2.5 Iris Precursor project. Due to integration problematics of SATCOM internal component (ADGW) it has been agreed to split the first prototype in two in order to anticipate integration with ATSU.

The verification exercise execution is as follow:

- Prototype #0 (L0) from 05/10/2014 to 19/06/2015
- Prototype #1 (L1) from 22/06/2015 to 09/10/2015
- Engineering Build Prototype #2 from 07/12/2015 to 17/12/2015
- Prototype#2 (L2) from 12/01/2016 to 15/01/2016

#### 6.2.2.3 Deviation from the planned activities

None

### 6.2.3 Verification exercise Results

#### 6.2.3.1 Summary of Verification exercise Results

Refer to section 4.1

#### 6.2.3.2 Analysis of Verification Exercise Results

This paragraph deals with the verification phase in Honeywell premisise. All tests defined in the Software Accomplishment Summary [10] were passed:

- The **timing performance** (i.e. position reporting delay and latency across AES) proved very difficult to measure accurately in realistic environment.
  - In the future for formal testing (including MOPS) more accurate test procedures will have to be defined in coordination with BPLT suppliers (SPCI)
  - The tests performed were not able to precisely decouple AES delays from test tools delays (BNE, BPLT). In this setup the end-to-end (i.e. pseudo air-to-ground) delays were between 1 and 2 seconds.

No blocking issues were identified at LUAR. The list of identified issues was tracked and all issues were fixed and re-tested by Honeywell for the final FFAR release.

##### 6.2.3.2.1 Unexpected Behaviours/Results

This section references open issues observed during the verification phase of SATCOM prototype #0 and #1 on phase 2:

- No leave after AAP timeout: Leave not reported in absence of AAP traffic and AAP keep alives expiration
- Timers inconsistency: The timers used by ADGW on BCC behave inconsistently in some tests (i.e. sometimes they seem to expire later than expected)
- PDP and AAP status reporting: The status of PDP and AAP is not correctly reported to the test controller from BCC
- Short outages: The “short outages” test is failing – Leave reported immediately

- BCC log files: The BCC log files format and content is to be consolidated

During the verification phase of SATCOM prototype #2 on phase 3, the following issues have been raised:

- BCC time not synchronized with UTC: The time available on BCC is the time provided by CP internal clock. This clock is not synchronized with UTC.
- Channel card crash: The long run test in Honeywell's test bench setup (with BPLT and BNE) was failing due to channel card crashes. This has never been observed when testing over the satellite from Airbus lab (during Phase 2 and Phase 3 lab test campaign) so it seems to be associated with the bench setup. Furthermore a mitigation is implemented in the FFAR version of the software – if the crash occurs, the channel card gets automatically reset.

## 6.2.4 Conclusions and recommendations

### 6.2.4.1 Conclusions

The overall verification exercise is deemed satisfactory although a slow start has been experienced during Phase 2 lab test campaign. This situation was caused mainly by two factors: testing environment definition and supplier test bench representativeness. The next paragraph is detailing recommendation to avoid the same downs in the future

### 6.2.4.2 Recommendations

Regarding the above conclusion recommendations that could be made are the following:

Environment testing definition: Put a particular focus on definition and development of test environment. Some test limitations have been experienced due to non-availability of test environment for proto#0 delivery

Supplier test bench representativeness: Ensure to have representative set of test performed on the complete real system and over the air. It has been experienced some regression when test on complete SATCOM system at supplier level were skipped.

# 7 Phase 2 - Verification Exercises reports

## 7.1 Verification Exercise Scope

The aim of this Verification Exercise was to validate the correct behaviour of the SATCOM and ATSU systems and their integration with the other avionics systems. The scope of these tests, on Long Range program, includes the verification of the newly introduced ATN for SATCOM function, as well as non-regression testing of the following functionalities:

- Cockpit voice
- BITE
- Warnings and alerts
- HMI
- ATSU dataloading

The verification exercise for Phase 2 is in accordance with [8]Iris Precursor Verification Strategy

### 7.1.1 Conduct of Verification Exercise

#### 7.1.1.1 Verification Exercise Preparation

All the tests were performed on CNS SA/LR integration bench, representative of a Long Range Airbus environment.

The CNS SA/LR integration bench is composed of following real avionics equipment:

- SATCOM
  - Satellite Data Unit (SDU) / High Speed Data Unit (HSDU)
  - HSDU Data Module (HDM)
  - High Power Amplifier (HPA) / Diplexer and Low Noise Amplifier (DLNA) / Beam Steering Unit (BSU) / High Gain Antenna (HGA)
- Air Traffic Service Unit (ATSU)
- Datalink Control and Display Unit (DCDU)
- Multipurpose Control and Display Unit (MCDU)
- Audio Management Unit (AMU)
- Audi Control Panel1/2/3 (ACP)
- Centralised Maintenance Computer (CMC)

The following tools have been used for the tests (instrumentation/monitoring/recording/test setting):

- ANETO AIO (IRIS v1.0.0.4373) to monitor the exchanges between HSDU and ATSU
- ANETO AIO (IRIS v1.0.0.4373) to simulate SATCOM unit and to interface ATSU
- ANETO A (V12.4) to simulate ATSU peripherals (FMS, FWS)
- ANETO AIR SOL (V9.1.2) to simulate VHF3 unit (Mode 2 AOA) and to interface ATSU
- SYGAM to simulate ADIRS
- Stable position switches to simulate LGCIU

#### 7.1.1.2 Verification Exercise execution

ATSU prototype#1 (CSB8.3.3) delivered on 22nd June 2015 as for SATCOM prototype#0 (L0). SATCOM prototype#0 was not embedding Airborne Datalink Gateway

SATCOM prototype#1 (L1 - full function) was delivered on 12th October 2015

GDGW was available on CGI premises since 30th September 2015 with a VPN link between Inmarsat network and CGI laboratory

Phase 2.1 execution start from 22nd of June and was concluded on 23rd October 2015

Phase 2.2 execution start from 12th October 2015 and was concluded on 6th November 2015

#### 7.1.1.3 Deviation from the planned activities

None

## 7.1.2 Verification exercise Results

### 7.1.2.1 Summary of Verification exercise Results

See paragraph 4.1 for details results of this verification exercise

### 7.1.2.2 Analysis of Verification Exercise Results

#### 7.1.2.2.1 Phase 2.1

A first SATCOM prototype L0 was delivered for phase 2.1 and tests have been performed with the following configuration:

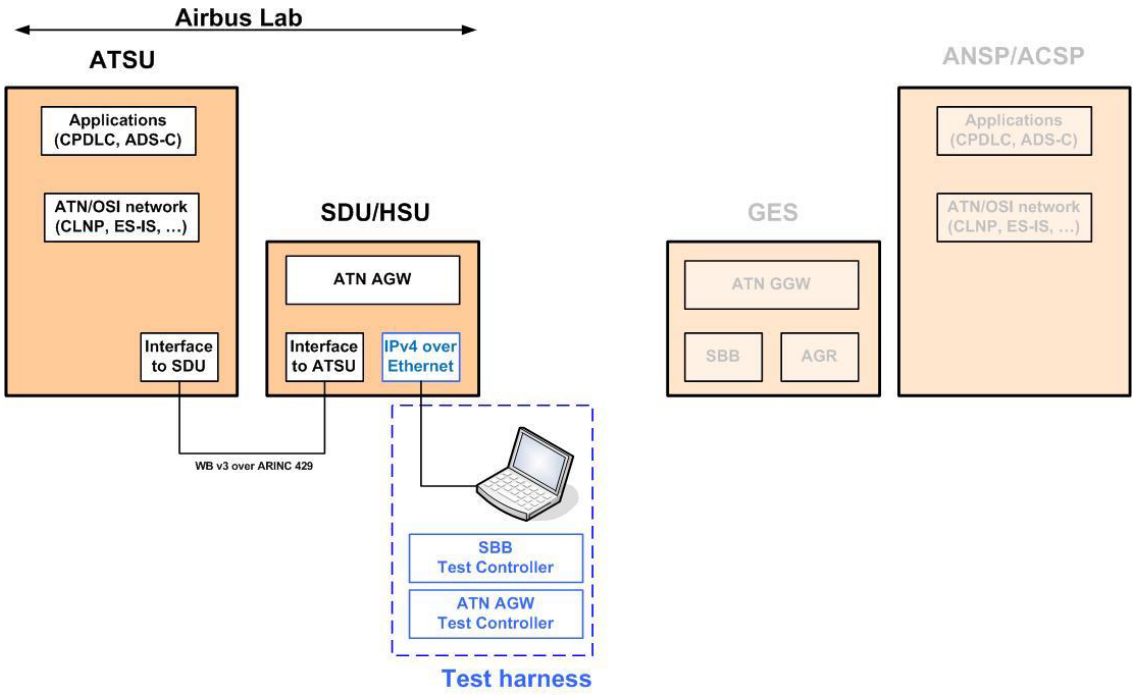


Figure 4: Phase 2.1 – ATSU-HSU integration

The AGGW was not implemented on this prototype, and AAP protocol was simulated by sending Join or Leave events from the test controller. Moreover, ground ES-IS and IDRP frames were hand-generated with the test controller.

A first ATSU prototype was delivered for phase 2.1 and phase 2.2.

##### 7.1.2.2.1.1 ATSU / SATCOM exchanges

ATSU and SATCOM exchange protocol messages using Williamsburg V3 over label 307 and label 304.
General Format Identifier (GFI) of SOF command frames is in accordance with ATN exchanges (GFI: 0x5 as reported by AAIO IRIS).

ATSU exchange NET address using [ES-IS] ISH PDU; it is possible to generate upstream ISH PDU using Test Controller and Python scripting.
It is possible to complete unusual IDRP connection sequence[1] – enabling ground ISH taking into account by ATSU – exchanging OPEN (↘/↗), UPDATE (↘/↗) and KEEPALIVE (↘) PDUs so as to achieve:

- NOTIFICATION AVAILABLE on MCDU NOTIFICATION page[2]
- VHF3 DLK AVAIL – ATC on MCDU DATALINK STATUS page[3]

No rejection was observed during tests.
ISH frames retransmissions from ATSU were observed: CSBR8.3.3 Open issue.

'SATCOM subnetwork access' functional block operations cannot be assessed (no AGGW implemented).

The following issues were noticed during tests:

- A429 layer – WilliamsBurg V3 Negotiation & Maintenance
  - ⇨ $[ATSU/SATCOM]_{DMD813}$ Unexpected/not systematic twin negotiation sequence, without noticed impact
- IDRP layer
  - ⇨ $[ATSU]_{DMD816}$ Unexpected IDRP connection restart sequence, with indeterminate impact (possible no guarantee of outstanding PDUs expiration before new BIS-BIS connection establishment)
  - ⇨ $[ATSU]_{DMD816}$ Unexpected IDRP sequence number increment, without noticed impact
  - ⇨ $[ATSU]_{DMD816}$ correct IDRP routes advertisement TBC, without noticed impact
  - ⇨ $[ATSU]_{DMD816}$ Unexpected/not systematic IDRP traffic (retransmissions), with pending analysis and possible impact on ATN connectivity

The OVV is stated Partially PASSED, with Open issues.

#### 7.1.2.2.1.2 Label 172 verification

From an initial state (ATSU powered on then SATCOM powered on), Williamsburg V3 protocol is established after V1 initialization and V3 switch on ATSU side upon reception of label 172 from SATCOM with bit 18 set to 1 (v3 capability).

However, after a SATCOM reset or SATCOM restart, the ATSU tries to establish WB V1, even if it receives label 172 with WB V3 capability from HSDU. One ATSU reset enables WB V3 negotiation recovery (not systematic). Without reset, protocol remains un-established – ALO V1 from ATSU and ALR V3 from SATCOM – and SATCOM is in accordance stated INOP in DATALINK status page.

The following issues were noticed during tests:

- A429 layer – WilliamsBurg V3 Negotiation & Maintenance
  - ⇨ $[ATSU]_{DMD813}$ does not switch to A429 WB V3 upon reception of Label 172 with V3 capability after SATCOM reset or restart
  - ⇨ $[ATSU]_{DMD813}$ switches to A429 WB V3 with more than approx 5s delay after its 1st ALO V1 whereas Label 172 with V3 capability is available and broadcasted 1Hz after ATSU reset

The OVV is stated FAILED.

[1] Refer to appendix regarding sequence implemented through test controller.
[2] Under NOTIFICATION supplementary conditions (pre-requisite).
[3] IRIS Precursor ATSU specific.

#### 7.1.2.2.1.3 Packets exchange verification

In phase 2.1 configuration, the AAP layer is not emulated at test controller level.
Therefore, AAP encapsulation and de-encapsulation of messages and PDU packets cannot be assessed.

The OVV is stated Not Completed.

#### 7.1.2.2.1.4 Join / Leave events

In phase 2.1 configuration, the join and leave events were manually generated by the test controller through Python command lines. Then the SATCOM forwarded the event to the ATSU.

When receiving a join event, ATSU starts sending ISH PDU, as expected.

When receiving a leave event, ATSU stops protocol traffic, as expected.
Nevertheless ATN loss is not reported (NOTIF and ATC remain available on MCDU HMI).
Furthermore, in case a join event is received before IDRP Hold Timer expiration, the IDRP route is actually not discarded and ATSU sends KEEPALIVE PDU on IDRP layer.
ATSU starts to establish a route from scratch after a join event received when Hold Timer is expired.
Respectively, after a leave event is received, ATC and NOTIF loss of availability are reported only after Hold Timer is expired.

The following supplementary issues were noticed during tests:

- ES-IS layer
  - ⇨ $[ATSU]_{DMD816}$ Unexpected/not systematic ISH delay vs. join event
- IDRP layer
  - ⇨ $[ATSU]_{DMD816}$ Unexpected/not systematic IDRP traffic after leave/join sequence on previously established/expired connection

The OVVs are respectively stated PASSED and FAILED.

#### 7.1.2.2.1.5 Label 270 verification

Content of label 270 is correctly updated according to the status of the systems, at the exception of Bit 17 which is not in accordance with SDU log-on status, without noticed impact. The reported datalink availability (Bit 11) is conforming to the join/leave events.

ATSU transmits data packets to SATCOM only when datalink is reported as available (SATCOM Label 270 bit 11).
Upon reception of leave event – datalink reported not available – ATSU does not transmit any more data packets to the SATCOM.
Nevertheless, in case ATN was established, ATN loss is not reported and it is apparently possible to send a downlink message: on MCDU

- DATALINK STATUS page: ATC is still declared available (VHF3 DLK AVAIL – ATC)
- NOTIFICATION page: NOTIF* is still declared available and it is actually possible to key NOTIFY (followed by 'ATC CENTER NOTIFYING' message but without downstream traffic)

The OVV is stated Partially PASSED.

#### 7.1.2.2.1.6 Logs assessment

- ATSU logs

ATSU ISM logs (ISM FLASH SYNC) can be retrieved off-line.
It was possible, using ATSU Dataloader IT Tool, to download ISM_FLASH_SYNC files.
Assessment of ATSU ISM logs by Design Office post analysis is correct.

- SATCOM logs

Depending upon the activated traces, the channel card BGAN status, the SpotBeam information, the attach state or the WBv3 events were available in real time via the RS232 interface.
On phase 2.2 prototype, the ADGW status could be observed with a Python tool installed on the test controller laptop.
However, the PDP context information was not available as the activation / termination is automatically managed by the channel card.

- Instrumentation logs

AAIO traces and logs assessment is included in Lab Test Procedure so as to support tests analysis and pre-requisites for phase 3 and phase 4 analysis activities.
They are not considered as part of VVO assessment.

The OVV is stated Partially PASSED.

#### 7.1.2.2.1.7 SATCOM non regression tests

As SATCOM was not connected to real network on phase 2.1, it has been decided to perform these tests on phase 2.2.

#### 7.1.2.2.1.8 ATSU non regression tests

- FWS Interface

This interface has not been tested with real FWS but by monitoring ATSU Label 270/271/272 on output bus:

- Label 270 Bit 14 (cf. COM VHF3 DATA FAULT) is consistently set to 1 when VHF3 is OFF
- Label 270 Bit 21 (cf. COM SATCOM DATA FAULT) is consistently set to 1 when SATCOM is OFF or WB V3 protocol is not established (no protocol established)
- Label 276 bit 24 (cf. COM HF DATA FAULT) is consistently set to 1 when HF1 is OFF

Therefore, each possible WARNING trigger actually observed is explained: no spurious warning expected.

SATCOM data loss simulation: in case of SATCOM bus loss simulation (jumper removed on ATSU BoB), Label 270 bit 21 is consistently set to 1; in case of loss of datalink service reported by SATCOM, Label 270 bit 21 is not impacted (datalink is not available but SATCOM is not failed for datalink).
SATCOM loss simulation: warning superseding (SATCOM FAULT vs. SATCOM DATA FAULT) is not assessed without real FWS on CNS SA/LR.

- BITE / CMC Interface

`ATSU1 (1TX1)` class 3 failure (462134) is to be justified: pending supplier analysis (spurious BITE message identified during ATSU LUAR).
`SDU1 (5RV1)/ATSU1 (1TX1)` class 3 failure (232834) is to be justified: pending supplier analysis.
`NO RESPONSE to <LAST LEG REPORT` request in some cases is to be justified: to be monitored vs. reproducible processing.

BITE failure regarding HSDU ALR V3 failure is not tested.

- ATSU Dataloading

ATSU Dataloading with PDL PMAT 2000 ® was performed without noticed regression with two methods: using A615-3 and A615-A.

USB media was used to upload ATSU packages from source CD to PMAT 2000 (no CD device).

No signature Present in loads: LA2T0J13099P0L1, LA2T0D60005E0F1, LA2T0D40005B0F1, LA2T0K39901K0F1, LA2T0EB0001E0F1, LA2T0D200J8B0L1, LA2T0C20030E0F1.

[ATSU Dataloading (previously loaded): CD, PDL PMAT 2000 ®, ARINC 615-3]
It was possible, using A615-3 interface, to upload from one previously loaded configuration:
- IRIS Precursor [Host Platform] item in approx. 24mn 59sec
- IRIS Precursor other items
- Another ARF configuration

It was also possible to upload a previous set of loads (CSB8.3).
ATIMS LRU identification from CMC pages was relevant.

[ATSU Dataloading (previously loaded): CD, PDL PMAT 2000 ®, ARINC 615-A]
It was possible, using A615-A interface, to upload from one previously loaded configuration:
- IRIS Precursor [Host Platform] item in approx. 1mn 59sec
- IRIS Precursor other items
- Another ARF configuration

It was also possible to upload a previous set of loads (CSB8.3).
Configuration verified using “Get Information” service from PMAT tool was relevant.

**Note**: CSB8.3 Host platform (SA) load was declared “Signature valid” (LA2T0J1307H00L1) in PMAT 615-3 tool, but stated “No signature present” (LA2T0J1307H00F1) in PMAT 615-A tool.

The OVV is stated Partially PASSED.

#### 7.1.2.2.1.9 Robustness verification

SDU reset / HSDU reset: Not applicable as it is not representative due to test setup issues in Phase 2.1[4] (no add-on to previous tests).

In case of ATSU reset, due to WB negotiation issues, establishment of ATN from scratch over SATCOM can occur whereas VDL2 is not established: ATC and NOTIFICATION will not be available under those circumstances.

Upon SATCOM System Test under ATN communication established over SBB, SATCOM is declared INOP on DATALINK status page, whereas ATC and NOTIFICATION remain available. See previous observations regarding traffic management. Test is not conclusive as HSDU reboots as a consequence to System Test: tests conditions are as initial ones.

As a consequence to WB V3 Negotiation issues, ATSU does necessarily re-initialize A429 WB V3.

The OVV is stated Partially PASSED.

### 7.1.2.2.2 Phase 2.2

Tests on phase 2.2 have been run in the following configuration:

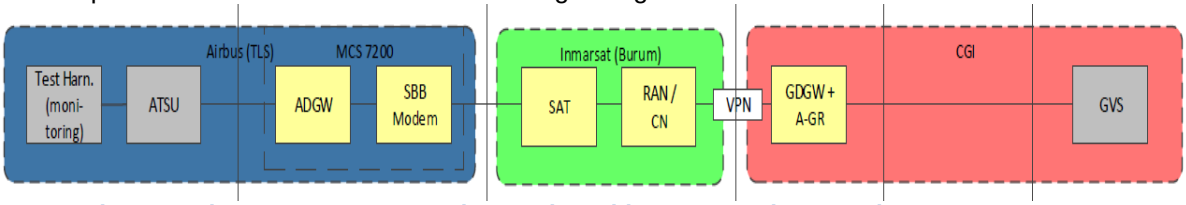


Figure 5: Phase 2.2 – ATSU-HSU integration with ATN-GGW in CGI Lab over INMARSAT

#### 7.1.2.2.2.1 Packet exchanges verification

ATSU and SATCOM exchange protocol data packets in both ways, so as to complete ATN connectivity establishment from scratch with a ground ATN router via SBB services.

[4] Phase 2.2 is concerned by limitations on GGW/AGR.

AAP correct encapsulation (respectively de-encapsulation) of packets can only be deduced from observations as no monitoring capability are provided regarding AAP layer on ATN/OSI GGW/AGR side.

The OVV is stated PASSED.

#### 7.1.2.2.2.2 Join / Leave events

In phase 2.2 configuration, the join and leave events are automatically managed by SATCOM in accordance with AAP log-on and ATN service availability.
ATSU behavior when a join event (resp. a leave event) is sent by SATCOM remains as per previously observed (refer to §7.1.2.2.1.4 Join / Leave events).
In case of manual log-off, or even I3 AOR-W log-on, leave event is broadcasted.
In case of auto log-on on I4 Alphasat, and deduced AAP established, join event is broadcasted.

The following supplementary issues were noticed during tests:

- AAP layer
  - ⇨ $[SATCOM]_{Anomaly\#1}$ Under constrained AES disconnection from ground (GGW), no leave event is generated and sent by SATCOM; and AAP link is not actually restored
  - ⇨ [SATCOM] Satellite ID (I4 Alphasat) is hardcoded in SATCOM S/W so as to enable AAP connection

The OVVs are respectively stated PASSED and FAILED.

#### 7.1.2.2.2.3 SATCOM filtering of overly frequent leave events

It was not possible to simulate overly frequent leave events: there is no operational case that can lead to short and frequent leave events. Moreover, this filtering has not been implemented in the HSDU. A leave event is transmitted as soon as a loss of link is detected.

This OVV could thus not be tested.

#### 7.1.2.2.2.4 ATN / GDGW connection

SATCOM manages partially automatically the connection to the ATN-GGW and reports datalink status to the ATSU:

- SATCOM self establishes log-on, registration and attachment to the network
- SATCOM self establishes one PDP context [5]
- SATCOM self establishes log-on to the ATN Ground Gateway
- SATCOM partly resolves IP address of ATN Ground Gateway
  - Satellite ID vs. AAP protocol primitives is hardcoded in SATCOM L1 prototype
  - CGI ATN Ground Gateway IP address is hardcoded in SATCOM L1 prototype
- SATCOM reports to ATSU the ATN service join event
- SATCOM reports to ATSU the leave event in case of (manual) log-off (constrained loss of link with the ground)
- SATCOM does not manage proper AES log-off with GDGW (see § 6.2.2)
- SATCOM reports to ATSU the join event after SATCOM auto log-on completed (activated from MCDU)

ATSU initiates a route with the ground after receiving a (first) join event.
If a Leave event is received, the ATSU does not reinitiate route with the ground router after receiving another join event: if a previously established route was pending with IDRP hold timer not expired, ATSU keeps it alive using KEEPALIVE PDU.

Routes completion testing was constrained due to GDGW/AGR limitation: in case of unusual disconnection, AES constrained log-off and AGR reset is requested.
Simulation of SATCOM satellite handovers (from I4 to I3 satellite and I3 to I4 reversion based on service preferences) so as to loss and recover link with the ground was not preformed.
Testing was not relevant as it was equivalent to testing from scratch (cf. GDW/AGR limitations).

[5] Could not been verified in the logs as the PDP context opening is managed by the channel card.

The OVV is stated Partially PASSED.

#### 7.1.2.2.2.5 SATCOM non regression

- Voice function:

Several Air-to-Ground and Ground-to-Air calls could have been established, and the call termination could be realized both from ground and ACPs.

P4 and P3 call priorities have been tested both on I-3 and I-4 satellites and the preemption has been performed successfully: a higher priority call preempts the in-progress communication as expected.

Audio quality, although not tested in an aircraft representative environment, has been judged correct both onboard and on ground.

- MCDU HMI:

All the SATCOM menus and pages could be accessed. Phone calls have been established from both directory and manual dialing pages.

The log-on status displayed is in accordance with the SATOM log-on state; log-off, manual and automatic log-on have been performed, as well as SAT / GES selection.

- FWS interface:

This interface has not been tested with real FWS but by verifying the status of label 270 at the output of the SDU.

The COM SATCOM FAULT (label 270, bit 20) was correctly triggered when simulating a SATCOM failure. The COM SATCOM VOICE FAULT could not be tested in lab as it was not possible to generate a SATCOM failure impacting only voice functionality.

No spurious alert has been noticed during the Phase 2 test campaign.

The SATCOM Alert memo (label 270, bit 24 or 25) was also correctly set when an incoming call of priority >P4 was received onboard.

- BITE / CMC interface:

The SATCOM BITE pages could be accessed through MCDU. No unexpected fault has been reported by the SATCOM, either in interactive or normal mode.

A system test has been performed and no fault was displayed at the end of the test.

PIM BIT test has also been done and test result has not shown any signal degradation.

- Dataloading :

It has been agreed with Design Office that no assessment of dataloading function would be done on SATCOM system as no SDU evolution is introduced and HSDU software change is to be assumed by the supplier.

The OVV is stated PASSED.

### 7.1.2.2.3 Unexpected Behaviours/Results

Tests performed were constrained by limitations on GGW/AGR:

- In case of unusual disconnection, it is required to reset service on ground segment (logging off AES and resetting AGR)

This paragraph references ATSU DMDs recorded in SESAR database (ATSU_R&D Grefie** database). ATSU IRIS stands for CSBR8.3.3.

- **ATSU IRIS Williamsburg V3 ATSU Negotiation with SATCOM robustness**
- **ATSU IRIS Loss of connectivity (ATN service) partially taken into account**

- **ATSU IRIS ISH frames retransmissions at [ES-IS] layer level**
- **ATSU IRIS IDRP questionable traffic**

This paragraph references the SATCOM anomalies discovered during the Phase 2 test campaign. SATCOM IRIS anomalies are monitored at Honeywell level using SESAR 15.2.5 SW Problems Tracking file: problems are “JIRA task” referenced.

**- Anomaly #1 (JIRA task IRISPREC-112, IRISPREC-137)**: Under constrained AES disconnection from ground (GGW), no leave event is generated and sent by SATCOM; and AAP link is not actually restored.

## 7.1.3 Conclusions and recommendations

### 7.1.3.1 Conclusions

IRIS Precursor Phase 2 objectives dealt with SATCOM-ATSU System integration verification:

- Phase 2.1: assessment of ATSU-HSU integration with one emulated SBB network regarding ATN OSI DATALINK transfer
- Phase 2.2: assessment of end to end network to provide ATN/OSI network services over SBB

Preliminary assessment of avionics integration was performed without AGGW on SATCOM side.

End to end network assessment was performed in a configuration not fully representative of final one with one VPN terrestrial link between INMARSAT and CGI Ground Gateway/Air-Ground Router, but with real SBB SATCOM services.

Laboratory test campaign enables to conclude ATSU and SATCOM L1 units provide basic capabilities with some issues regarding operations and robustness:

- Subject to VDL2 settings condition and nominal WB V3 negotiation, initial ATN connectivity establishment can be processed and maintained
- Loss of ATN services and ATN connectivity is partly managed (ATSU and SATCOM sides)
- WB V3 ATSU negotiation with SATCOM is not robust
- ATN layers traffic events require forward analysis (retransmissions, sequences, delays)
- Filtering of overly frequent join/leave events is not implemented

As a consequence, possible inconsistency can occur between single actual SATCOM status, and ATC/NOTIFICATION availability status reported on MCDU pages.

Regarding non-regression testing:

- No FWS spurious alert event trigger observed
- ATSU dataloading performed without noticed regression (some loads with no signature present)
- Spurious BITE failures and spurious BITE interactive behaviour are noticed on ATIMS

They do not constitute blocking points regarding next phase (phase 3) V&V objectives. Only specific end-to-end pre-requisites are required as S/W evolutions.

### 7.1.3.2 Recommendations

The phase 2 verification exercise was deemed satisfactory so there is no specific recommendations to be addressed.

# 8 Phase 3.1 - Verification Exercises reports

## 8.1 Verification Exercise #1 Report

### 8.1.1 Verification Exercise Scope

The purpose of this Verification Exercise was to assess ATSU and SATCOM L2 systems – developed in the frame of the SESAR P15.2.5 project – with ground IRIS systems via real ATN network over SATCOM SBB for i4D operations:

- CMA Logon procedure
- CPDLC exchanges
- ADS-C contracts
- Connectivity management
- End to end transmissions performances

The verification exercise for Phase 3 is in accordance with [8] Iris Precursor Verification Strategy.

### 8.1.2 Conduct of Verification Exercise

#### 8.1.2.1 Verification Exercise Preparation

Tests were performed on CNS SA/LR system integration bench, representative of a Long Range Airbus environment, and on SA/ATM functional integration bench (coupled to CNS for communication means capabilities), and representative of a SA Airbus environment with real i4D FMS capabilities.

Real avionics equipments of the CNS SA/LR benches are the same than those described in the §7.1.1.

The following tools have been used for the tests (instrumentation/monitoring/recording/test setting):

- ANETO AIO (IRIS v1.0.0.4373 beta v1.1) to monitor the exchanges between HSDU and ATSU, including protocol data at avionics level
- ANETO A (V12.4) to monitor the exchanges between FMS and ATSU (including label 232)
- ANETO A (V12.5) to monitor the ATSU FTI internal traces (Debug Trace)

The following tools have been used for tests post-processing:

- VmeDlsDecoder 1.0
- Applicative Decoder 1.0

For this project, MUAC used the usual SESAR Datalink test bench. This test bench is composed of:

- One frontend (DLFEP): this frontend allows to connect to the SITA ATN network and was not upgraded for this project. It is the same release that was used for i4D Step C, and which is also used in the frame of the SESAR PEGASE project with Airbus.
- One ground chain emulator (AFAME): this emulator enables to emulate the ground ATC chain. It triggers the sending of CPDLC messages and ADS-C contracts by the frontend, and also enables to analyse the messages received by the frontend. This emulator was upgraded for the PEGASE project and reused as such within the 15.2.5 project.

#### 8.1.2.2 Verification Exercise execution

ATSU prototype#2 (CSB8.3.4) was delivered on 17th December 2015.

SDU prototype#2 was delivered on TBD.

Phase 3 was divided into three parts:

- A 1st test session (as a pre-test session) took place the 10th of December 2015 with MUAC TEST CTR using a simulated VHF3 and:

  - ATSU CSBR 8.3.3 (L1)
  - HSDU L2

- The 2nd test session during which VVOs were checked, took place the 15th of January 2016 with MUAC TEST CTR using a real VHF3 unit set in Voice mode and:
  - ATSU CSBR 8.3.4 (L2)
  - HSDU L2 FFAR
- As all VVOs have not been checked, a third session took place from February 15th to Marck 9th on the CNS SA/LR SIB bench.

Two FMS were used for the tests: FMS THALES/GE and FMS HONEYWELL. Tests performed with FMS THALES/GE (resp. FMS HONEYWELL) will be notified under **THA** configuration (resp. **HWL** configuration) wording.

#### 8.1.2.3 Deviation from the planned activities

SATCOM/ATN Test network current implementation does not enable ATN connectivity with Airbus ground end systems. Only one single ATN connectivity with MUAC test centre was possible.

Filtering of messages unintended to the aircraft (i.e. wrongly addressed) has not been assessed: the capability to send such messages was not implemented at MUAC ATC GND centre facilities.

Multiple ADS-C connections have been assessed with specific contract requests definitions (including flight test preparation) without impact on verification objective.

Release of CPDLC connection has not been assessed for all airborne termination use cases.

ADS-C Periodic contracts have been assessed with specific contracts requests definition (Reporting rate constrained at 2mn) and specific durations without impact on verification objectives.
ADS-C – Loss of SATCOM communication means has been assessed with specific contracts requests definition (Reporting rate and Number of waypoints) without impact on verification objectives.

ADS-C – Loss of SATCOM communications means has been adapted so as to demonstrate capability to resume in case of short time recovery.

ADS-C Performances assessment distribution exposure in THA configuration for event contracts is under 24 transactions.

## 8.1.3 Verification exercise Results

### 8.1.3.1 Summary of Verification exercise Results

See paragraph 4.1 for details results of this verification exercise.

### 8.1.3.2 Analysis of Verification Exercise Results

#### 8.1.3.2.1 CMA – Logon procedure

The A/C initiated CM logon procedure was achieved with **TESTEDYA**, up to CPDLC connection:

- E2E transport connection is established for CM application in less than 3s
- CM logon response is received in less than 3s with consistent versions of ADS and PM-CPDLC applications

- MCDU notification page is consistently updated (e.g. `TESTEDYA NOTIFIED 0921Z`)
- E2E transport connection is released for CM application
- CPDLC connection is established, and `NEXT ATC: TESTEDYA` is consistently displayed
- CPDCL connection is activated, and `ACTIVE ATC: TESTEDYA` consistently displayed (on MCDU with 1st operational clearance, on DCDU as per UM#285 reception)

The A/C initiated CM logon procedure was achieved with **LFCB**, in particular:
- MCDU notification page is consistently updated
- CM logon response uplinks from ground are not received on board when sent with another addressed aircraft (cf. OVV "Messages Filtering")
- PM-CPDLC start request messages from ground are not received on board when sent with another addressed aircraft (cf. OVV "Messages Filtering")

The OVV is stated PASSED.

### 8.1.3.2.2 CPDLC exchanges

Ground initiated CPDLC exchanges were performed between **TESTEDYA** and the aircraft:
- Loadable clearance uplink messages (**HWL** configuration, **THA** configuration)

| | Is received on board with compliant numbering | ↘ LACK is received on ground | RTA constraint is loadable in the FMS | Message acknowledgement is received on ground |
|---|---|---|---|---|
| **CROSS [position] AT [RTAtimesec]** | ✓ (N 252) | ✓ (DM#100) | ✓ | ✓ (↘ WILCO)<br>↗ LACK (UM#227) received on board |
| **CROSS [position] AT [RTAtimesec] AT [level]** | ✓ (N 256) | ✓ (DM#100) | ✓ | |
| **CLEARED TO [position] VIA [route clearance enhanced]** | ✓ (N 266) | ✓ (DM#100) | **HWL**: Unabled (loaded in secondary only) | ✓ (↘ UNABLE)<br>↗ LACK (UM#227) received on board |
| | | | **THA**: Unabled (loaded in secondary only) | |
| **AT [position] CLEARED [route clearance enhanced]**<br><br>**REST OF ROUTE UNCHANGED** | ✓ (N 268) (N289) | ✓ (DM#100) | **HWL**: Unabled (loaded in secondary only) | |
| | | | **THA**: ✓ ; WILCO sent | |

- Standard clearance uplink messages (**HWL** configuration, **THA** configuration)

| | Is received on board with compliant numbering | ↘ LACK is received on ground | Message acknowledgement is received on ground |
|---|---|---|---|
| **MAINTAIN TIME CONSTRAINT** | ✓ (N 338) | ✓ (DM#100) | ✓ (↘ WILCO)<br>↗ LACK (UM#227) received on board |
| **CANCEL [position] TIME CONSTRAINT** | ✓ (N 336) | ✓ (DM#100) | ✓ (↘ WILCO)<br>↗ LACK (UM#227) received on board |

- No answer uplink messages (**THA** configuration)

| | Is received on board with compliant numbering | ↘ LACK is received on ground |
|---|---|---|
| **REST OF ROUTE UNCHANGED** | ✓ (N 289) | ✓ (DM#100) |

Capability to perform controller initiated end to end CPDLC exchanges was therefore demonstrated.

Furthermore, uplink messages (assessed with LFCB and UM#338) from ground are not received on board when sent with another addressed aircraft (cf. OVV "Messages Filtering").

The VVO is stated PASSED.

**Supplementary**:

When using the THALES FMS, it was possible to load RTA constraint (e.g. N 252) into FMS: but LOADING was still displayed on DCDU. Nevertheless, it was possible to send WILCO answer from board (nominally acknowledged on ground). FMS acceptance of the loading is under analysis.

### 8.1.3.2.3 CPDLC connection management

SATCOM/ATN test network enabled to terminate the CPDLC connection:

- Connection can be released by ATC centre (**HWL** configuration) (under no NDA condition, no more connection): CPDLC end request and CPDLC user abort request enabled to terminate the connection; it was possible to restore CPDLC connection afterwards.
- Connection can be released by the aircraft (**THA** configuration): upon 'DISCONNECT CONFIRM' keyed on MCDU, CPDLC user abort indication is received on ground with consistent reason (commanded-termination) in less than 10s.

No assessment of airborne specific management of unprocessed/processed U/L messages (resp. cockpit crew initiated D/L) has been performed.

Normal "multiple" Airborne initiated disconnection (CD & NDA) has not been tested.
Abnormal Airborne initiated disconnections have not been tested (change of flight number, end of flight).

CPDLC connection can be properly terminated over SATCOM/ATN test network.

The OVV is stated PASSED.

[CPDLC – Loss of SATCOM communications means] has not been processed. Nevertheless partial results regarding *Loss of CPDLC connection* can be derived from [ADS-C – Loss of SATCOM communications means] and [SATCOM and ATN Ground Gateway Connectivity management] tests.
After SATCOM log off, one CPDLC provider abort is received on ground with consistent reason (communication-service-failure) 6mn after last COTP4 CPDLC downstream traffic. Loss of CPDLC connection is also detected on board side: ATC DISCONNECTED message system is displayed on DCDU with approx. 6mn timer expiry after last COTP4 CPDLC upstream traffic (loss of CPDLC detected earlier than loss of ADS in the sequence as last ADS upstream traffic is after CPDLC one – delay between both application loss is consistently approximately the same on board and on ground). It was possible to restore CPDLC connection afterwards (ACTIVE ATC consistently reported).

The OVV is stated PASSED.

### 8.1.3.2.4 ADS-C contracts

#### 8.1.3.2.4.1 ADS-C contract management

SATCOM/ATN test network and IRIS Precursor avionics enabled to manage ADS-C contracts:

- On Event contract requests from the ground, accepted by the A/C: requests received on board, associated ACK received on ground, 1st baseline report sent and received on ground and DCDU (resp. MCDU) display consistently updated **ADS CONNECTED (1)**
- On Event contract connection cancellation from A/C: DISCONNECT order sent and received on ground (ADS user abort), DCDU (resp. MCDU) display consistently updated, no more event report transmission
- On Event contract connection cancellation from ground centre: cancel request sent and received on board, associated ACK sent and received on ground, DCDU (MCDU) display consistently updated, no more event report transmission
- Periodic contract requests from the ground, accepted by the A/C: requests received on board, associated ACK received on ground, 1st periodic report sent and received on ground and DCDU display consistently updated **ADS CONNECTED (1)**
- Periodic contract connection cancellation from A/C: DISCONNECT order sent and received on ground (ADS user abort); capability to recover one ADS connection
- Periodic contract connection cancellation from ground centre: cancel request sent and received on board, associated cancel confirmation sent and received on ground, DCDU (resp. MCDU) display consistently updated, no more periodic report transmission; capability to recover one ADS connection

Acceptation and cancellation mechanisms operated correctly.

Due to limitations on available tests configurations (no ATN connectivity with Airbus end systems, ATN connectivity enabled for one single end system: MUAC), ADS-C contracts acceptation/cancellation mechanisms have not been assessed in multiple connections use cases for SA real FMS configuration (**SA/ATM FIB** sessions).
Those use cases have been assessed without noticed anomaly with ANETO A FMS simulation for LR simulated FMS configuration (**CNS SA/LR** sessions). Refer to **Erreur ! Source du renvoi introuvable. Erreur ! Source du renvoi introuvable.**.

The VVO is stated PASSED.

#### 8.1.3.2.4.2 ADS-C demand contract

SATCOM/ATN test network and IRIS Precursor avionics enabled to perform E2E ADS-C Demand contract operations:

- Requests of demand contracts from **LFCB**, positively acknowledged or confirmed (with Non Compliance stated in accordance with request) by ATSU
  - **contract on demand for ETA min max on a waypoint of the trajectory**
  - **contract on demand for EPP with EPP reporting window set to 32** waypoints
  - **contract on demand for EPP with EPP reporting window set to 64** waypoints
  - **contract on demand for EPP with EPP reporting window set to** various values **(64...128)** waypoints and **for ETA min max on a waypoint of the trajectory**
  - **contract on demand for EPP with EPP reporting window set to 128** waypoints
- Reports received on ground with consistent ETA-min-max indication OR consistent number of waypoints (32, 64, 72,… 127 in accordance with simulated 3D frame content)
- ADS-C Demand contract transactions transparent on cockpit HMIs as expected (DCDU without indication, CONNECTION STATUS on MCDU still stated ARMED)
- Request of demand contracts from ground are not received on board when sent with another addressed aircraft (cf. OVV “Messages Filtering”)
  - **contract on demand for ETA min max on a waypoint of the trajectory**
  - **contract on demand for EPP with EPP reporting window set to 32 waypoints**

The following issue was noticed during tests:

In one test session, it was not possible to process operation for 128 waypoints: only positive acknowledgement was received on ground (no report); it was then not possible to process other demand requests – no positive acknowledgement received on ground – until Provider abort due to Timer expiry; afterwards it was possible to process other requests for 32 and 64 waypoints but not for 128 waypoints (only POS ACK).
ADS freeze is questioned.
It was not possible to reproduce the sequence for further analysis during next test session as request for 128 waypoints was completed (see above).

The VVO is stated PASSED.

#### 8.1.3.2.4.3 ADS-C On Event contract

SATCOM/ATN test network and IRIS Precursor avionics enabled to perform E2E ADS-C On Event contract operations:

- Requests of event contracts from **TESTEDYA**, positively acknowledged by A/C
  **event contract for EPP-change with EPP reporting & monitoring windows set to 32 waypoints**
  **event contract for EPP-change with EPP reporting & monitoring windows set to 64 waypoints**
  **event contract for EPP-change with EPP reporting & monitoring windows set to 128 waypoints**

Event reports received on ground (baseline reports and downlinks under event processed[6]: waypoint sequenced or inserted/deleted) with consistent number of waypoints

The following issues were noticed during tests:

- (COTP4) Transport issue leading to ground (**TESTEDYA**) Disconnection Request and ADS provider abort

During January 15th **AM semi session** (**HWL** configuration), it was not possible to complete ADS contract request for 128 waypoints as per test procedure: request of contract was received and positively acknowledged by A/C, no report (including baseline report) was received on ground whereas COTP4 (upstream and downstream) traffic was observed (both on air and ground sides). 22s after contract request, ADS Provider abort indication is detected on ground with reason 'communications-service-failure'. Disconnect Request is sent from ground (and Confirmed by A/C). 3mn39s after disconnect confirm, ground BIS sent IDRP ERROR PDU due to Hold Timer expiry: indicative of not received KEEPALIVE from ATSU by AGR in the questioned interval or in the prior minute to request.
The sequence has not been reproduced during PM semi session (**THA** configuration).

⇨ After analysis on MUAC (**TESTEDYA**) frontend (DLFEP) side, a limitation regarding the sizes of the reports managed (reports larger than 16Kbits) induces inability to manage correctly those reports and leads to spurious short term provider abort. It is to be noted that this anomaly is not specifically linked to the usage of SATCOM communication.

The OVV is stated PASSED.

#### 8.1.3.2.4.4 ADS-C Periodic contract

SATCOM/ATN test network and IRIS Precursor avionics enabled to perform E2E ADS-C Periodic contract operations:

- Requests of periodic contracts from **TESTEDYA** with 2mn reporting rate, positively acknowledged by A/C
  **contract with ETA min max on a WPT of the trajectory and EPP with EPP extent set to 32 waypoints**
  **contract with ETA min max on a WPT of the trajectory and EPP with EPP extent set to 64 waypoints**
  **contract with ETA min max on a WPT of the trajectory and EPP with EPP extent set to 128 waypoints**

[6] As per FMS Trajectory status on EPP computation: Point Sequenced event, or Flight Plan Change event.

- Periodic reports sent by A/C, including Basic data, Extended Projected Profile (with respectively 32/64/128 waypoints) and ETA min-max on requested waypoint, with approx. 2mn rate timer (cf. DMD 613 ATSU limitation)
- Periodic reports received on ground, with consistent number of waypoints and periodicity of approx. 2mn with variable drift limited to 8s as observed.

The following issues were noticed during tests:

- (COTP4) Transport issue leading to ground (**TESTEDYA**) Disconnection Request and ADS provider abort

During January 15th **AM semi session** (**HWL** configuration), it was not possible to complete ADS periodic contract request for 64 waypoints as per test procedure (OK for 32, not tested for 128): request of contract was received and positively acknowledged by A/C, no report was detected on ground whereas COTP4 (upstream and downstream) traffic was observed (both on air and ground sides). Between 6s and 29s after contract request, ADS Provider abort indication is received on ground with reason 'communications-service-failure'. Disconnect Request is sent from ground (and Confirmed by A/C).
The sequence has not been reproduced during PM semi session (**THA** configuration).

⇨ After analysis on MUAC (**TESTEDYA**) frontend (DLFEP) side, a limitation regarding the sizes of the reports managed (reports larger than 16Kbits) induces inability to manage correctly those reports and leads to spurious short term provider abort. It is to be noted that this anomaly is not specifically linked to the usage of SATCOM communication.

The OVV is stated PASSED.

#### 8.1.3.2.4.5 ADS-C connection management

Refer to 8.1.3.2.4.1 for connections cancellation mechanisms.

Regarding loss of SATCOM communication means and loss of ADS-C connection:
After SATCOM log off, ATN link is no more available (Leave event): ATC DATALINK COM NOT AVAILABLE is displayed on DCDU, ADS is still stated CONNECTED on MCDU as long as specific timer is not expired. As long as ATC datalink is not available, no ADS report is sent.
In case of ATN recovery (SATCOM log-on plus ATN self-recovery up to IDRP layer) before specific timer expiry, ADS remains stated CONNECTED as expected and reports periodic sending is resumed: first with staked reports in the interval, then with 'on time' reports.
Nevertheless, sequence observed questions the resuming mechanism implemented as staked (delayed) reports are sent with supplementary delay: as observed:

- 13:44:10 periodic report sent
- 13:44:38 loss ATN (SATCOM log-off)
- 13:48:01 ATN recovered – (2 reports stacked @13:46 and @13:48)
- 13:49:15 74s after ATN recovery, periodic report sent (Time Stamp 13:46:16)
- 13:49:18 periodic report sent (Time Stamp 13:48:21)
- 13:50:25 periodic report sent

In case of (ATN recovery after) specific timer expiry, ADS is stated ARMED on MCDU (loss of connection detected on board) approx. 6mn after last periodic report sent.
On ground side, ADS provider abort is received with consistent reason (communications-service-failure).
After ATN recovery, it is possible to restore one ADS connection.

The VVO is stated PASSED.

#### 8.1.3.2.4.6 ADS-C Multiple connections

SATCOM/ATN test network and IRIS Precursor avionics enabled to perform E2E multiple ADS-C connections operations: up to maximum number of established contracts (i.e. 4 contracts)

- Successive establishment of 1, then 2, 3, 4 concurrent ADS connections
- Requests of contracts positively acknowledged by A/C
  From **LFCB** (contract #1), **periodic** (5mn) **contract with ETA min max on a Fix and EPP with 32 waypoints**
  From **LFCB** (contract #1bis), **event contract for EPP-change with EPP reporting set to 20 waypoints**
  From **TESTEDYA** (contract #2), **event contract for EPP-change with EPP reporting set to 20 waypoints**
  From **LFSA** (contract #3), **periodic** (5mn) **contract with ETA min max on a Fix and EPP with 32 waypoints**
  From **LFTN** (contract #4), **periodic** (5mn) **contract with ETA min max on a Fix and EPP with 64 waypoints**
- Reports received on ground with consistent content
- Supplementary Requests of demand contract from **LFCB** positively acknowledged by ATSU
  **contract on demand for ETA min max on a waypoint of the trajectory**
- Supplementary demand-contract Reports received on ground with consistent ETA-min-max indication
- ADS-C Demand contract transactions transparent on cockpit HMIs as expected
- ADS-C Demand contract transactions transparent over other pending ADS connections (reports received on ground)
- DCDU display consistently updated from 'ADS CONNECTED (1)' to 'ADS connected (4)'
- MCDU ADS detail page consistently updated with centers connected
- connection cancellation from A/C to **LFTN**: DISCONNECT order sent and received on ground (ADS user abort), without noticed impact on pending connections and DCDU and MCDU display consistently updated
- ground connection cancellation from **LFSA**: cancel request associated cancel confirmation received on ground
- ground connection cancellation from **LFCB**: cancel all contract request confirmation received on ground

The OVV is stated PASSED.

### 8.1.3.2.5 CPDLC performances

CPDCL end to end transmissions performances are assessed processing CPDLC Transaction Time values for each transaction performed.

The end to end transmission and performance criteria are based on:

- **ET Transaction time**: time delay between U/L and D/L reception of operational answer at ATC GND centre level
- **TT95% Transaction time**: time at which 95 percent of all transactions are operationally completed

The considered sample is hereby a limited distribution exposure: CPDLC loadable clearance UMs and CPDLC standard clearance UMs were performed as per the following sessions:

- January 15th AM under FMS HWL configuration, with **TESTEDYA** end system
- January 15th PM under FMS THA configuration, with **TESTEDYA** end system
- March 11th PM under FMS THA configuration, with **LFDE** end system
- March 21st PM under FMS HWL configuration, with **LFCB** end system

Operational representativeness (Cockpit operations and workload, Controller operations and workload) is not managed but as per definition operation to process tests are in the loop and impact values.
Network load representativeness is assumed to be partial:

- SBB network configured so as service provided is under 'safety service' priority
- Dedicated IRIS Precursor AGGW/AGR in Burum INMARSAT GES
- Adjacencies with SITA Test (staging) ATN router

Therefore, CPDLC performances assessment provides a tendency regarding RCP 130 compliance (67 seconds TT95% transaction time).

The following table provides one synthesis of prior CPDLC measured performances: based on January 15th test session

| CPDLC Type | # (sample size) | FMS configuration | ET Transaction Time | | TT95% [s] | ET Transaction Time |
|---|---|---|---|---|---|---|
| | | | Min [s] | Max [s] | | Av. [s] |
| Loadable Clearance UMs | 10 | HWL | 18s | 7mn24s | N/A | **73,2s** |
| Standard Clearance UMs | | HWL | | | | |
| Loadable Clearance UMs | 8 | THA | 11s | 1mn58s | N/A | **63,25s** |
| Standard Clearance UMs | | THA | | | | |

IRIS Precursor Phase 3 CPDLC performances with MUAC

CPDLC end to end transactions times are satisfying regarding CPDLC operational qualitative expectations, especially considering each sub-part of the transactions.
Delays are preferentially due to operational issues (on board management of clearances with FMS) than Network delays.
Transactions times over 67s in **THA** configuration deal with irrelevant operational management of loadable constraints (significant delay in operational answer to close transaction; see above Supplementary: flight plan size was within the limits of the flight management system).

Further CPDLC upstream and downstream operations have been processed with **LFDE** and **LFCB**. The following table provides one synthesis of those CPDLC measured performances:

| (PM)-CPDLC Type | # (sample size) | FMS configuration | ET Transaction Time | | TT95% [s] ±1s | ET Transaction Time |
|---|---|---|---|---|---|---|
| | | | Min [s] ±1s | Max [s] ±1s | | Av. [s] ±1s |
| UMs (LFCB) | 43 | HWL | 17s | 95s | **62s** | **34s** |
| DMs (LFCB) | 10 | (HWL) | 19s | 63s | | **34s** |
| UMs (LFDE) | 29 | THA | 14s | 172s | **90s** | **43s** |
| DMs (LFDE) | 11 | (THA) | 23s | 60s | | **34s** |

IRIS Precursor Phase 3 CPDLC performances with LFDE & LFCB

Transactions times over 67s in **THA** configuration with LFDE deal with not nominal operations:
- 1 out of 3 delayed transaction due to loss of ATN link and recovery
- 1 out of 3 delayed transaction due to operational delay in board answer
- 1 out of 3 delayed transaction is N 098 UPLINK DELAYED IN NETWORK AND REJECTED. RESEND OR CONTACT BY VOICE after loss of ATN link

Considering compliance with the Required Communication Performance nominal time (TT95%) of 67 seconds:
- 95% of transactions sampled in **HWL** configuration are under 67s (63s)
- 95% of transactions sampled in **THA** configuration are under 106s
- 85% of transactions sampled in **THA** configuration are under 67s (64s)
- Removing not nominal transactions in **THA** configuration, 95% of transactions are under 57s

The OVV is stated PASSED.

### 8.1.3.2.6 ADS-C performances

ADS-C end to end transmissions performances are assessed processing ADS Contract Delivery Time values for each Event Contract and Periodic Contract transactions performed.

The end to end transmission and performance criteria are based on:

- **DT Delivery time**: time delay between request of periodic contract and 1st periodic report reception (resp. between periodic timeout and periodic report reception) with 60s surcharge (on board data consolidation not implemented); time delay between request of event contract and 1st baseline report (resp. between event and event report reception) with 45s surcharge (on board data consolidation not implemented
- **DT95% Delivery time**: maximum nominal time within which 95 percent of surveillance data is required to be successfully delivered

The considered sample is hereby a limited distribution exposure: ADS-C connections were performed as per the following sessions:

- January 15th AM under FMS HWL configuration, with **TESTEDYA** end system
- January 15th PM under FMS THA configuration, with **TESTEDYA** end system
- March 21st PM under FMS HWL configuration, with **LFCB** end system
- March 21st PM under FMS THA configuration, with **LFCB** end system

Operational representativeness is assumed to be covered with constrained reporting rate (2mn) and constrained EPP data content (up to 128 waypoints).
Flight management representativeness is assumed to be partial:

- Flight managed with one specific flight plan (From LFBO To EKCH 'loaded' with more than 128 waypoints), followed under AP A/THR conditions in a simulated environment (Operations with **TESTEDYA**)
- On board data consolidation not implemented

Network load representativeness is assumed to be partial:

- SBB network configured so as service provided is under 'safety service' priority
- Dedicated IRIS Precursor AGGW/AGR in Burum INMARSAT GES
- Adjacencies with SITA Test (staging) ATN router for operations with **TESTEDYA**

Therefore, ADS-C performances assessment provides a tendency regarding RSP 160 compliance (90 seconds DT95% delivery time).

The following table provides one synthesis of ADS-C measured performances:
Note: DT includes data consolidation surcharge (45s and 60s)

| ADS-C Type | Supplementary | # (sample size) | FMS configuration | DT Delivery time | | DT95% [s] |
|---|---|---|---|---|---|---|
| | | | | Min [s] ±1s | Max [s] ±1s | |
| Event Contract | Overall **DT95% Delivery time**: 99s<br>With single 45s surcharge: 92s | **30** | HWL | **49s** | **103s** | **97s** |
| Periodic Contract | With single 45s surcharge: DT93% is 90s | **32** | HWL | **67s** | **105s** | **98s** |
| Event Contract | Overall **DT95% Delivery time**: 90s<br>With single 45s surcharge: 88s | **11** | THA | **57s** | **96s** | **91s** |
| Periodic | | **26** | THA | **64s** | **163s** | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Contract | | | | | | **88s** |

IRIS Precursor Phase 3 ADS-C performances with MUAC (TESTEDYA)

Performances are impacted by ATSU limitation (DMD 613 – periodic timer biased) inducing supplementary delay (≥ 2 seconds for 2mn periodic reports, ≥ 10 seconds for 5mn periodic reports).This supplementary delay removed does not enable to comply with 90 seconds target for periodic transactions.

Nevertheless, in normal operation (no loss of ATN inducing stacked reports with significant delay for instance), no periodic report has been delivered in more than 88s (operations with **TESTEDYA**).

Delivery Time increases with number of waypoints.
Reports including EPP with 128 waypoints would consist in upper limit to comply with the RSP.
Furthermore, simple Flight Plan change events (A/C "on track") appears to induce much less delays than complex FMS computations (insertion/deletion of waypoints with pilot in the loop): in those cases, DT would also tend to reach DT limit.

ADS-C end to end transmissions with **HWL** FMS in the loop are under 99s for 95% of transactions sampled.
ADS-C end to end transmissions with **THA** FMS in the loop are under 90s (RSP 160 Compliant) for 95% of transactions sampled.
With regards to operations processed and considering distribution exposure, no conclusion or relation is to be done regarding FMS type.
Surcharge value (60s for periodic contracts vs. 45s for event contracts) has a significant impact on statistical values.

The OVV is stated Partially PASSED.

### 8.1.3.2.7 Quality of service

**CMA Logon procedure**

CM logon request message data at GND CENTER level (**TESTEDYA**) is consistent vs. Flight number, AEQualifiers and versions of ADS and PM-CPDLC applications, departure and destination airports.
CM logon response data is consistent vs. versions of ADS and PM-CPDLC applications.

The following table provides one synthesis of network transition times observed under nominal CMA Logon procedure conditions:

| Traffic Type | # (sample size) | FMS conf. | Transport connection transition time [from COTP4 CR to DR] | | | CM Logon transition time | | |
|---|---|---|---|---|---|---|---|---|
| | | | Min [s] | Max [s] | Av. [s] | Min [s] | Max [s] | Av. [s] |
| CM logon | 4 | HWL | 4,516s | 4,890s | **4,739s** | 1,594s | 2,016s | **1,782s** |
| CM logon | 3 | THA | 4,000s | 4,631s | **4,414s** | 1,375s | 1,922s | **1,703s** |

Phase 3 network transition time QoS assessment for CM logon (ATSU vs. TESTEDYA)

They are noticeably satisfying regarding 60s expiry constraint to answer the request for notification.

**CPDLC Operations**

No data inconsistency has been observed on CPDLC messages exchanges as:
- No MIN/MRN inconsistency has been observed @ATC GND CENTER level
- No message User-abort was sent vs. Integrity check

The following table provides one synthesis of network transition times observed under nominal CPDLC operation conditions: based on January 15th test session

| Traffic Type | # (sample size) | FMS conf. | E2E RoundTrip Time | | | E2E one way time | | |
|---|---|---|---|---|---|---|---|---|
| | | | Min [s] | Max [s] | Av. [s] | Min [s] | Max [s] | Av. [s] |
| Up – CPDLC | 14 (UMs) | HWL | 2s | 4s | **3s** | NOT COMPUTED (time synchronization issue) | | |
| Down - CPDLC | 11 (DM99, WILCOs, ENABLEs) | HWL | 1s | 3s | **2s** | NOT COMPUTED (time synchronization issue) | | |
| Up – CPDLC | 13 (UMs) | THA | 2s | 8s | **3s** | NOT COMPUTED (time synchronization issue) | | |
| Down - CPDLC | 11 (DM99, WILCOs, ENABLEs) | THA | 1s | 4s | **3s** | NOT COMPUTED (time synchronization issue) | | |

Phase 3 network transition time QoS assessment for CPDLC (ATSU vs. TESTEDYA)

**E2E Round Trip Time**: delay between message transmitted and associated (Logical) acknowledgement.
**E2E one way time**: delay between message embedded timestamp and actual message reception timestamp.
They are noticeably constrained allocating spare time to end users for operational purpose in the objective of 67s for 95 per cent of end to end transmissions operationally completed.

**ADS-C Operations**

The following table provides one synthesis of network transition times and functional transport times observed under nominal ADS-C operation conditions: based on January 15th test session

| Traffic Type | # (sample size) | FMS conf. | E2E one way Time | | Basic 3D Position delay | | Predictive Trajectory delay | |
|---|---|---|---|---|---|---|---|---|
| | | | Max [s] ±1s | Av. [s] ±1s | Max [s] ±1s | Av. [s] ±1s | Max [s] ±1s | Av. [s] ±1s |
| Event Contract | 16 (E2E owT) 38 (Pos/Traj.) | HWL | 5s | **4s** | 13s | **9s** | 2mn35s | **55s** |
| Periodic Contract | | HWL | | | | | | |
| Event Contract | 18 (E2E owT) 39 (Pos.) 34 (Traj.) | THA | 59s | **9s** | 3mn07s | **18s** | 1mn01s | **30s** |
| Periodic Contract | | THA | | | | | | |

Phase 3 network transition time QoS assessment for ADS-C (ATSU vs. TESTEDYA)

**E2E one way time**: delay between message embedded timestamp and actual message reception timestamp.
**Basic 3D Position delay**: delay between basic 3D Position group timestamp from FMS and actual message reception timestamp.
**Predictive Trajectory delay**: delay between EPP computation time from FMS and actual message reception timestamp.

95% of measurable transactions during January 15th test session showed:
- 24s delay regarding Basic 3D Position
- 1mn18s delay regarding Predictive Trajectory computation

Extreme values in the table (59s One way time, 3mn07s Basic 3D Position delay) deal with reports sent with supplementary delays after link loss and recovery and reports staking: refer to paragraph **Erreur ! Source du renvoi introuvable. Erreur ! Source du renvoi introuvable.**.

The Datalink connection via SATCOM/ATN test network and IRIS Precursor avionics enabled to support CM operations, CPDLC operations, ADS-C operations:

- Network transition time qualitatively satisfactory
- Data consistency without noticed issue

No operational blocking point was observed: general ADS reporting + loss of SATCOM

- From cockpit crew (A/C) point of view
- From ATC ground center point of view

QoS assessment is nevertheless processed under the same issues expressed in performances paragraphs (operational and network load representativeness, limited distribution exposure).

The OVV is stated PASSED.

### 8.1.3.2.8 SATCOM Link management transparency

SATCOM Link management transparency was assessed by simulating one SBB narrow beam handover. GES handovers and RAN/Core Network failures were not tested (N/A): no ground capability in term of implementation or test means.

Under the established initial conditions - ATN over SATCOM/SBB established, CPDLC connection established with **TESTEDYA** (UM285 received and acknowledged), and ADS connection established with **TESTEDYA** (5mn periodic contracts reported on ground) – it was simulated one narrow beam handover setting SATCOM hybrid latitude (Label 254) with specific values.
After narrow beam transition from #90 to #91 (as per HSDU A741 real time traces, SATCOM logged on EMEA/Alphasat), ATN connection is not impacted by handover:

- No SATCOM Leave event is issued to ATSU
- No ATN connection loss
- No CPDLC connection loss (UM289 received and acknowledged)
- No ADS connection loss (following 5mn periodic contract reported on ground)

The OVV is stated PASSED.

### 8.1.3.2.9 ATC warnings

Tests were performed on **SA/ATM FIB**, on which:

- FWS is simulated and no audio HMI capability is enabled
- ‘ATC MSG’ P/Bs are activated with continuous lighting vs. flashing illumination

No inhibition mechanisms assessment has been processed, as per test procedure.
No audio HMI assessment (low level oral alert – ATC audio after 10s, repetitive, with 10s frequency) in case of ATC uplink (UM285, or UM252, UM256, UM266, UM268, UM338, UM336 or UM289) has been processed.

Nevertheless, audio oral alert mechanisms has been successfully verified by monitoring (sampling on CPDLC transactions) <ATC MESSAGE SOUND> parameter on ATSU SYS 1 bus (Label 272 bit 13) using Real time Arinc Reader (RAR) tool:

- State 1 (<ATC MESSAGE SOUND ON>) after approx. 10s, repetitive with approx. 10s frequency after message reception on board

‘ATC MSG’ P/Bs were activated during the following events:

- **ATC DISCONNECTED** system message displayed, as a consequence to CPC user abort from ground system
- Upon reception of UM#285 (**CURRENT ATC UNIT [unitName]**)
- Upon reception of Loadable clearance Uplink messages
- Upon reception of Standard clearance Uplink messages
- Upon reception of No answer Uplink messages

The OVV is stated PASSED.

#### 8.1.3.2.10 Communication status

On DCDU is consistently displayed:
- 'SENDING' in the information zone after SEND key has been pressed for one downlink message when CPDLC connection is active
- 'RECEIVD BY ATC' in the information zone after reception of the LACK from ground
- 'ATC DATALINK COM NOT AVAILABLE' as message system after loss of SATCOM communication means (log off)
- 'ATC DISCONNECTED' as message system after loss of CPDLC connection

On MCDU is consistently displayed:
- <ACTIVE ATC> dashed value in CONNECTION STATUS page after CPDLC end request automatically accepted by A/C
- Respectively "All ATC Disconnect" command removed
- <ACTIVE ATC> dashed value in CONNECTION STATUS page after CPDLC User Abort request from ground (**TESTEDYA**) (and "All ATC Disconnect" command consistently removed)
- <ACTIVE ATC> dashed value in CONNECTION STATUS page after command of 'All ATC DISCONNECT' on MCDU leading to CPDLC User Abort indication on ground (commanded termination) (and "All ATC Disconnect" command consistently removed)
- <NEXT ATC> valued in CONNECTION STATUS page with ATC GND CENTER ICAO code after reception of CPDLC start request message
- <ACTIVE ATC> valued in CONNECTION STATUS page with ATC GND CENTER ICAO code after first CPDLC transaction

Communication status displayed to the crew (DCDU and MCDU) is in conformity with the real status of the communication link with the ground.
As per procedure, no ECAM display deals with the real status of the communication link.

The OVV is stated PASSED.

#### 8.1.3.2.11 Unexpected Behaviours/Results

No ATSU anomaly was noticed during the Phase 3 test campaign (January 15th session).
No SATCOM anomaly was noticed during the Phase 3 test campaign (January 15th session).

**Supplementary notice**: The following points are not considered as anomaly on IRIS Prototype
- Satellite ID vs. AAP protocol primitives is hardcoded in SATCOM L1 prototype
- CGI ATN Ground Gateway IP address is hardcoded in SATCOM L1 prototype
- IMSI missing digit bug regarding access to SATCOM service (observed on L2 Prototype Flight Test unit during Flight Test Preparation at Flight Test A/C level)
- ICAO code is hardcoded in HSDU IRIS (22047516) regarding access to SATCOM service (observed on L2 Prototype during Flight Test Preparation at Flight Test A/C level)

The following issue is however under pending analysis:
- (COTP4) Transport issue leading to ground (**TESTEDYA**) Disconnection Request and ADS provider abort

  ⇨ After analysis on MUAC (**TESTEDYA**) frontend (DLFEP) side, a limitation regarding the sizes of the reports managed (reports larger than 16Kbits) induces inability to manage correctly those reports and leads to spurious short term provider abort. It is to be noted that this anomaly is not specifically linked to the usage of SATCOM communication.

The following table provides the status for each anomaly stated on ATSU IRIS CSBR8.3.3:

| DMD reference[7] | Title / Description | STATUS (CSBR8.3.4) |
|---|---|---|
| DMD 813 | **ATSU IRIS Williamsburg V3 Negotiation with SATCOM robustness** | NOT CORRECTED |
| DMD 814 | **ATSU IRIS Loss of connectivity (ATN service) partially taken into account** | **OK** (CORRECTED) |
| DMD 815 | **IRIS ISH frames retransmissions at [ES-IS] layer level** | **OK** (CORRECTED) |
| DMD 816 | **ATSU IRIS IDRP questionable traffic** | Analysis pending |

Phase 3 ATSU CSBR8.3.4 Anomalies Correction Status

The following table provides the status for each anomaly stated on SATCOM IRIS L1:

| Anomaly reference | Title / Description | STATUS (L2 FFAR) |
|---|---|---|
| Anomaly #1 | **JIRA task IRISPREC-112, IRISPREC-137**<br>Under constrained AES disconnection from ground (GGW), no leave event is generated and sent by SATCOM; and AAP link is not actually restored | **OK** (CORRECTED)<br>(validated during L2 acceptance review) |

Phase 3 SATCOM L2 Anomalies Correction Status

## 8.1.4 Conclusions and recommendations

### 8.1.4.1 Conclusions

Tests campaign enables to conclude ATSU and SATCOM L2 units provide capabilities to perform ATN operations over SATCOM SBB:

- CMA Logon procedure
- CPDLC exchanges
- ADS-C contracts

Connectivity management is functionally satisfactory.
Network service enables to perform ATN operations.

End to end transmissions performances comply with Required Communication Performance nominal time for CPDLC operations (RCP 130 as per ED228) under tests campaign distribution exposure.
ADS-C End to end transmissions performances comply with Required Surveillance Performance nominal delivery time (RSP 160 as per ED228) under tests campaign distribution exposure but was not statistically demonstrated for both FMS configurations.

2 DMDs processed on previous ATSU IRIS CSBR8.3.3 are corrected:

- DMD 814 - **ATSU IRIS Loss of connectivity (ATN service) partially taken into account**
- DMD 815 - **ATSU IRIS ISH frames retransmissions at [ES-IS] layer level**

1 Anomaly processed on previous SATCOM IRIS L1 is corrected:

- Anomaly #1 - **Under constrained AES disconnection from ground (GGW), no leave event is generated; and AAP link is not actually restored**

[7] SESAR database

### 8.1.4.2 Recommendations

In terms of operational validation, the phase 3 verification exercise was deemed satisfactory, no noticeable issue being detected during the tests session. A COTP4 Transport issue leading to ground (**TESTEDYA**) Disconnection Request and ADS provider abort is under investigation but this issue is probably linked to ground test means described in 4.2.1.

Dealing with ADS-C performances assessment, test results only provide tendency regarding RSP 160 compliance for the following reasons:

- minimum sample size for time statistics computation was not met
- partial representativeness of flight management
- partial representativeness of network load

Moreover performances were impacted by an ATSU limitation inducing supplementary delay (≥ 2 seconds for 2mn periodic reports).

However test results tend to comply with the Required Surveillance Performance nominal delivery time (DT95%) of 90 seconds.
Reports including EPP with 128 waypoints would consist in upper limit to comply with the RSP.

Dealing with CPDLC performances assessment, test results only provide tendency regarding RCP 130 compliance for the following reasons:

- minimum sample size for time statistics computation was not met
- partial representativeness of flight management
- partial representativeness of network load

However CPDLC end to end transactions times are satisfying regarding CPDLC operational qualitative expectations.
Delays are mostly due to operational issues (on board management of clearances with FMS) than Network delays.

To achieve a better assessment of both ADS-C and CPDLC performances during the flight test, a larger amount of messages should be exchanged between MUAC and the A/C. This requirement will be hard to meet for CPDLC exchanges but it could be met for ADS-C exchanges by using ADS-C on event reports which would be sent on ‘waypoint sequenced” event. Such a procedure will not allow testing various size of ADS-C reports since there is no capability to dynamically modify that size and MUAC is not able to manage heavy ADS-C reports, but it will offer a better assessment of ADS-C performances for a given messages size.

# 9 Phase 4 - Verification Exercises reports

## 9.1 Verification Exercise #1 Report

### 9.1.1 Verification Exercise Scope

The Phase 4 aims at assessing performances of SATCOM SBB subnetwork to exchange ATN data (including ADS-C INITIAL 4D data and CPDLC data) in flight, using dedicated SDU & ATSU IRIS prototypes and ATC ATN applications developed in the frame of the SESAR project WP9.1.
A specific flight was planned between Toulouse and Balearic Islands on a LR flight test aircraft and was performed with Maastricht and Airbus (Toulouse Technique) ATC ground centres.

The verification exercise for Phase 4 is in accordance with [8] Iris Precursor Verification Strategy.

### 9.1.2 Conduct of Verification Exercise

#### 9.1.2.1 Verification Exercise Preparation

The flight was foreseen to take place between Toulouse and Balearic Islands, with provider SITA Europe used with SATCOM only.
Purpose of such a trajectory was to maximize number of SATCOM spotbeam handovers and to check that they were fully transparent to ATN over SATCOM connections.

The flight occurred on A330 development aircraft, with the participation of Toulouse Technique ground station LFCB and real ATC SESAR centre TESTEDYA at Maastricht.

On Ground Station side, Toulouse Technique ANETO tools simulated one ATC centre and one AOC centre:

- AOC Centre = FANSH7X
- ATC Centre 1 SESAR+ = LFCB

Tests involving ADS-C messages were performed with MUAC and Toulouse Technique ATC ground centres.
Tests involving CPDLC messages were performed with Toulouse Technique ATC ground centre.

It was decided to mainly focus on ADS-C exchanges during the flight, especially on ADS-C On Event reports because:

- ADS-C On Demand reports require more human intervention and there was no easy way to automate their transmission.
- Currently, ADS-C periodic reports are not correctly handled, an untimely delay being systematically added to expected transmission period during previous tests.

Performances requirements associated to ADS-C On Event reports seem also to be the most difficult to meet.

Regarding on board configuration, the aircraft was equipped with ANETO A tool installed on a laptop embedded on board. Purpose of this tool was to allow simulation of an i4D capable FMS, as no i4D capable FMS was available for a LR aircraft. Wiring is described hereafter:

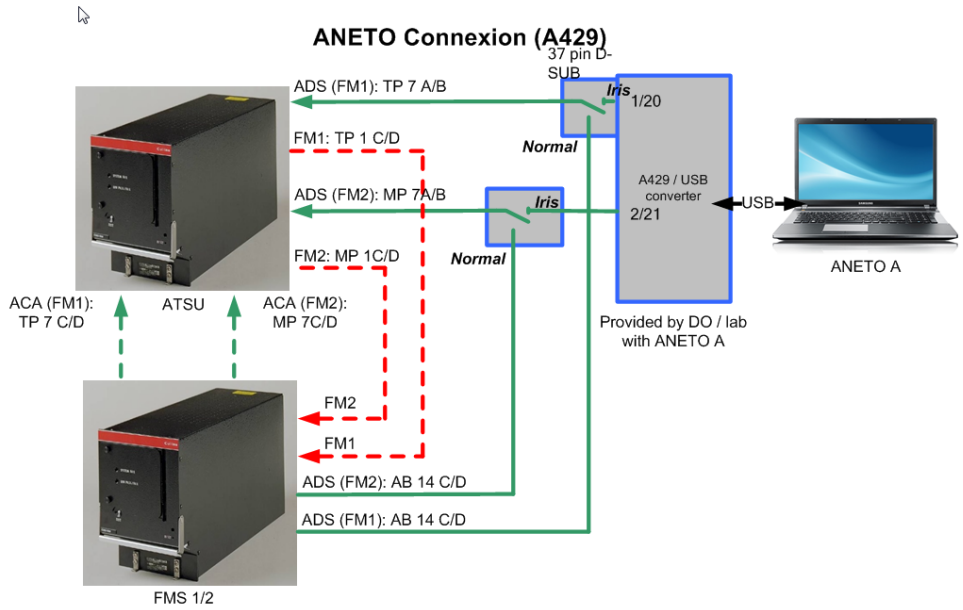


Figure 6: ANETO connection (A429)

For tests post-processing, following means were used:

- A replay of exchanges between ATSU and SDU (ARINC 429, A618 and applicative messages) by ANETO tool from FTI recording,
- Applicative exchanges performed with Toulouse Technique were recorded on ground by ANETO All In One during the flight,
- The crew wrote their observations on a logbook during the flight,
- MUAC ground traces.
- SATCOM logs

### 9.1.2.2 Verification Exercise execution

The flight took place February the 23th 2016.
Trajectory followed by the aircraft is given hereafter:


That flight can be divided into 2 parts:

- A first one from take-off until crossing back French border in Biarritz area
- From Biarritz to Toulouse

During the first part of the flight, numerous messages were exchanged:

- ADS-C on event contract containing 20 waypoints established with MUAC
- ADS-C on event contract containing 20 waypoints established with Toulouse Technique
- CPDLC messages with Toulouse Technique

An ADS-C report has been sent approximatively each 20 seconds towards the two ground centres. No problem has been observed during that phase.

Once back in France, it was decided to increase the size of ADS-C reports from 20 waypoints to 128 for the connection with Toulouse technique (see §9.1.2.3). No ADS-C report can then be forwarded to the ground due to an ADS-C application freeze, anomaly being already known.

### 9.1.2.3 Deviation from the planned activities

The following deviations were noticed compared to Flight preparation:

- Event contract request for EPP with 20 waypoints instead of 128 waypoints: previous test phases showed that some problem may happen when exchanging ADS-C messages with 128 waypoints
- No log-on with TESTEDYA was possible: CM database did not contain that address. It was however possible to perform a CM CONTACT via LFCB.
- ADS-C disconnection after engine shutdown could not be checked due to the ADS freeze that occurred at the end of the flight.

## 9.1.3 Verification exercise Results

### 9.1.3.1 Summary of Verification exercise Results

See paragraph 4.1 for detailed results of this verification exercise.

## 9.1.3.2 Analysis of Verification Exercise Results

### 9.1.3.2.1 CMA – Logon procedure

The A/C initiated CM logon procedure was achieved with **LFCB**, up to CPDLC connection.

- Transport connection is established for CM application
- CM logon response is received with consistent versions of ADS and PM-CPDLC applications
- MCDU notification page is consistently updated
- Transport connection is released for CM application
- CPDLC connection is established

The VVO is stated PASSED.

### 9.1.3.2.2 ADS-C contracts

#### 9.1.3.2.2.1 ADS-C contract management

SATCOM/ATN network and IRIS Precursor avionics enabled to manage ADS-C contracts:

- On Event contract requests from the ground, accepted by the A/C: requests received on board, associated ACK received on ground, 1st baseline report sent and received on ground and DCDU (resp. MCDU) display consistently updated **ADS CONNECTED (1)**
- On Event contract connection cancellation from A/C: DISCONNECT order sent and received on ground (ADS user abort), DCDU (resp. MCDU) display consistently updated, no more event report transmission
- Establisment of new contracts after the disconnection.

The VVO is stated PASSED.

#### 9.1.3.2.2.2 ADS-C On Event contract

SATCOM/ATN network and IRIS Precursor avionics enabled to perform ADS-C On Event contract operations:

- Requests of event contracts from the ground, positively acknowledged by A/C
  **event contract for EPP-change with EPP reporting & monitoring windows set to 20 waypoints**
- Event reports received on ground (downlinks under event processed: waypoint sequenced or inserted/deleted

No issue was noticed when using reports containing 20 waypoints.

In the 2nd part of the flight, it was decided to modify LFCB ADS-C contracts to switch to 128 waypoints but no message was then received on ground.

There is an ATSU issue for the ADS message of 128 waypoints: the first part of the ADS report was sent by the ATSU, but the rest of the report was never sent, as if the ADS application had suddenly stopped. This message was retransmitted but no COTP4 acknowledgment was ever received.
ADS reports of 128 waypoints were already successfully sent at laboratory, and no anomaly was observed. This problem is probably linked to the ADS freeze that was identified just after. This anomaly is already known.

Regarding behaviour of IRIS systems, other points that were noticed may not be considered as “real” anomalies. They can probably be explained by the fact that ATSU was in a degraded state at this moment. They are given hereafter:

- A reset of the VHF was observed at the end of the flight.
- A CEASE IDRP was also received at the end of the flight. It is probably due to missing KEEPALIVE IDRP PDUs which were not received on ground any more.

Moreover a datalink loss has also been detected. It is linked to an internal SATCOM error. This point is under investigation at Honeywell facilities.

The VVO is stated Partially PASSED.

### 9.1.3.2.3 CPDLC performances

During the flight, 22 operational uplink CPDLC messages were sent to the aircraft, and 35 CPDLC downlink messages were received on ground.
2 Downlink were not received on ground, and were retransmitted after 15s (5% of total downlinks).

The RoundTrip is the delay between the sending of the uplink message and the time of reception of the LACK on ground.

RoundTrip Performance

| | Nb | Min | Average | Max | σ | Obs 95% |
|---|---|---|---|---|---|---|
| Requested (ED228) : RCTP | | | | | | 20,00s |
| SATCOM IRIS | 22 | 1,93s | 6,06s | 51,96s | 10,70s | 16,06s |

We can also measure the network delay: the time spent for the message between the sending by the ATSU to the SATCOM and the time of reception on ground. The ATSU to SATCOM time is measured from FTI recordings.

| | Nb | Min | Average | Max | σ | Obs 95% |
|---|---|---|---|---|---|---|
| SATCOM IRIS | 35 | 0,35s | 1,16s | 2,90s | 0,61s | 1,75s |
| Typical VHF Mode 2 performance | | | 1,00s | | | 2,00s |

We can observe that the measured performance for CPDLC via SATCOM IRIS is compliant with ED228 requirements, and is comparable to the performance observed when connected to the VHF Mode 2.

The VVO is stated passed.

### 9.1.3.2.4 ADS-C performances

During the flight, 223 ADS messages were sent to LFCB. 201 were received on ground (and lost messages were retransmitted after 15s)
During the flight, 388 ADS messages were sent to TESTEDYA. 364 were received on ground (and lost messages were retransmitted after 15s)
=> 7% of messages were retransmitted

The DeliveryTime is the delay between the EPP Computation Time in the message and the time of reception on ground.

DeliveryTime Performance with LFCB

| | Nb | Min | Average | Max | σ | Obs 95% |
|---|---|---|---|---|---|---|
| Requested (ED228) | | | | | | 90,00s |
| SATCOM IRIS | 201 | 4,02s | 7,19s | 45,43s | 4,66s | 17,67s |

DeliveryTime Performance with TESTEDYA with 20 waypoints reports

| | Nb | Min | Average | Max | σ | Obs 95% |
|---|---|---|---|---|---|---|
| Requested (ED228) | | | | | | 90.00s |
| SATCOM IRIS | 356 | 1.67s | 6.81s | 54.36s | 5.22s | 19.11s |

DeliveryTime Performance with TESTEDYA for bufferized ADS (with 128 waypoints reports)

| | Nb | Min | Average | Max | σ | Obs 95% |
|---|---|---|---|---|---|---|
| Requested (ED228) | | | | | | 90.00s |
| SATCOM IRIS | 8 | 14.83s | 307.11s | 404.28s | 123.99s | 398.09s |

The OneWay is the difference between the Basic Group Timestamp and the time of reception on ground.

Oneway Performance with LFCB

| | Nb | Min | Average | Max | σ | Obs 95% |
|---|---|---|---|---|---|---|
| SATCOM IRIS | 201 | 1.91s | 6.69s | 45.43s | 4.60s | 16.54s |

We can observe that the retransmissions after 10:00 were due to frames that were lost in the network. The higher loss was correlated to a higher traffic: two ADS connections instead of one. After analysis, it was found that there was a ground network issue: when the traffic is higher, a part of the traffic is sent to a second communication port that was badly configured. As consequence, the traffic sent to that second port was never delivered.

Due to unavailability of communication link after switch from 20 to 128 waypoints, the ADS reports generated during that time were buffered in the ATSU and sent later. It questions the buffering and resuming mechanisms implemented for old ADS messages, notably considering the performance requirements.

Except for buffered ADS messages, we observe that the measured performance is compliant with ED228 specifications. We should keep in mind, however, that the ADS data was not generated by the real FMS, but by an ANETO tool. With a real FMS, the ADS data can become unavailable if the FMS needs to perform computations (changes of route, of altitude …). Furthermore, an algorithm will be implemented at FMS level to wait until predicted data are available. The additional delay should be 45s. Supposing that all frames are delayed by 45s (worst case scenario), the performance would still be compliant with ED228:

- DT95% for LFCB worst case = 17.67s + 45s = 62.67s, below 90s requested in ED228
- DT95% for TESTEDYA worst case = 19.1s + 45s = 64.1s, below 90s requested in ED228

The VVO is stated passed (TBC).

#### 9.1.3.2.5 SATCOM Link management transparency

SATCOM Link management transparency was assessed during the flight by performing three SBB narrow beam handovers under the established initial conditions - ATN over SATCOM/SBB established, CPDLC and ADS connections established.

ATN connection was not impacted by handover:
- No SATCOM Leave event is issued to ATSU
- No ATN connection loss
- No CPDLC connection loss
- No ADS connection loss

The OVV is stated PASSED.

#### 9.1.3.2.6 ATC warnings

No problem was detected by the crew during the flight test.

The VVO is stated PASSED.

#### 9.1.3.2.7 Communication status

No problem was detected by the crew during the flight test.

The VVO is stated PASSED.

#### 9.1.3.2.8 Unexpected Behaviours/Results

When not using reports with 128 waypoints, no issue was observed.
But anomalies occurred after having switched to ADS-C message of 128 waypoints: no message was received on ground.
This issue is probably linked to an ADS freeze that was identified just after. This anomaly is already known.
At the end of the flight two anomalies were seen Unexpected outage and AAP packet loss.

- Unexpected outage: the root cause was a conflict on the control bus between the SATCOM CP and the BCC. Possible solution in order to fix this issue are handle the exception on the BCC so that the link gets recovered, or adjust both CP and BCC software so that the control data have a higher priority over the control bus.
- AAP packet loss: a large number of AAP packet loss was observed only in the air to ground direction. Load balancers were used to distribute traffic. The root cause was a wrong source port on the ADGW. That implies that load balancers would refuse connections for the same source/destination IP/port pairs and the packets would not being routed through to the GDGW. The fix was to change the source port of the ADGW so that a unique tuble could be obtained for front end and back end connections.

Other anomalies were noticed but they may be not considered as “real” anomalies. They can probably be explained by the fact that ATSU was in a degraded state at this moment.

### 9.1.4 Conclusions and recommendations

#### 9.1.4.1 Conclusions

A large number of ADS-C reports with 20 waypoints and several CPDLC messages were sent to the ground during the first part of the flight test, from Toulouse until coming back to France.

We can observe that the retransmissions after 10:00 were due to frames that were lost in the network. After analysis, it was found that there was a ground network issue: when the traffic is higher, a part of the traffic is sent to a second communication port that was badly configured. As consequence, the traffic sent to that second port was never delivered.

Considering only the 1st part of the flight, post flight analysis have shown that the ATN link via SATCOM offered a performance compliant with performance requirements for both ADS-C and CPDLC messages.
No major issue at ATSU or at SDU level was noticed and Satcom spotbeam handovers were transparent to the crew, no communication link disruption being observed.

Tests performed can be considered as a satisfactory assessment of i4D operations in a realistic environment.

### 9.1.4.2 Recommendations

As a complement of the flight test achieved during phase 4, another flight test with a real FMS would allow checking the performance in a more realistic environment.
Other kinds of ADS-C report (i.e. On Demand and Periodic contracts) should also be tested to give a global assessment of ATN/SATCOM performances.

# 10 References

## 10.1 Applicable Documents

**[1]** Template Toolbox 03.00.00
https://extranet.sesarju.eu/Programme%20Library/SESAR%20Template%20Toolbox.dot

**[2]** Requirements and V&V Guidelines 03.00.00
https://extranet.sesarju.eu/Programme%20Library/Requirements%20and%20VV%20Guidelines.doc

**[3]** Templates and Toolbox User Manual 03.00.00
https://extranet.sesarju.eu/Programme%20Library/Templates%20and%20Toolbox%20User%20Manual.doc

**[4]** European Operational Concept Validation Methodology (E-OCVM) - 3.0 [February 2010]

**[5]** EUROCONTROL ATM Lexicon
https://extranet.eurocontrol.int/http://atmlexicon.eurocontrol.int/en/index.php/SESAR

## 10.2 Reference Documents

The following documents provide input/guidance/further information/other:

**[6]** **LTR Phase 2 – Iris Precursor** - LR2328RE1409356 issue 1.0, April 2015

**[7]** **LTRA Phase 2 – Iris Precursor** - TRA154413 issue 1.0, April 2015

**[8]** **D02 - Iris Precursor Verification and Validation Strategy Plan –** SESAR WP 15.2.5 D02 Edition 1.0, April 15, 2014

**[9]** **D04 – System Interface Requirements Iris Precursor** – SESAR WP 15.2.5 D04 Edition 1.2, January 26, 2015

**[10]** **SESAR-15.2.5-SAT-SAS Software Accomplishment Summary**, January 2016

**[11]** **LTR Phase 3 – Iris Precursor** – X46RE1507883 issue 1.0, June 2015

**[12]** **LTRA Phase 3 – Iris Precursor** - TRA160416 issue 1.0, March 2016

**[13]** **FTR SESAR Iris Precursor – WP15.2.5** – LR4620FTR160029 issue 1.0, February 2016

**[14]** **FTRA A330/A340 SESAR Iris Precursor** - **Erreur ! Nom de propriété de document inconnu.** issue 1.0, April 2016

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