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Authors of the document

Beneficiary	Date
DSNA	17/04/2023

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ADSCENSIO

ADS-C ENABLES AND SUPPORTS IMPROVED ATM OPERATIONS

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Abstract

This TRL7 Contextual note provides SESAR Solution description for industrialisation consideration.

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1 Purpose

This contextual note provides to any interested reader (external and internal to the SESAR programme) an introduction to the SESAR Solution PJ.38-01 “ADS-C common service” in terms of scope, main operational and performance benefits, relevant system impacts.

The ADS-C common service is recommended by the SDM deployment programme for the implementation of ATM functionality “Initial trajectory information sharing” (AF6) as it will support a fast and efficient ADS-C contract management.

The ground ADS-C Common Service (**ACS**) is based on a common service definition addressing ADS-C contract management, service interfaces, communication protocols and key performance indicators. The service will distribute the ADS-C/EPP data (e.g. EPP Extended Projected Profile, Speed Schedule or Met Information) to the relevant ground users (e.g. ATS Units and NM System).

Solution PJ.38-01 “ADS-C common service” achieved TRL7 thanks to the demonstration activities performed in PJ.38.

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2 Improvements in Air Traffic Management (ATM)

While in flight execution phase, the aircraft systems have a unique access to information that has an undisputable value for improving flight profile predictions. In particular:

- Actual wind conditions;
- Airframe configuration (e.g. engine type, or individual aerodynamic performance);
- Airline policy settings;
- Current flying mode;
- Exact weight.

Each of these parameters taken separately might require heavy processing to provide significant value, but when combined altogether, the aircraft avionics systems use this information to generate very accurate predictions (trajectory, speeds, estimated time of arrival on flight plan waypoints …) that can be then shared as the Extended Projected Profile (EPP). The downlink of the EPP allows the integration of this aircraft view on the ground system to provide a more accurate and reliable prediction that in the end improve the following ATM processes:

- Traffic Flow management;
- 2D consistency check and conformance monitoring;
- Vertical profile monitoring (Top Of Climb and Top Of Descent);
- Conflict Detection and Resolution;
- Traffic sequencing, and
- Facilitation of continuous vertical evolution (for descending or climbing flights).

ATS B2 equipped aircraft are required to be capable of supporting ADS-C contracts with at least 4 ground facilities in parallel (5 for current Airbus operated implementations). However, downlinking several times the same (or similar) information from any aircraft to any ground user may become an issue regarding the scarce resources of air-ground datalink, in particular VHF Datalink mode 2.

To limit the number of simultaneous contracts to obtain the same ADS-C data, the ACS will assume the responsibility for collecting ADS-C data from airborne users and distribute this data to the relevant ground users. The ACS will establish one periodic and one event contract per aircraft flight for all its users. In addition, the service also supports ADS-C demand contract establishments to meet specific user data requests.

In particular, the operation of an ACS not only reduces ground investment costs but also alleviates the air-ground communication infrastructure for ADS-C[1] and improves spectrum efficiency as VHF band is identified as scarce resource. The ACS aims at optimising the use of datalink resources to:

- Reduce the number of simultaneous ADS-C connections;

[1] The use of the ACS does not affect the existing infrastructure for CPDLC (controller - pilot datalink communications)

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- Communalize ground customers' needs;
- Avoid that a same information be downlinked several times.

Such rationalization should provide performance benefits as avionics routers would have to manage multiple reports to multiple ground centres sequentially, possibly resulting in delays.

Incidentally, the implementation of ACS reduces the risk of interoperability issues minimising deployment fragmentation and accelerating the deployment of Initial Trajectory Information Sharing.

The ACS is seen to be implemented and used at European level.

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3 Operational Improvement Steps (OIs) & Enablers

Solution PJ.38-01 “ADS-C Common service” consists of a common service that distributes the ADS-C/EPP data downlinked from aircraft to the relevant ground users (e.g. ATS Units and NM Systems but potentially also Airlines, MET providers or other). The ACS covers:

- The collection of ADS-C data from the aircraft via a single ATS B2 ADS-C application dialogue to reduce ATN air-ground network load and use of radio spectrum;
- The distribution of data to clients via SWIM ground distribution services (AMQPS and HTTPS technologies).

The overall objective of the ACS is to establish and maintain an ADS-C connection with an aircraft as early and as long as possible, covering all phases of its flight. The ACS will collect data whether its departure (ADEP) and/or arrival (ADES) lies outside or inside the area covered by the service.

The solution builds on the following pre-requisites:

- Aircraft must be equipped with the capability to automatically down-link trajectory information using ADS-C (Extended Projected Profile group) as part of the ATS B2 services;
- A reliable, fast and efficient air/ground communication infrastructure must support initial trajectory information sharing;
- The ATS units and NM must be capable to subscribe to ADS-C data collected by the ACS for equipped aircraft within their area of interest (or even beyond if operationally required), receive related data publications from ACS and process the received ADS-C Data information;
- Data link communications ground systems must support ADS-C (downlink of aircraft trajectory using EPP) as part of the ATS B2 services while keeping compatibility with controller - pilot datalink communications (‘CPDLC’) services as required by Commission Regulation (EC) No 29/2009, including provision of service to flights equipped only with the Aeronautical Telecommunication Network Baseline 1 (‘ATN-B1’);
- The SWIM TI Yellow Profile (solution #46) is the required ground SWIM infrastructure that enables the ADS-C common service.

The solution is linked to:

- POI-0081-COM ADS-C Common service (Business Improvement).
- Enabler SVC--076 Distribution of ADS-C reports to ground users using a common service.

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4 Background and validation process

The SESAR solution #115 “Extended projected profile (EPP) availability on ground” (delivered in SESAR 1 in Release 5) represented the first step towards a full ground-air trajectory synchronization required for the implementation of the targeted Trajectory Based Operations (TBO). The solution allows the provision to the ground systems of the aircraft view on the planned route and applicable restrictions known to the airborne system, together with the corresponding optimal planned trajectory computed on-board and speed preferences. This information is automatically downlinked from the airborne Flight Management System via ADS-C datalink to the ground ATC unit, which has subscribed to the needed service contract (e.g. Extended Projected Profile & Speed Schedule Profile contracts) and then made available to the controllers. The solution also enabled initial ground system automation tools for conformance monitoring. Based on the comparison between the ground and the air planned routes, the solution provided 2D discrepancy indicators to the controllers, so that potential differences are highlighted and can be corrected. Solution #115 is a key element of CP1 AF#6 functionality “Initial trajectory information sharing”.

As part of Release 10 activities in SESAR 2020, the VLD project PJ.31 “Initial trajectory information sharing” (DIGITS) and its mirror project for addressing AUs contribution (DIGITS-AU) contributed to bridge the gap between the results obtained in SESAR 1 and the deployment activities as part of CP1. The projects aimed at demonstrating the ATM benefits that can be realized using downlinked 4D trajectory data (e.g. EPP) in ground systems. DIGITS activities considered commercial flights that downlinked ADS-C data to be processed in ATM ground systems of participating ANSPs, covering together a substantial part of European airspace and air traffic under a variety of operational conditions.

By equipping airlines aircraft with certified ATS B2 equipment in real operation, PJ.31 provided a real insight on the challenges and benefits of deploying ATS B2. A total of 91 aircraft from 6 airlines were upgraded as preparation to support PJ.31/DIGITS-AU demos, including the last Air France retro-fit upgrade. In retrospective, retro-fit upgrade proved to be much more challenging for the airlines than forward-fit upgrades, which are complete in the assembly line and therefore more straightforward.

Despite technical, economical, operational and institutional issues and challenges, PJ.31 DIGITS succeeded in performing a more than significant number of flights (~20K flights) covering a wide range of operational conditions: multiple airlines, different weather conditions, traffic sample covering all Europe and, in particular, the participating ANSPs. On the airside, the ATS B2 equipment was used in operational conditions while, on the groundside, the project addressed both pre-operational use at MUAC and shadow mode / test uses at DFS, EEC, ENAV and NATS. The large amount of collected data was analysed from both a technical and an operational point of view using a set of technical and operational performance metrics defined by the project partners and based on their operational interests.

The CP1 regulation is not prescriptive regarding the way the EPP data (ADS-C reports) should be distributed on the ground. One of the key recommendations provided by PJ.31 was to avoid each ground user establishing its own connection with each flight. The use of multiple connections with multiple ground users (e.g. ANSPs) per aircraft has the potential to overload the network because of the number of contracts being agreed as well as potentially blocking connections to the aircraft. The project strongly advised to develop an ACS that could allow distributing the ADS-C reports downlinked from the aircraft between ground users. This common service is referred to as “solution PJ.38-01”, and is the subject of this contextual note.

The validation and demonstration of the ACS took place in SESAR 2020 Wave 3 during 2022 and 2023.

Some PJ 38-ADSCENSIO partners are using data provided by the ACS in their exercises. The technical results related to the use of the ACS are provided in final Demonstration report (Release 2) delivered in May 2023.

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5 Results and performance achievements

In December 2022, the PJ38 Work Package 5, dedicated to ADS-C Common Service, achieved the objectives set at the launch of the project:

- Produced and agreed between all PJ38 partners two comprehensive specification deliverables on ADS-C Common Service, namely:
    - The "ADS-C Common Service requirements". This document:
        - ✓ introduces the topic of ACS and its goals,
        - ✓ describes a high-level architecture / reference architecture,
        - ✓ outlines the intended Concept of Operations (CONOPS) of the Service within the Wave 3 demo and beyond,
        - ✓ drafts more detailed ACS requirements including architectural principles,
        - ✓ addresses Service Deployment and Validation.
    - The "ADS-C Common Service SWIM ICD". This document provides a description that is sufficiently detailed that PJ38 industry partners can develop interoperable software prototypes for ACS SWIM service and client interfaces.

These 2 documents were included in DEMOR R1 and also provided as inputs for the standardisation process engaged by the Operational Excellence Program Workstream 12.2,

- Developed, tested and accepted 3 ACS prototypes according to these specifications;
- Demonstrated the ADS-C Data Collection Capability in flight trials: 52,352 flights data, 2,932,037 ADS-C reports were collected from December 2020 to end March 2023 and more than 2 million ADS-C reports were collected & distributed by the PJ38 ACS since January 2022;
- Demonstrated the ADS-C data distribution capability via SWIM in real time for the benefit of operational evaluations performed in Work Package 4.

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6 Recommendations and Additional activities

Documents dedicated to the ACS (tasked at PJ38 WP 5 level) provided to the Operational Excellence Program Workstream 12.2 are in DEMOR R1 (Early Dec-22) and DEMOR R2 (May 23).

In DEMOR R2, the following recommendations have been proposed

1. ANSPs should give priority to join the ACS. Its implementation would make the deployment quicker, easier and simplify the ground systems infrastructure architecture rather than multiplying the instances and the number of ATN links to be established.

2. The availability and the use of an ADS-C Common Service should be promoted and recognized as a means of compliance to the AF6 CP1 as the PJ38 has demonstrated the benefits of the use ADS-C Common service by ANSPs.

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7 Actors impacted by the SESAR Solution

7.1 Airspace Users

The new service will facilitate the work of flight operations and crews introducing a single manual flight deck logon by crews covering ADS-C applications; accordingly, Crew Procedures and trainings will need to be adapted.

7.2 NM

The Network Manager will be user of the ACS to perform trajectory revisions but may also avail of the Logon Service to facilitate its datalink monitoring tasks.

7.3 ANSPs

ANSPs will be users of the ACS and will be able to subscribe to ADS-C data without running local datalink infrastructure and ADS-C Contract Management for this purpose. This will reduce investment costs related to the use of ADS-C data and increase access to ADS-C data.

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8 Impact on Aircraft System

None, assuming the pre-requisites described in section 3: in order to downlink ADS-C/EPP reports to the ground are met, the aircraft must be upgraded with avionics systems implementing EPP functionalities. The avionics systems impacted are:

- Flight Management System (FMS);
- Airborne system supporting the ADS-C application as per ATS B2 standards;
- Airborne router. v

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9 Impact on Ground Systems

The assumption is that the pre-requisites described in section 3 for the ground are in place; therefore, for the purpose of ADS-C, ATS Ground systems using ACS no longer have to implement ATS B2 standard datalink services themselves, as this is delegated to ACS.

In this case, ATS ground systems will have to be upgraded to process ADS-C data publications via SWIM YP (AMQP for publish/subscribe and HTTPS for request/reply, e.g. for subscription management).

Beyond these pre-requisites, the ground systems shall implement the required interfaces and communication protocols to be able to consume the ADS-C reports as distributed via the ADS-C common service.

The ACS provides a ground data distribution interface compliant with the SWIM yellow profile service specifications, so that remote ADS-C users can receive ADS-C/EPP data over ground infrastructure.

The ACS can be improved by being connected to the NM B2B Flight Data Service as a source of flight status data and/or aircraft position information.

In accordance with the CP1 regulation, ANSPs and NM must make use of the downlinked ADS-C/EPP data. However, additional users[2] would also benefit from the data further justifying the rationale of an ACS (e.g. airline operators for fleet management, meteorological services to obtain airborne weather data, etc.).

[2] Property rights should be addressed before providing ADS-C Data to additional users

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10 Regulatory Framework Considerations

The Commission implementing regulation (EU) 2021/116 of 1 February 2021, so called Common Project One (CP1), includes the following requirement: “Ground systems must ensure that trajectory data downlinked from the aircraft is distributed between ATS units and between ATS units and the Network Manager systems”.

The regulation is not prescriptive on the means to distribute the trajectory data downlinked from the aircraft between ground users. However, the SESAR Deployment Manager, taking into consideration the recommendations from PJ.31, states in the deployment programme that the ADS-C common service “…is not part of CP1 and therefore not mandatory; however, it is deemed as beneficial as it supports fast and efficient ADS-C contract management”. The ACS is expected to be established as an acceptable means of compliance regarding the CP1 AF requirements.

During the execution of ADSCENSIO, the need for standardising the ACS has been raised to support implementation of the CP1 Regulation on AF6 (Initial Trajectory Sharing). After a thorough exchange between the European stakeholders on the most appropriate organisation to proceed with this standardisation, it was decided that this activity will be carried out under the umbrella of the Operational Excellence Programme (OEP) Workstream 12.2. This activity started in spring 2022 and has to be completed before the end of 2023, i.e. the industrialisation date is defined in CP1 AF6.

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11 Standardization Framework Considerations

The standardisation documents for EPP functionality validated by the PJ38 team are:

- ED-228A Safety and Performance Requirements Standard for Baseline 2 ATS Data Communications;
- ED-229A Interoperability Requirements Standard for Baseline 2 ATS Data Communications;
- EUROCONTROL Specification for Datalink Ground Distribution SWIM Services, based on PJ.38 deliverables and demonstrations and addressing the gaps for SWIM service standardization - Publication target date: end of 2023;
- EUROCONTROL Specification for Datalink Common Services for the Aeronautical Telecommunication Network (ATN), based on PJ.38 deliverables and demonstrations - An Institutional enabler STD-179 has been created in EATMA . Publication target date: end of 2023

Forthcoming revisions of Requirements Standards for ATS Data Communications including recommendations for improvements from PJ38 should be considered and validated for industrialisation after validation by next SESAR3 projects.

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12 Solution Data pack

Two documents provided for the ACS:

- "ADS-C Common Service requirements" (including the CONOPS)
- "ADS-C Common Service SWIM ICD"

These documents have been integrated to PJ38W3-ADSCENSIO DEMOR R1 (D1.2) and DEMOR R2 (D1.6).

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