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# SESAR SOLUTION PJ.02-W2-14.5 CONTEXTUAL NOTE V3

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# Copyright Statement





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# AART

AIRPORT AIRSIDE AND RUNWAY THROUGHPUT

This Contextual Note is part of a project that has received funding from the SESAR3 Joint Undertaking under grant agreement No 874477 under European Union's Horizon 2020 research and innovation programme.

## Abstract

This V3 Contextual note provides SESAR Solution PJ.02-W2-14.5 description for industrialisation consideration.

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# 1 Purpose

This contextual note describes the solution PJ.02-W2-14.5 with a summary of the results stemming from R&D activities contributing to deliver it. It provides (to both those external and internal to the SESAR programme) an overview of the solution in terms of scope, main operational and performance benefits, relevant system impacts and recommends additional activities that should be conducted during the industrialisation phase or as part of deployment.

This contextual note complements the solution Data Pack comprising the SESAR deliverables required for industrialisation and deployment.



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# 2 Improvements in Air Traffic Management (ATM)

## 2.1 Solution description & Scope

Initial R&D work on "Increased Glide Slope to Second Runway Aiming Points (IGS-to-SRAP)" started in **SESAR 2020 Wave 1 solution PJ02-02** which was grouping five different new approach procedures. At the end of Wave 1, the solution PJ02-02 was split into five different solutions.

This contextual note is about solution PJ.02-W2-14.5 solution only, "Increased Glide Slope to Second runway aiming point (IGS-to-SRAP)". The solution is limited to the cases when the distance between the two thresholds is at least 1100m.

PJ02 Wave 2 built on previous work to further validate the solution to V3 maturity level.

Increased Glide Slope to Second Runway Aiming Point (IGS-to-SRAP) will allow inbound aircraft reducing noise footprint impact in the surrounding areas of the airport and possibly runway occupancy time and/or taxi-in time, while also allowing potential increased runway capacity (via optimised wake separations).

The IGS-to-SRAP concept is a published approach procedure, enabling aircraft to land on a second further runway aiming point (with associated runway ground markers, lights and visual aids) and using a glide slope higher than the one to the first threshold.

The IGS-to-SRAP procedure is designed with a glide slope higher than the nominal one operated for the first aiming point. See Figure 1 and Figure 2.

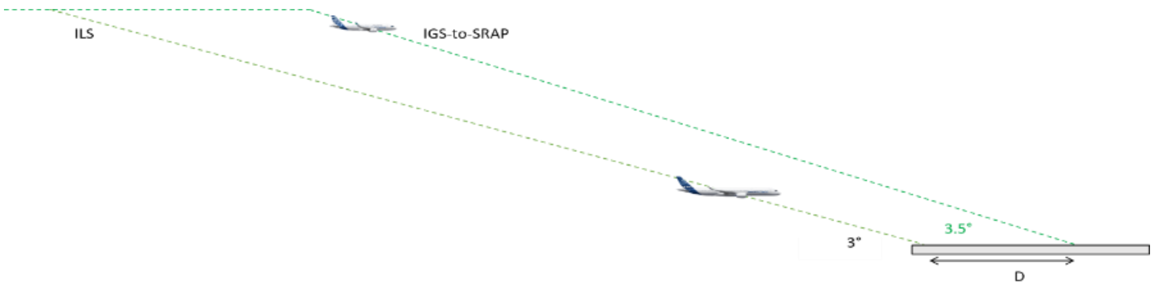


**Figure 1: IGS-to-SRAP procedure with one interception altitude (D >= 1100m)**

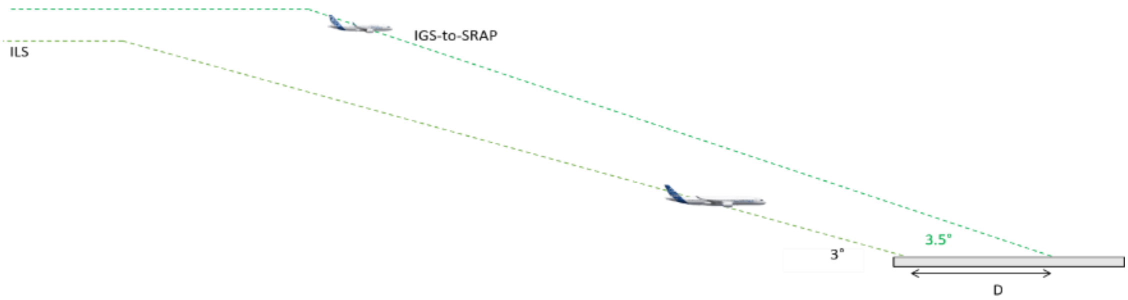


**Figure 2: IGS-to-SRAP procedure with two interception altitudes (D >= 1100m)**

Choosing an IGS-to-SRAP approach (over the conventional one) could be the result of the best compromise between available runway length, preferential runway exit use, noise, wake turbulence separation constraints, and the runway occupancy time.

## 2.2 Relevant Operational Environments

| OEs | Sub Operating Environments | Definition |
|---|---|---|
| Airport | Very Large Airport | Airports with more than 250k movements per year |
| | Large Airport | Airports with more or equal than 150k and less or equal than 250k |
| | Medium Airport | Airports with more or equal than 40k and less than 150k movements per |
| TMA | Very High Complexity | TMA with an Aggregated Traffic Complexity Score greater or equal to 10 or, if score is not available, with a number of serviced IFR flights greater or equal to 200000 per year. |
| | High Complexity | TMA with an Aggregated Traffic Complexity Score greater or equal to 6 and less than 10 or, if score is not available, with a number of serviced IFR flights greater or equal to 100000 and less than 200000 |
| | Medium Complexity | TMA with an Aggregated Traffic Complexity Score greater or equal to 2 and less than 6 or, if score is not available, with a number of serviced IFR flights greater or equal to 20000 and less than 100000 per year. |

## 2.3 Expected Benefits

The following KPAs express benefits from IGS-to-SRAP:

- **Environment / Fuel Efficiency** (reduction kg of fuel per flight);
- **Environment / Noise and Local Air Quality** (reduction of affected residents around airport with large fraction of MEDIUM aircraft);
- **Airport Capacity (Runway Throughput Flights/Hour)** (increase in movements/hour). The benefits are highly linked to local airport configuration (such as exit locations) and to local traffic mix.
- **Cost Efficiency / Human Performance** (increase in movements/hour).

# 3 Operational Improvement Steps (OIs) & Enablers

Applicable OI Step:

**AO-0331 —** Enhanced approach operations using an increased glide slope to a second runway aiming point (IGS-to-SRAP)

Dependent OI Step:

**None**

Required Enablers:

**AERODROME-ATC-102** - Aerodrome ATC system to support final approach operations (distinguish approach procedures)

**AIRPORT-56 -** Runway marking and lighting for IGS-to-SRAP/IGS-to-SRAP approach procedures

**APP ATC 170** - Approach ATC system upgraded to support approach procedure assignment

**HUM-024 -** Flight Crew new role for handling IGS-to-SRAP approach

**HUM-033** – ATC new role for handling IGS-to-SRAP approach

**REG-0533** - Regulatory provisions for Increased Glide Slope to Second Runway Aiming Point operations (IGS-to-SRAP)

**STD-112** - Update of EASA and ICAO regulatory frameworks for new visual ground aids (SRAP)

Optional Enablers:

**AERODROME-ATC-94** - Aerodrome ATC System to support Second Runway Aiming Point (SRAP) operations (separation delivery)

**APP ATC 163** – APP ATC System to support Second Runway Aiming Point (SRAP) operations (separation delivery).

**A/C-86** - On-board assistance to aircraft energy management

**A/C-87** - On-board assistance to flare

The two enablers for ATC systems are qualified as optional, however in case of airports with complex separation minima scheme in high traffic environment, these enablers become required as the controllers cannot have in mind the complex separation minima to apply.

The two aircraft enablers are qualified as optional. However, depending on the value of the slope and on the type of aircraft, they may become required. For example, trials made in the scope of VLD1 showed that Dassault aircraft do not need any enabler for slope up to 4.4deg, while Airbus considers that their aircraft may require assistance above 3.5deg.

Applicable Integrated Roadmap Dataset is DS23.

# 4 Background and validation process

The solution has been validated through a series of validations activities performed in SESAR 2020 Wave 1 and Wave 2.

**SESAR2020 Wave 1 Validation activities**

- **Fast-time simulations**
  - A fast time simulation about IGS-to-SRAP at Barcelona Airport assessed the performance of IGS-to-SRAP.
  - A fast time simulation evaluated the impact of IGS-to-SRAP procedures on both noise emission and overall airport capacity.
  - A fast time simulation assessed the benefits of IGS-to-SRAP in terms of runway capacity and fuel burn savings with environmental impact due $CO_2$ reductions.

- **Real-time simulations**
  - Two real time simulations on Paris CDG Airport assessed, from the air traffic controllers' point of view, the use of IGS-to-SRAP, in comparison to the conventional approach procedure only (ILS featuring a 3° glideslope)
  - A real time validation assessed IGS-to-SRAP runway aids from pilots' point of view, via flight cockpit simulations using high level professional Level D/Type 7 flight crew training simulator. The simulator of the type Airbus A319 has full motion, control loading and a configurable visual system.
  - Two real time simulations assessed the use of the two aircraft enablers (energy management and assistance to flare) on an Airbus aircraft cockpit simulator.

**SESAR2020 Wave 2 Validation activities**

- **Real-time simulations**
  - A real time simulation assessed the ways proposed to air traffic controllers, to manage the non-nominal situations involving aircraft flying IGS-to-SRAP procedures. These non-nominal situations were the loss of the controller separation support tool, the go-around/missed approaches and cases when an aircraft was not performing the expected/cleared approach procedures (i. e. ILS approach when IGS-to-SRAP expected or cleared, or IGS-to-SRAP when ILS expected or cleared).
  - A real time simulation for pilots assessed the two proposed solutions for IGS-to-SRAP runway lighting, steady and switching, via flight cockpit simulations using high level professional Level D/Type 7 flight crew training simulator. The simulator of the type Airbus A319 has full motion, control loading and a configurable visual system. The proposed solution for the PAPI for IGS-to-SRAP was as well evaluated.
  - A real time simulation for pilots assessed several proposed solutions for IGS-toSRAP runway marking, via flight cockpit simulations using high level professional Level D/Type 7 flight crew training simulator. The simulator of the type Airbus A319 has full motion, control loading and a configurable visual system. The proposed solution for the PAPI for IGS-to-SRAP was as well evaluated.

- Following the results of the simulation about lighting, a last real time simulation for pilots assessed the steady solution for lighting with pilots that had never seen the other solution (switching). The simulator was the same as before. The proposed solution for the PAPI for IGS-to-SRAP was as well evaluated.

- **Flight trials**

  - A flight trial campaign took place at Twente airport, as part of VLD1 project, involving both airline aircraft (non revenue flights) and pilots, and test aircraft and pilots. It assessed, under VMC conditions, the marking, dual PAPI set-up and runway designator increment, as recommended from Wave 2 flight simulations and the PAPI for IGS-to-SRAP. However, there were no IGS-to-SRAP Approach Lighting system, neither ATC service available at Twente for these trials. The navigation guidance was based on a (temporary) GBAS GAST-D ground station, which was compatible for a test flight, having the test aircraft used a GAST-D onboard receiver and the Airline aircraft (A319ceo and B737Max8) using GAST-C avionics.
  - A flight trial took place at Rome Ciampino airport, as part of VLD1, to assess different glide slope angles and the two aircraft enablers developed by Honeywell, with solutions different from the ones evaluated in Wave 1 by Airbus.

# 5 Results and performance achievements

## 5.1 Results from ATC side

Wave 1 assessed the use of IGS-to-SRAP approach procedures in nominal situations. The results are the following:

- The proposed ATC HMI for IGS-to-SRAP was found usable and acceptable for the controllers. The supporting ATC HMI design of the Air Surveillance Display was adapted to enable the Approach Controllers to select and record the expected / cleared approach. On the Tower Runway Control CWP the HMI was adapted to facilitate identification of which traffic is cleared on which procedure.
- Thanks to the vertical difference between the 'upper' IGS-to-SRAP and 'lower' conventional final approach profiles, the wake turbulence separation minima can be reduced when Medium (e.g. Airbus A320) and Light aircraft types are flying on the (upper glide') final approach while the Heavy and Super category types are assigned to the 'Lower glide' one. The design of the IGS-to-SRAP wake turbulence separation minima is based on the RECAT-EU methodology previously endorsed by EASA. However it is intended that a specific safety case will be introduced to EASA as part of the V4 phase and regulatory acceptance.
- For operating IGS-to-SRAP, in order to support the more complex separation management between the traffic on 'lower' and 'upper' glides, the Air Traffic Controllers were supported by the ORD tool (developed by PJ02-01 in Wave 1). The use of ORD tool was found beneficial from a safety point of view as reducing the risk of under-spacing.
- The use of two interception altitudes can enable to take full advantage of the wake separation reduction (since longitudinal separation can already be reduced before glideslope interception), however this might introduce higher operational complexity that will need to be managed by Air Traffic Controllers or with the ORD tool support.

Following recommendations from Wave 1, Wave 2 considered the following non-nominal situations, from the air traffic controllers' side:

- Sudden loss of the ATC ORD separation tool.
- Detection by a support tool of a wrong glide slope interception by an aircraft, not intercepting the expected or cleared slope.
- Go-arounds/Missed approaches.

For each case, the way to manage it was defined in close link with air traffic controllers, then assessed, through real-time simulation, refined, re-assessed until reaching a solution safe and manageable for the controllers.

## 5.2 Results from Pilots' side

As a general result, almost all of the participating pilots indicated that they can imagine using the concept of Increased Glide Slope to Second Runway Aiming Point in an every-day operation, and that they would find it acceptable that ATC consistently puts them on the 2nd threshold during the approach to the airport, provided the increased slope is manageable by them. Therefore it can be concluded that the concept is operationally feasible.

From onboard side, the key changes concern the visuals aids, including the PAPI, runway markings and approach lighting system. Different solutions were evaluated through cockpit simulations.

In addition, VLD1 project evaluated the two aircraft enablers through flight trials.

### 5.2.1 Approach lighting system

For the lighting system, two design options were assessed both in Wave 1 and Wave 2 using flight simulation exercise: a steady configuration where both threshold/aiming point and touchdown zone (TDZ) area were permanently illuminated, and a switching configuration where the approach lighting was illuminated for one of the thresholds, depending on which approach was the next landing. The switch took place as soon as the lead aircraft left the TDZ area, in case the next landing aircraft was assigned onto the other final approach slope. Each aiming point was supported by a dedicated PAPI.

The results of the tests of Wave 1 and Wave 2 showed that one solution was preferred in certain cases, and the other in other cases. Having that in mind and considering the complexity and the cost of the development of the switching solution, a last set of cockpit simulation was organised with the steady solution only, and with pilots that had never seen the other solution.

The final conclusion is that the steady approach lighting is found acceptable and safe in all situations.

### 5.2.2 Runway marking

In Wave 2, a cockpit simulation was performed to assess different proposals for the runway marking of the second threshold. The conclusion of these simulations was that pilots prefer the duplication of the ICAO marking or the chequered option of the ICAO marking.

For the flight tests in Twente, the ICAO duplicated solution was implemented, and the pilots found it acceptable and safe.

As a conclusion, both duplication of the ICAO marking and chequered option of the ICAO marking can be used for the second threshold.

### 5.2.3 PAPI

All the flight simulations performed in Wave 1 and Wave 2 used a PAPI for the first threshold positioned on one side of the runway and one for the second threshold on the other side.

The same was implemented for the flight trials performed in Twente.

The conclusion of all the tests is that both proposed solutions, red/white or red/green, are acceptable.

### 5.2.4 Second threshold numbering

In Wave 1 and 2 validation activities including the flight trials, the second threshold number was first one plus one (08 and 09, or 05 and 06).

During the flight simulations, discussions took place with pilots about other possible solutions, and the conclusion was that the chosen option was acceptable.

### 5.2.5 Charts

For the flight simulations and the flight trials, charts were developed for the IGS-to-SRAP approaches. They included:

- For both standard and IGS-to-SRAP procedures, the indication about PAPI location for the procedure.
- For IGS-to-SRAP procedure, the indication of the second threshold location, highlighted in red, and the corresponding vertical profile.

### 5.2.6 On-board assistance to aircraft Energy Management

The Energy Management system was tested by the Honeywell flight crew during 23 approaches (plus final Honeywell flight testing of improved EM prototype[1] was done in US based on results from Ciampino demo).

Overall, the Energy Management system proved to be useful during ISGS procedure, especially during the approach to an unfamiliar airport in bad weather conditions. With modified EM prototype it was observed improved crew awareness about timing of configuration changes when performing ISGS procedures. Nevertheless, prototype needs further improvement to increase level of usability and effectiveness, how it supports the crew during ISGS procedures. More specifically and based on final EM flight test results conducted in November 2022 in US following needs for improvements were identified:

- Improve drag component of the performance model
- Harmonize further FMS & Displays messages – timing and content of the messages

*Maturity status*

- EM on Embraer 170 reached TRL5 and is close to TRL6 (NASA TRL process). After improvements identified in last flight demonstrations, plan is to have it available on NG FMS[2] core with entry to service from 2025-2026.
- It is expected further expansion to more NG FMS equipped platforms under Honeywell Primus® Epic (exact aircraft type is not specified yet, however full list of Primus® Epic equipped aircraft can be found here).
- EM on Airbus, if agreed with Airbus and after dedicated re-design per Airbus requirements as well as adaptation of the Airbus FMS platform, development phase and testing, the EM function could target an FMS update by ~2030.
- Boeing – plans still to be defined.

[1] It has to be noted that it was an experimental prototype with known limitation, which still need to be considered during the result interpretation.

[2] NextGen FMS

### 5.2.7 On-board assistance to Flare

The Flare Assistant was implemented on the Honeywell primary flight display (E170 used within Ciampino demo was not equipped with HUD). Due to safety reasons, pilots did not look at the primary flight display during the Flare phase of flight. Therefore, the post evaluation video review was conducted with 2 pilots, who were asked to observe 4 recorded ISGS approaches captured during the Ciampino trials, where Primary Display with the Flare Assistant was visible.

Overall, Pilots' feedback suggest that the Flare Assistant proved to be useful and could effectively support pilot during ISGS procedures. Nonetheless, the usability of the system needs to be further improved and especially, in the case where the Flare related cues are provided on the *head-up* instead of the *head-down* display.

*Maturity status*

- Given the limitation of not having HUD equipped a/c for flight demo during concerned demonstration activities, the maturity estimated for this technology is currently within range of ~TRL4 - TRL5 (or e.g. TRL5 ongoing).
- Based on the results, *head-down display* (HDD) solution is not preferred. Flare assistant shall be integrated on *head-up display* (HUD).
- Next steps with respect to HUD implementation and entry to service still to be defined.

## 5.3 Performance achievements

### 5.3.1 Runway throughput

Most of the validation runs from Wave 1 show an increase in throughput as a result of IGS-to-SRAP and associated wake turbulence separation minima reduction. This can reach up to 7% depending on the separation scheme used (ICAO, RECAT-EU or RECAT-EU-PWS) and the traffic mix, as smaller aircraft types (Medium and Lights) are assigned to the approach with the aiming point located downstream and the larger types (Heavy and Super) are left on the 'lower' approach.

### 5.3.2 Environmental impact

SRAP has a positive impact on fuel burn savings as the flight duration is reduced.

Regarding the exposure of residents living in immediate vicinity of the airport, there is a reduction of affected residents since the noise contour location is shifted closer to the airport area.

The VLD1-W2 DREAMS Demonstration exercise at Twente (EHTW) airport concludes with noise reduction due to IGS-to-SRAP with 3.5° glide slope. Aiming for an IGS-to-SRAP threshold further down the runway displaces the ground noise impact area towards the airport and away from inhabitants and makes the aircraft noise benefit from the altitude difference. The IGS-to-SRAP procedure with 3.5° glide slope makes the aircraft noise benefit by increasing the altitude difference. For IGS-to-SRAP procedures, noise reduction is visible when looking at the LAmax levels under-track, and area shift is visible when reviewing noise contours.

# 6 Recommendations and Additional activities

Flight trials already took place in Wave 2, but only the runway marking and the second PAPI were evaluated.

It would be great to have as well the possibility to evaluate in additional live trials, the steady lighting and the impact on the controllers, of the management of IGS-to-SRAP procedures mixed with standard approach procedures. However, due to the cost of the installation of the light for the steady lighting and for the upgrade of controllers HMI to accommodate IGS-to-SRAP, it seems to be very unlikely to be possible as part of new validation activities.

Regarding regulation and standardisation, engagement with regulatory bodies, EASA and ICAO should be undertaken to seek the necessary regulatory evolution associated to IGS-to-SRAP visual aid (AMC/GM to Aerodrome regulation EU 139/2014 and ICAO Annex 14) and AMC/GM to Common Requirements regulation EU 2020/469 Part-ATS).

Regarding ATS, the IGS-to-SRAP procedure and phraseology should also be subject to the necessary regulatory framework.

Besides these aspects, there is also a need to seek for regulatory endorsement of the adaptation of wake turbulence separation minima applicable to IGS-to-SRAP operations. In this view, EUROCONTROL developed a generic safety case to be submitted to EASA (using a similar approach as previously applied for RECAT-EU and TBS wake minima).

The VLD1-W2 DREAMS flight trial at Twente led to the following additional recommendations

- When implementing such solutions in daily operations, it is highly recommended to have both PAPI's operating at equal brightness.
- In case the IGS-to-SRAP procedures are to be performed in worse weather conditions than the VMC encountered during the tests, the use of (some kind of) IGS-to-SRAP approach lights is recommended.
- For approaches to runways with conventional and IGS-to-SRAP procedures, it may be good for the mindset to include the runway designation also in the 500 ft call.
- Small changes/additions to the approach briefing and crosschecks to verify the correct runway end will need to be incorporated in the SOPs.
- For a good mental picture, it may be helpful to include "lower/higher glide" in traffic info messages.
- In IGS-to-SRAP charts it may be even more clear when using "2nd Threshold" in the header.
- If PAPIs are on opposite sides of the runway for first and second threshold, it could be possible and considered to add that information to the phraseology as an additional distinguishing factor.
- Inclusion of "first/second runway" in the landing clearance is acceptable, whereas the choice of runway designator remains subject of personal preference: some Pilot subjects prefer e.g. "05A/B" over "05/06".

Further demonstration activities are recommended to assess the ATC impact and demonstrate the HP and SAFETY feasibility of the proposed solutions before the deployment.

# 7 Actors impacted by the SESAR Solution

The following actors are impacted by the introduction of IGS-to-SRAP:

- Air Traffic Controllers;
- Flight Crews;
- ANSPs;
- Regulatory Authorities.



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# 8 Impact on Aircraft System

SRAP has no impact on aircraft system.

# 9 Impact on Ground Systems

Impact on the Approach ATC system as it must allow the controller to assign an IGS-to-SRAP approach procedure to a flight when required.

Impact on the Tower ATC system as it must allow the controller to distinguish between flights using IGS-to-SRAP approaches and others.

Impact on airport infrastructure as the marking and lighting for the second threshold have to be installed, as well as a second PAPI.

# 10 Regulatory and standardisation Framework Considerations

The following regulatory and standardisation needs are anticipated:

- Development of corresponding AMC into the Part-ATS of regulation EC. 2017/373 Common requirements for Air Traffic Management / Air Navigation Service
    - based on generic safety cases on the evolution of wake turbulence separation minima associated to EAP, to be submitted for EASA regulatory approval
- Proposal for Amendment of the ICAO Document 4444 PANS-ATM
    - with the EASA AMC on EAP wake turbulence separation minima
- Development of requirements for visual aids supporting IGS-to-SRAP and integration into EC. 139/2014 on Aerodromes
- Proposal to Amendment ICAO Annex 14 with provisions for visual aids, supporting IGS-to-SRAP based on EASA requirements.

# 11 Solution Data pack

The solution Data Pack includes the following documents:

- D4.5.002 - PJ.02-W2-14.2 SPR-INTEROP/OSED final. Part I of the document contains requirements for the solution.
- D4.2.008 - PJ.02-W2-14.2 TS/IRS Final. The document contains the technical requirements of the solution.
- D4.2.006 - PJ.02-W2-14.2 VALR Final. The document contains the results of the validation activities performed in W2 (ATC real time simulation for non-nominal situations and flight simulations)
- D4.2.010 - PJ.02-W2-14.2 CBA Final. The document is the cost benefit analysis of the solution.

In addition, the following document are as well available:

- VLD1 D1.4 – DEMOR. The document has been developed as part of VLD1-W2 DREAMS and gathers the results of the flight trials performed in that project.
- PJ02 Wave 1 D2.1.04 - PJ02-02 VALR (Final), Edition 00.01.00, 19 March 2020. This document was developed in PJ02 EARTH project (Wave 1) and gathers the results of the validation activities performed in solution PJ02-02 which was encompassing in particular IGS-to-SRAP.

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