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SESAR SOLUTION PJ.02-W2-14.3 CONTEXTUAL NOTE V3

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Authors of the document

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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-W2-14.3 description for industrialisation consideration.

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1 Purpose

This contextual note describes the solution PJ.02-W2-14.3 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 Second Glide Slope (ISGS)" started in **SESAR1 P06.08.08** (at that time, the procedure was called "Increased Glide Slope") and continued 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-W2-14.3 solution only, "Increased Second Glide Slope (ISGS)". The solution is limited to glide slopes up to 4.49 degrees.

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

By flying higher, Increased Second Glide Slope (ISGS) will allow inbound aircraft reducing noise footprint impact in the surrounding areas of the airport, but may imply to increase the separations between aircraft, thus reducing the runway throughput. That solution is then recommended to be used in periods of time when traffic demand is less, at night for example, or on airports that are not capacity-constrained.

IGS procedures are published approaches which feature a glide slope between the published one (commonly 3 degrees) and 4.49 degrees (limit above which steep approach concept applies), in order to provide a significant reduction in ground noise level (order of magnitude: -3 dBA in approach between 15 NM and 4 NM from runway threshold).

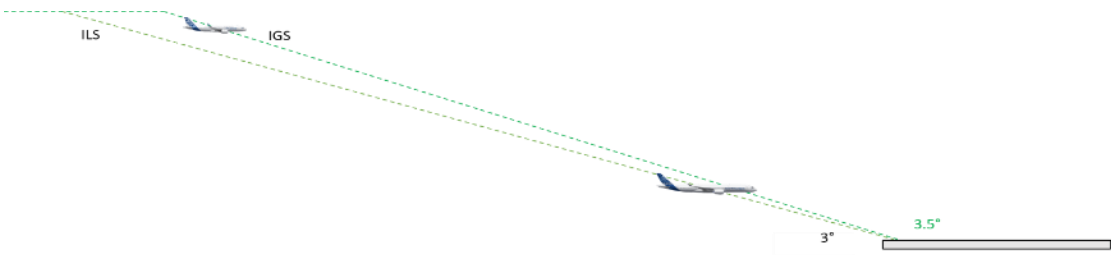

Figure 1: ISGS procedure with one interception altitude

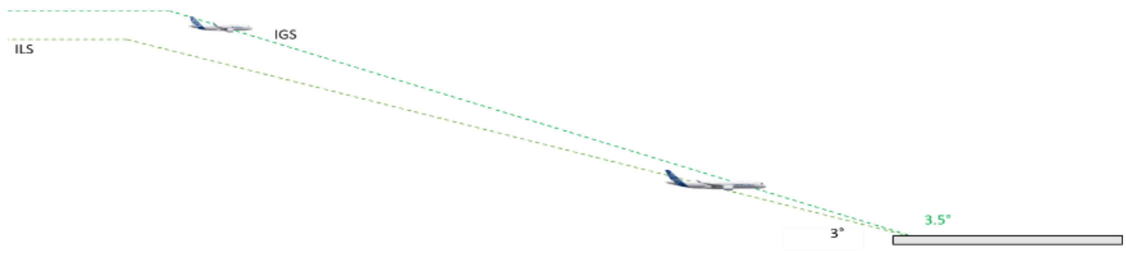

Figure 2: ISGS procedure with two interception altitudes

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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
	Small Airport	Airports with more or equal than 15k and less than 40k movements per year
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.
	Low Complexity	TMA with an Aggregated Traffic Complexity Score less than 2 or, if score is not available, with a number of serviced IFR flights less than 20000 per year.

2.3 Expected Benefits

The following KPAs express benefits from ISGS:

- **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).

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3 Operational Improvement Steps (OIs) & Enablers

Applicable OI Step:

AO-0320 — Enhanced approach operations using an increased second glide slope (ISGS)

Dependent OI Step:

None

Required Enablers:

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

AIRPORT-53 - PAPI for ISGS approach procedures

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

HUM-022 - Flight Crew new role for handling ISGS approach

HUM-032 – ATC new role for handling ISGS approach

REG-0530 - Regulatory provisions for increased second glide slope operations (ISGS)

STD-113 - Update of EASA/ICAO regulatory frameworks for new visual ground aids (ISGS)

Optional Enablers:

AERODROME-ATC-71 - Aerodrome ATC System to support ISGS operations (separation delivery)

APP ATC 114 – Approach ATC System to support ISGS 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 can benefit from assistance above 3.5deg.

Applicable Integrated Roadmap Dataset is DS23.

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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. The validation performed in SESAR 1 are not reported here.

SESAR2020 Wave 1 Validation activities

- **Fast-time simulations**
  - A fast time simulation evaluated the impact of ISGS procedures on both noise emission and overall airport capacity.
  - A fast time simulation assessed the benefits of ISGS in terms of runway capacity and fuel burn savings with environmental impact due CO_2 reductions.

- **Real-time simulations**
  - A real time simulation on Paris CDG Airport assessed, from the air traffic controllers' point of view, the use of ISGS, in comparison to the conventional approach procedure only (ILS featuring a 3° glideslope)
  - 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 ISGS 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 ISGS expected or cleared, or ISGS when ILS expected or cleared).
  - A real time simulation for pilots assessed the proposed solutions for the PAPI (no PAPI for ISGS, standard colour-PAPI for ISGS on one side of the runway with PAPI for standard glideslope on the other side, and PAPI with non-standard colours for ISGS on one side of the runway with PAPI for standard glideslope on the other side), 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.

- **Flight trials**
  - A flight trial campaign was performed by Lufthansa German Airlines at Frankfurt airport with the objective to assess the noise benefits. The ISGS slope was 3.2° and no specific PAPI was installed for that procedure. The existing 3° PAPI was used for both slopes.
  - A flight trial took place at Ciampino airport and assessed the impact of ISGS on pilots and noise benefits. For that trial, no PAPI was available for ISGS approaches. Three aircraft

types participated to the trial, ENAV P180, Dassault Aviation Falcon 7x/8x and Honeywell Embraer 170. Slopes at 3.9 and 4.4 ^{o} were flown.

- A flight trial campaign took place at Twente airport involving NLR's Cessna Citation II research aircraft. It assessed, under VMC conditions, the dual PAPI set-up, as recommended from Wave 2 flight simulations. Both red/white and red/green solutions were assessed for the ISGS PAPI.

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5 Results and performance achievements

5.1 Results from ATC side

Wave 1 assessed the use of ISGS approach procedures in nominal situations. The results are the following:

- The proposed adaptation of the ATC HMI of the Air Surveillance Display was acceptable to the Approach Controllers, enabling them to adequately select and record the expected / cleared approach, and IGS is found operationally feasible from ATC perspective. However, the lack of proper glide alerting function and of non-nominal cases (e.g. management of go-around or coping with sudden loss of the ATC ORD separation tool), were considered as not sufficiently evaluated to achieve V3 maturity level.

- The wake turbulence separation minima were adapted due to the vertical difference between the 'upper' IGS and 'lower' conventional final approach profiles, increasing the wake turbulence exposure when the lead aircraft flies higher than the follower while aiming for the same aiming point. The design of the ISGS wake turbulence separation minima is based on the RECAT-EU methodology previously endorsed by EASA. It must however be noted that the separation increase is fixed and independent of the ISGS slope (up to 4.49°), and this can be considered as conservative. A safety case on the revised ISGS wake minima will then need to be introduced to EASA as part of the V4 phase and regulatory acceptance.

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.

The way to manage each case 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

Pilots found the approaches fully acceptable and were confident in flying the ISGS operations. The general concept for the usage of an increased second glide slope was accepted and the benefits with respect of environment clearly understood.

The existing SOPs could be used, however, a crew briefing item on which PAPI to use, should be added and trained.

5.2.1 PAPI for ISGS

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The second PAPI was considered as acceptable both during the flight simulations and the flight trials at Twente. The recommendation from Twente tests is that ISGS PAPI must have the same intensity as the PAPI used for the nominal glide slope.

5.2.2 Charts

For the flight simulations and the flight trials, charts were developed for the ISGS approaches. They included:

- For both standard and ISGS procedures, the indication about PAPI location for the procedure, with the mention of the other existing one.
- For ISGS procedure, the indication of the second slope angle, the corresponding vertical profile, and the colour of the PAPI.

5.2.3 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).

[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

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- 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.

5.2.4 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 Environmental impact

ISGS has a positive impact on fuel burn savings.

Regarding the exposure of residents living in immediate vicinity of the airport, there is a reduction of affected residents since the noise contour area is reduced due to the higher slope.

The VLD1-W2 DREAMS Demonstration exercise at Rome Ciampino airport led to the following conclusions regarding noise impact:

- The ISGS procedures provided clear positive relative noise scale results:
    - **for the 3.9° approach path**: up to 4dBA on the first part of the final approach (depending on the moment where the landing configuration is extended) and 1 dBA when the aircraft is stabilized in the approach configuration.
    - **for the 4.4° approach path**: up to 4dBA on the first part of the final approach and 3dBA when the aircraft is stabilized in the approach configuration.
- Additionally, further dedicated analysis reported in output that the 65 dBA (LA_{max}) noise contour, for the reference approach runs (RNAV Z – GA 3.5°) and the ISGS runs (RNAV Y – GA 3.9° and RNAV X – GA 4.4°), is considered as representative metrics for the dedicated demonstration activities. Indeed, it was assessed the size of the noise contour is reduced in

average for the flights by 27% for the 3.9° approach and by 44% for the 4.4° approach when compared with the reference 3.5° approach.

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6 Recommendations and Additional activities

Flight trials already took place in Wave 2, but with a limited number of aircraft types, and mainly with test pilots. It would be interesting to perform live trials with the involvement of more airlines and aircraft types, together with ATC interactions

The development and validation of aircraft cockpit assistance, EM – energy management and FA – flare assistance, should be pursued to enable more (larger) aircraft to fly ISGS procedures, and (significantly) increase the benefits

It would as well be valuable to perform tests with a second PAPI installed for the ISGS approach, in addition to the PAPI for the standard approach.

Regarding regulation and standardisation, engagement with regulatory bodies, EASA and ICAO should be undertaken to seek the necessary regulatory evolution associated to ISGS PAPI (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 ISGS 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 ISGS 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).

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

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7 Actors impacted- by the SESAR Solution

The following actors are impacted by the introduction of SRAP:

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

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8 Impact on Aircraft System

Depending on aircraft types and on the slope angle of the ISGS procedure, enablers may be required for the aircraft. With high angles, ISGS may become impossible to fly for some aircraft types, with or without these additional enablers. It is recommended that local situation is assessed before designing and implementing such a procedure.

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9 Impact on Ground Systems

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

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

Impact on airport infrastructure as a second PAPI needs to be installed.

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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 ISGS and integration into EC. 139/2014 on Aerodromes
- Proposal to Amendment ICAO Annex 14 with provisions for visual aids, supporting ISGS based on EASA requirements.

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11 Solution Data pack

The solution Data Pack includes the following documents:

- D4.2.002 - 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-W2 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 SRAP.

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