INDUSTRIAL RESEARCH

SESAR DEMO VLD01 Report - Part IV - ENVAR

Deliverable ID	D1.4
Dissemination Level:	PU
Project Acronym	DREAMS
Grant:	874469
Call:	H2020-SESAR-2019-1
Topic:	SESAR-IR-VLD-WAVE2-14-2019 VLD.01 W2 GBAS/SBAS precision approaches including variable approach path
Consortium coordinator:	INDRA
Edition date:	01 December 2022
Edition:	00.01.02
Template Edition	02.00.05

EUROPEAN PARTNERSHIP

Co-funded by the European Union

Authoring & Approval

Authors of the document

Beneficiary	Date
ENAV	01/12/2022
DASSAULT	02/08/2022
HONEYWELL	02/08/2022
NLR	02/08/2022
DFS	02/08/2022

Reviewers internal to the project

Beneficiary	Date
AIRBUS	03/11/2022
DASSAULT	03/11/2022
DFS	03/11/2022
DLR	03/11/2022
NLR	03/11/2022

Reviewers external to the project

Beneficiary	Date

Approved for submission to the S3JU By - Representatives of all beneficiaries involved in the project

Beneficiary	Date
AIRBUS	04/11/2022
DASSAULT	04/11/2022
DFS	04/11/2022
DLR	04/11/2022
ENAV	04/11/2022
EUROCONTROL	04/11/2022
HONEYWELL	04/11/2022
INDRA	04/11/2022
NLR	04/11/2022

EUROPEAN PARTNERSHIP

Co-funded by the European Union

Rejected By - Representatives of beneficiaries involved in the project

Beneficiary	Date

Document History

Edition	Date	Status	Beneficiary	Justification
00.00.01	31/05/2022	Draft	ENAV	Initial draft providing noise benefits principle linked to overall geometrical effects in appendix A
00.00.02	14/06/2022	Draft	ENAV	Intermediate version internal review comments' integration
00.00.03	19/07/2022	Draft	ENAV	Document Updated
00.00.04	02/08/2022	Draft	ENAV	Intermediate version internal review and SJU comments' integration
00.00.05	24/08/2022	Draft	ENAV	Intermediate version internal review
00.00.06	18/10/2022	Draft	ENAV	Intermediate version internal review
00.00.07	31/10/2022	Draft	ENAV	Final version for review
00.01.00	03/11/2022	FINAL	ENAV	Final version for approval
00.01.01	07/11/2022	Final	ENAV	Final Version approved for the submission to SJU
00.01.02	01/12/2022	Final	ENAV	Final Version Integrating SJU comments

Copyright Statement

DREAMS

VLD1 WAVE 2 DEMONSTRATION OF RUNWAY ENHANCED APPROACHES MADE WITH SATELLITE

This ENVAR Report is part of a project that has received funding from the SESAR3 Joint Undertaking under grant agreement No 874469 under European Union's Horizon 2020 research and innovation programme.

Abstract

This document is the Environment assessment report for the Very Large Demonstrator (VLD) VLD.01-W2 DREAMS (DEMONSTRATION OF RUNWAY ENHANCED APPROACHES MADE WITH SATELLITE) project. It provides a synthesis of essential information (qualitative and quantitative) related to the assessment of the impact on the environment that VLD1 could have when implemented. This information comes mainly from the environment assessment plans (which are an integral part of the Validation Plan Reports), the results of the environment activities (which are an integral part of the Validation Reports), and the Performance Assessment Report related to this solution.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

Table of Contents

Abstract ... 4

1 Executive Summary ... 7

2 Introduction ... 8

2.1 Purpose of the document ... 8

2.2 Intended readership ... 8

2.3 Scope of the document ... 8

2.4 Environment work schedule within the Solution ... 9

2.5 Structure of the document ... 9

2.6 Terminology ... 10

2.7 Acronyms ... 12

3 The Environment Assessment Process: Objective and Approach ... 13

4 Environment Performance Assessment ... 15

4.1 Assessment Sources and Summary of Validation Exercise Performance Results ... 15

4.2 Conditions / Assumptions for Applicability ... 16

4.3 Environment: Fuel Efficiency / CO2 emissions ... 17

4.4 Environment: Noise, Local Air Quality, and non-CO2 Emissions ... 19

4.5 Overall conclusion on the environmental impact of the Solution ... 24

5 References ... 25

Appendix A Noise benefits principle linked to overall geometrical effects – Ciampino Use Case 26

List of Tables

Table 1:Exercise schedule ... 9

Table 2: Terminology ... 11

Table 3: Acronyms ... 12

Table 4: SESAR2020 Validation Exercises ... 15

Table 5: Summary of Validation Results ... 15

Table 6: Applicable Operating Environments ... 16

Table 7: Fuel burn and CO2 emissions saving per Exercise ... 17

Table 8: Fuel burn and CO2 emissions saving relative benefit per OI step ... 17

Table 9: Fuel burn and CO2 emissions saving for Mandatory KPIs /PIs ... 18

Table 10: Average fuel burn and fuel burn savings per phase of flight. 18

Table 15: Noise and Local Air Quality benefits per Exercise 21

Table 16: Noise and Local Air Quality relative benefit per OI step 21

Table 17: Noise and Local Air Quality benefit for Mandatory PIs 22

List of Figures

Figure 1: SESAR environmental impact assessment process. 13

1 Executive Summary

The SESAR 2020 Very Large Demonstrator (VLD) VLD.01-W2 DREAMS project encompasses three SESAR operational solutions enhancing the approach procedure operations to reduce noise and possibly wake turbulence separations: Increased Second Glide Slope (ISGS), Second Runway Aiming Point (SRAP), Increased Glide Slope to Second Runway Aiming Point (IGS-to-SRAP) supported by ground and space-based augmentation systems (GBAS & SBAS).

This document collects the results and the conclusions of the demonstration exercises conducted to bring enhanced approach procedure operations to the next maturity stage (V4) through a proof of concept (PoC) with flight trials, tests and preparations for the necessary changes in standardisation and regulations.

The demonstration exercise took place at:

- Twente to demonstrate SRAP, IGS to SRAP and ISGS
- Frankfurt to demonstrate ISGS
- Rome Ciampino to demonstrate ISGS

The demonstration exercises involved business jet, mainline aircraft (with Airbus and Boeing aircraft) and operators (two airlines). Participating air navigation service providers (ANSPs) developed new approach procedures and further assessed ground and space-based augmentation systems (GBAS & SBAS) at Twente, Frankfurt and Rome Ciampino airports.

The objectives of the demonstration are expected to demonstrate the impact on environment quantifying the noise benefits of the enhanced approach procedures above mentioned.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

2 Introduction

2.1 Purpose of the document

This document describes the results of the activities carried out, normally in accordance with the SESAR Environment Assessment Process [3], in order to assess the environmental impact that the VLD01 W2 DREAMS, focused on GBAS/SBAS precision approaches including variable approach path could have when implemented.

That information mainly comes from the environment assessment plans (which are an integral part of the main Validation Plan Report), the results of the environment activities (which are an integral part of the Validation Reports), and the Performance Assessment Report related to this solution.

Although this report is synthesised and it is considered as the most relevant for understanding the environmental impact of this solution, it cannot be considered stand-alone but it needs to be complemented with all the other Deliverables, and better, it will be considered as a detailed Report for the ENV KPA.

2.2 Intended readership

The intended audience for this document is primarily all the partners involved in SESAR 2020 VLD01, but may be of interest as well to the following stakeholders:

- PJ.02-W2-14.2, PJ.02-W2-14.3 and PJ.02-W2-14.5 solutions
- PJ.14-W2-79a solution
- ANS providers
- ATM infrastructure and equipment suppliers
- Airspace users
- Aircraft Manufacturer
- Airport owners/providers
- Affected NSA
- Affected employee unions.

2.3 Scope of the document

This document provides an overview of the environmental performance of the SESAR VLD01 W2 DREAMS project at the local level but also, when possible, extrapolated to the ECAC region. It covers the following environmental aspects:

- fuel used and CO_2 generated (at local and ECAC level), ***(N/A)***
- non-CO_2 emissions generated (at local and ECAC level), ***(N/A)***
- noise at local level.

2.4 Environment work schedule within the Solution

EXE	EAP	Airport	Timeframe	DEMOR Status
EXE-VLD-01-001 Coordinator: NLR	SRAP IGS-to-SRAP	Twente	*29 SEP – 08 OCT 2021*	**Exercise execution**: *completed* **Exercise report development**: *completed*
EXE-VLD-01-002 Coordinator: DFS	ISGS	Frankfurt	*From DEC 2021 to JUN 2022 (POSSIBLY SEPTEMBER)*	**Exercise execution**: *completed* **Exercise report development**: *completed*
EXE-VLD-01-003 Coordinator: ENAV	ISGS	Ciampino	*From NOV 2021 till April 2022*	**Exercise execution**: *completed* **Exercise report development**: *completed*
EXE-VLD-01-004 Coordinator: NLR	ISGS	Twente	*22 TO 28 JUN 2022*	**Exercise execution**: *completed* **Exercise report development**: *completed*

Table 1:Exercise schedule

2.5 Structure of the document

This document follows the self-explanatory section of the official templates established in SESAR2020 W2 programme.

1. Executive Summary
2. Introduction
3. The Environment Assessment Process: Objective and Approach
4. Environment Performance Assessment
5. References
6. Annexes

2.6 Terminology

Term	Description
Benefit and Impact Mechanism	A cause-effect description of the impacts of the solution proposed by a project. It describes the positive and the negative impacts that the project solution is expected to provide or demonstrate.
Benefit Diagram	A Benefit and Impact Mechanism is usually shown in a diagram giving an overview of the links between the (new) features that the project is bringing to the world of ATM and indicators (aspects which can be measured or calculated from other metrics), Positive or Negative Impacts for each performance area, and Key Performance Areas (KPAs) or Key Performance Indicators (KPIs). This diagram is supplemented by textual descriptions of the feature, the numbered links and impacts.
Business Case	A Business Case is a tool for decision-makers; it aims to provide them with the information they need to make a fully informed decision on whether funding should be provided and/or whether an investment should proceed. A Business Case is much more than just a financial analysis as it also includes quantitative and qualitative arguments on performance and transversal activities that are key elements to determining the value of the project.
Deployment Scenario	Deployment Scenario consists of a set of SESAR Solutions selected to satisfy the specific performance needs of operating environments in the European ATM System and based upon the timescales in which their performance contribution is needed in the respective operating environments
Environment	Surroundings in which humans interact with the air, water, landscape, natural resources, flora and fauna. In terms of ATM, 'the environment' will be the surroundings in which Air Traffic Management activities are planned or conducted, including research through to development, deployment, and operations.
Environmental Impact	Any modification of the environment that has or could have an effect on the ecosystem. In this document the main environmental impacts of concern are: • Aircraft noise in the vicinity of an airport, • Airport Local Air Quality (mainly CO, NO_x and Particulate Matter), • Global emissions (mainly CO_2) Fuel burnt is also of concern for the environment because of the direct relationship between fuel burnt and CO_2.

Environmental Impact Assessment (EIA)	The process of identifying and evaluating the environmental impacts of projects as well as proposing mitigations to reduce these impacts on the environment. The assessment scope, as it relates to ATM, considers impacts on the environment that can be affected by aircraft operations or that can affect aircraft operations, e.g. through mitigation rules. The main impacts on the environment related to aircraft movements are caused by emissions resulting from fuel burn and noise produced by the engines and airframe.
EIA plan	The Environmental Impact Assessment plan describes the hypothesis to test, metrics to assess, the tools to use, the required input variables for the tools and methodology used for analysing the results.
EUROCONTROL	European Organisation for the Safety of Air Navigation
S3JU Work Programme	The programme which addresses all activities of the SESAR3 Joint Undertaking Agency.
SESAR Programme	The programme that defines the Research and Development activities and Projects for the S3JU.

Table 2: Terminology

2.7 Acronyms

Term	Description
CO	Carbon Monoxide
CO_2	Carbon Dioxide
IMPACT	EUROCONTROL web portal for the analysis of aircraft noise and emissions
JU	Joint Undertaking
KPA	Key Performance Area
KPI	Key Performance Indicator
LAQ	Local Air Quality
NO_X	Oxides of Nitrogen, including nitrogen dioxide (NO2) and nitrogen oxide (NO).
PM	Particulate Matter
SEL	Sound Exposure Level
S3JU	SESAR3 Joint Undertaking (Agency of the European Commission)
SO_X	Oxides of Sulphur
SPR	Safety and Performance Requirements
VOC	Volatile organic compounds

Table 3: Acronyms

3 The Environment Assessment Process: Objective and Approach

The SESAR Environment Assessment Process [3] was derived from the ICAO Guidance document (Doc 10031) [4] “Guidance on Environmental Assessment of Proposed Air Traffic Management Operational Changes” and adapted to the SESAR validation framework.

As can be seen in on the Figure below, which shows the correspondence between the ICAO assessment process (right-hand side) and the one adopted for SESAR (left-hand side), the resulting process is quite generic and straightforward. Results from the environmental impact assessments can also be used to refine the ATM change, making the process cyclic and compatible with the classic Plan-Do-Check-Act approach to validation.

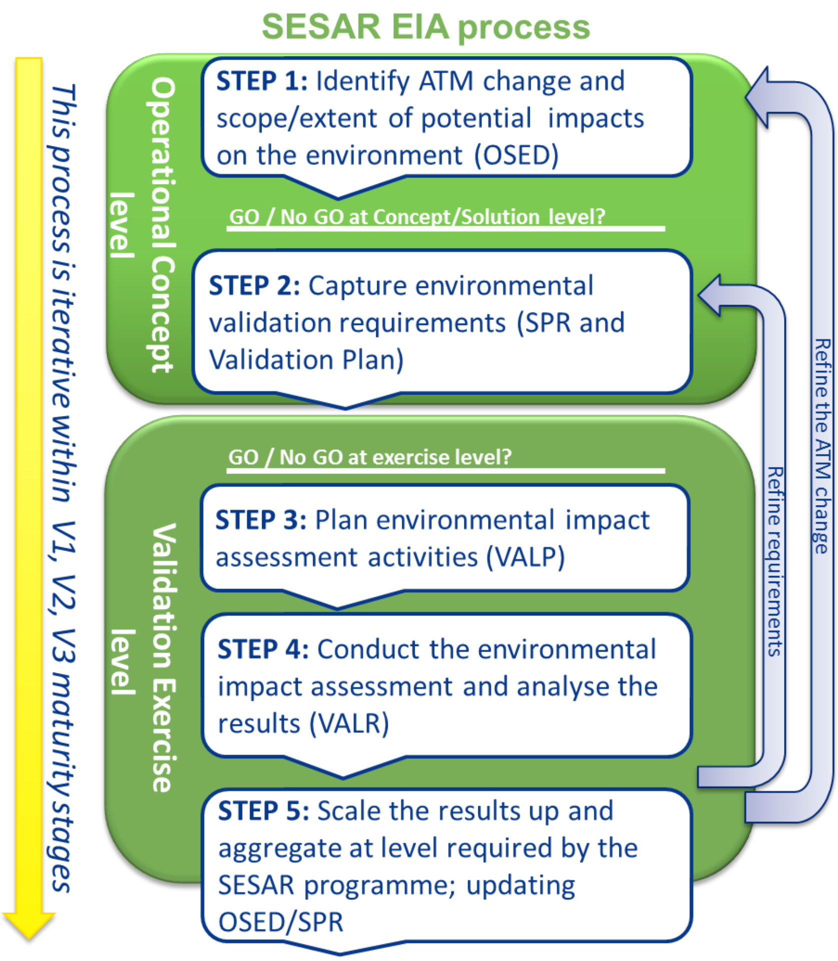


Figure 1: SESAR environmental impact assessment process.

This process should enable environmental impact assessment activities to be easily carried out as part of the overall validation process where necessary.

The SESAR EIA process consists of 5 main steps:

- EIA Step 1: Identify ATM change and the scope of potential impacts on the environment;
- EIA Step 2: Define environmental validation requirements;
- EIA Step 3: Plan environmental impact assessment activities;
- EIA Step 4: Conduct the environmental impact assessment exercise;
- EIA Step 5: Scale the results up and aggregate.

The SESAR EIA process encompasses two "Go-No-Go" decisions about carrying out further environmental impact assessments. The first one occurs after EIA Step 1 in order to identify very early on in the process whether it is worth undertaking an environmental impact assessment or whether or not more assessments are required later on in the process. The second one occurs at the Exercise level and allows the decision on conducting a detailed environmental impact assessment to be taken before the writing of the validation plan for that exercise. This decision will be based on criteria determined by the validation exercise management. In any case, every "Go-No-Go" decision should be included in the validation plan.

Please refer to the SESAR Environment Assessment Process for full guidance [3].

4 Environment Performance Assessment

4.1 Assessment Sources and Summary of Validation Exercise Performance Results

SESAR Validation Exercises of this Solution (completed ones and planned ones) are listed below.

Exercise ID	Exercise Title	Release	Maturity	Status
EXE-VLD-01-001	Exercise VLD1-01 Report - SRAP & IGS-to-SRAP Twente Demonstration	22	V4	Completed
EXE-VLD-01-002	Exercise VLD1-02 Report ISGS Frankfurt Demonstration	22	V4	Completed
EXE-VLD-01-003	Exercise VLD1-03 Report - ISGS Ciampino Demonstration	22	V4	Completed

Table 4: SESAR2020 Validation Exercises

The following table provides a summary of information collected from available performance outcomes.

Exercise	OI Step	Exercise scenario & scope	Performance Results	Notes
EXE-VLD-01-001	AO-0319 AO-0331	Exercise VLD1-01 Report - SRAP & IGS-to-SRAP Twente Demonstration	HP-SAF (see Part I)	
EXE-VLD-01-002	AO-0320	Exercise VLD1-02 Report ISGS Frankfurt Demonstration	HP-SAF (see Part I)	
EXE-VLD-01-003	AO-0320	Exercise VLD1-03 Report - ISGS Ciampino Demonstration	HP-SAF (see Part I)	

Table 5: Summary of Validation Results.

4.2 Conditions / Assumptions for Applicability

The following Table 6 summarises the applicable operating environments.

OE	Applicable sub-OE	Special characteristics
Airport	Small, Medium, Very Large	The solution has been validated in: • Twente (Small Airport) • Frankfurt (Very Large Airport) • Ciampino (Medium)

Table 6: Applicable Operating Environments.

4.3 Environment: Fuel Efficiency / CO2 emissions

Does the Solution impact this KPA? ***No***

N/A

4.3.1 Performance Mechanism

Is there a Benefit Mechanism available? ***No***.

N/A

4.3.2 Assessment Data (Exercises and Expectations)

N/A

Exercise ID or Expert judgement	Benefits contribution to FEFF1	Benefits contribution to ENV1
EXE-xx	***N/A***	***N/A***
Add additional rows for all the Exercises from your Solution		

Table 7: Fuel burn and CO2 emissions saving per Exercise

OI step	Relative benefits contribution to FEFF1	Relative benefits contribution to ENV1
XX-XXXX	***N/A***	***N/A***
Add additional rows for all the OIs from your Solution		
TOTAL	***N/A***	***N/A***

Table 8: Fuel burn and CO2 emissions saving relative benefit per OI step

4.3.3 Extrapolation to ECAC wide

N/A

KPIs / PIs	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
FEFF1 Actual Average fuel burn per flight	Kg fuel per movement	Total amount of actual fuel burn divided by the number of movements	YES	*N/A*	*N/A*
ENV1 Actual Average CO2 Emission per flight	Kg CO2 per flight	Amount of fuel burnt x 3.15 (CO2 emission index) divided by the number of flights	YES	N/A	N/A

Table 9: Fuel burn and CO2 emissions saving for Mandatory KPIs /PIs

Table 10 is showing the average fuel burn per phase of flight (provided when applicable).

	Taxi out	TMA departure	En-route	TMA arrival	Taxi in
FEFF1 Actual Average fuel burn per flight	N/A	*N/A*	*N/A*	*N/A*	*N/A*
ENV1 Actual Average CO2 Emission per flight (Kg)	N/A	N/A	N/A	N/A	N/A

Table 10: Average fuel burn and fuel burn savings per phase of flight.

Were there any benefits obtained in SESAR2020 Wave1 for this Solution? ***No***.

If yes, does the S2020 Wave2 performance comes in addition to S2020 Wave1 or replace it?
N/A

4.3.4 Discussion of Assessment Result

N/A

4.3.5 Additional Comments and Notes

N/A

4.4 Environment: Noise, Local Air Quality, and non-CO2 Emissions

Does the Solution impact this KPA? ***Yes***

The *noise* Focus Area only covers aircraft *noise* source; other *noise* sources around the airport contributing to the background *noise* are not considered. This KPA focuses on the quantification of the number of people exposed to aircraft noise, using different types of metrics, capturing different aspects of *noise* impact such as the notion of *noise* exposure (noise energy perceived on the ground), peaks in noise levels (maximum noise level perceived on the ground), and the frequency of "noisy" events (number of flights/operations exceeding a given noise level threshold during a certain time period).

Airport Local Air Quality is a commonly used term to designate the condition of the ambient air to which humans and nature are typically exposed in the vicinity of an airport. In most cases, determining the quality of the air around an airport is based on an estimation of the concentration of pollutants. These concentrations are compared with regulations and standards that are established to define acceptable levels of *Local Air Quality*, including the necessary measures to achieve them. Many issues particular to the *Local Air Quality* in and around airports are subject to these same regulations. Normally, airport environments comprise a complex mix of emission sources including aircraft, ground support equipment, terminal buildings and ground vehicular traffic (see ICAO Doc 9889). In the context of SESAR, in most cases only exhaust emissions resulting from jet-fuel consumption can be estimated and only these are considered, therefore.

Aviation emissions are not limited to CO2, which is the biggest *Green House Gas* resulting from the combustion of fuel, there are also a large range of *non-CO2 emissions*, which might have a significant contribution to climate change.

Although no performance targets have been defined for these environmental aspects, they need to be reported to help figure out the overall environmental impact of the deployment of the Solution.

Extrapolation at the ECAC level is not provided as not possible for *NOISE* and *Local Air Quality*, and not required for *non-CO2 emissions*.

4.4.1 Performance Mechanism

Is there a Benefit Mechanism available? ***No***.

4.4.2 Assessment Data (Exercises and Expectations)

4.4.2.1 **SRAP & IGS-to-SRAP Twente Demonstration**

Please refer to DEMOR Part I Sections A.3.2.19.1, A3.2.19.2, A3.2.20, A3.2.20.1, A3.2.20.2, A3.2.20.3 and A3.2.20.4 [5].

4.4.2.2 **ISGS Frankfurt Demonstration**

Please refer to DEMOR Part I Sections B.3.1, B.3.2.6 [5].

4.4.2.3 ISGS Ciampino Demonstration

The flight trials campaigns were conducted by Dassault with a FA8X, by the ENAV's P180 and by Honeywell with an E170 and all the 3 different campaigns brought the same results.

The positive qualitative feedback that has been revealed following the implementation (albeit only in the R&D phase) of the new EAPs in terms of optimization of the glide path and therefore of the management of the speed and power of the engines in the approach phase for landing, as well as the parallel (and connected) benefit in quantitative terms that is identified with the reduction of NOISE in the vicinity of the airport and of the inhabited area that is located in the vicinity of the same, both represent the expectations that are the OI associated with the VLD DREAMS.

The pilots applied two strategies to intercept the glideslope (in level flight or following a continuous descent) and followed the Standard Operations Procedures.

Additionally, the pilots applied a delayed or an anticipated deceleration on some approaches to establish the noise impact of such procedures.

Previously, flight crew performed the existing published approaches (both on RWY 33 and on RWY 15 too) to establish noise footprint before IGS implementation. Then, it was possible to measure the differences by the evaluation of the noise benefits principle linked to overall geometrical effects, enabled by ISGS.

The IGS procedure's effectiveness was assessed by comparing the noise levels generated during a IGS run (3.9° or 4.4° approach angle) to the noise levels generated during the reference run (3.5° approach angle) under the final approach.

The same operating technique was performed both by the crew of DASSAULT's FACON and was simultaneously programmed and "flown" by the crew of Honeywell's E170, and after each run, pilots performed a go-around below the published minima (approx. 1100m from threshold for category C aircraft) and so, consequently, the remaining segment/part of the approach affected by the increase of thrust has been removed from the noise analysis.

Exercise ID or Expert judgement	Benefits contribution to NOI1	Benefits contribution to NOI2	Benefits contribution to NOI4	Benefits contribution to LAQ1
EXE-VLD-01-003	3.9° APP: up to -4dBA on initial APP to -1dBA stabilized 4.4° APP: up to -4dBA on initial APP to -3dBA stabilized 3.9° APP: up to -4dBA on initial APP to -1dBA stabilized 4.4° APP: up to -4dBA on initial APP to -3dBA stabilized	3.9° APP: -27% regard to 65 dBA (LA,max) 4.4° APP: -44% regard to 65 dBA (LA,max) (Medium OE) 3.9° APP: -27% regard to 65 dBA (LA,max) 4.4° APP: -44% regard to 65 dBA (LA,max) (Medium OE)	***35.000*** ***population counted inside the Arrival Area's contour*** ***(Medium OE)***	

Table 12: Noise and Local Air Quality benefits per Exercise

4.4.2.4 Noise and Local Air Quality relative benefit per OI step and Mandatory PIs

OI step	Relative benefits contribution to NOI1	Relative benefits contribution to NOI2	Relative benefits contribution to NOI4	Relative benefits contribution to LAQ1
AO-0319				
AO-0320	30%	30%	30%	
AO-0331				
TOTAL	100%	100%	100%	100%

Table 13: Noise and Local Air Quality relative benefit per OI step

PIs	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
NOI1 Relative noise scale	-2 to +2	It is a qualitative scale based on expert judgment. -2 very negative effect or benefit, 0 neutral and +2 very positive effects or benefit. The objective of this metric is to provide a global assessment of the noise impact. This metric is built upon the other quantitative noise PIs (NOI2, NOI3, NOI4, NOI5)	YES for Airport OE Solutions	3.9° APP: up to **-4dBA** on initial APP to **-1dBA** stabilized 4.4° APP: up to **-4dBA** on initial APP to **-3dBA** stabilized	+1 (Medium positive effect upon NOISE reduction benefits)
NOI2 Size and location of noise contours	Contours of noise level thresholds (e.g. LDEN 55 see ERM document for the list of recommended PIs). Surface of these contours(Km^2)	Noise contours to be calculated according to the ECAC Doc.29 methodology. Surface of the noise contours calculated using a GIS tool or modules. **Recommended tool: IMPACT.**	YES for Airport OE Solutions	3.9° APP: -27% regard to 65 dBA (LA,max) 4.4° APP: -44% regard to 65 dBA (LA,max) ***(Medium OE)***	N/A

PIs	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
(NOI4) Number of people exposed to noise levels exceeding a given threshold	Number of people inside noise contours.	Population count inside the contours calculated above. Need the availability of population census data. Calculated using a GIS tool or modules. **Recommended tool: IMPACT.**	YES for Airport OE Solutions	***35.000*** ***population counted inside the Arrival Area's contour*** ***(Medium OE)***	***13.300*** ***population counted inside the Arrival Area's contour*** ***Medium*** ***(76/200)***
LAQ1 Geographic distribution of pollutant concentrations	Airport Local Air Quality Studies (ALAQS) inventory method generally uses mg/m^3 for each pollutant	Measurement to be performed within LTO cycle. • NOx: Nitrogen oxides, including nitrogen dioxide (NO2) and nitrogen oxide (NO); • VOC: Volatile organic compounds (including non-methane hydrocarbons (NMHC)); • CO: Carbon monoxide; • PM: Particulate matter (fraction size PM2.5 and PM10); • SOx: Sulphur oxides. • **Recommended tool: Open-ALAQS**	YES for Airport OE Solutions relative to LTO (=>below 3000ft)	*N/A*	*N/A*

Table 14: Noise and Local Air Quality benefit for Mandatory PIs

Were there any benefits obtained in SESAR2020 Wave1 for this Solution? ***No***.

If yes, does the S2020 Wave2 performance comes in addition to S2020 Wave1 or replace it?
N/A

4.4.3 Extrapolation to ECAC wide

The results counted at the end of the post analysis' activity were extrapolated to ECAC Level by considering that Rome Ciampino airport is classified as *OE Medium*, and similarly for the other 2 aerodromes as Twente classified as Small/Other and Frankfurt classified as Very Large.

Therefore, considering that *76 airports in the ECAC* area have been classified *OE MEDIUM* (by the Deliverable issued by the PJ20), out of a total of 200 airports which have been classified by the PJ20, hence the analysis that brings us back to consider the benefits of the NOISE reduction obtained thanks to the EAPs drawn on Ciampino airport can be reproduced with the same possible results/output/benefits (NOISE pollution reduction) also for all the similar airports in the ECAC area.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

4.4.4 Discussion of Assessment Result

The following sections provide the details concerning the assessments

4.4.4.1 SRAP & IGS-to-SRAP Twente Demonstration

N/A

4.4.4.2 ISGS Frankfurt Demonstration

N/A

4.4.4.3 ISGS Ciampino Demonstration

The new approach configuration (EAPs) above described allows to reduce the NOISE contour surrounding the original area around the Aerodromes where the planned flight trials have been performed by:

- ✓ LPV -3.9° - 1dB below the glide path
- ✓ LPV -4.4° - 1 to 3dB below the glide path based on a Noise benefit assessment (ΔLAMAX)

To complete this picture, it was acknowledged a positive result in terms of operational performance with no (or minimal) impact on the pilot's workload. Furthermore, the experience acquired during the demonstration activities led the experts to foresee the ATCOs' acceptability as well, although this aspect was not addressed during the flight trials.

As far as the airport scenario is concerned, given the nature of the location of Ciampino's RWY 33, and the types of aircraft, 2 Executive (FA8X and P-180 Avant) and a commercial E-170, that are not exactly some largest aircraft such as A320 or B737 or similar and therefore with a certain performance and/or "mass" ratio, *we can say that the same positive results that occurred at Ciampino can certainly be repeated on airports with the same characteristics and with similar airport traffic*. *But certainly, a similar result on an airport with different characteristics and overall, with different types of aircraft, is currently neither evaluable nor comparable.*

For this reason, given the positive benefits achieved and demonstrated in terms of NOISE reduction and ENV benefits, mixed with the more than positive feedbacks reported, the hope is that we can continue the outlined and that we can plan and develop further tests on other airports in ECAC with the aim to confirm what has been shown to be good and positive in Ciampino.

4.4.5 Additional Comments and Notes

Even if it is, actually, limited as reported above, it represents a positive result for the people that live surrounding the Airport and so that can help them to have a NOISE reduction and mainly a "cleaner" air to breath.

The final recommendation that is available from the above post analysis is to present, parallelly to the performance results in terms of flight efficiency and flight performances, to SJU the possibility to have the same results also at ECAC level, but both the results and the benefits might be considered absolutely in similar Operational contests.

Concluding, regarding the demonstrated *NOISE* benefits that helps to comply with the green deal objectives, *it is recommended to pursue to allow large deployment of such operations in Europe by implementing ISGS operations simultaneously to the deployment of LPV approaches at all instrument runway ends of 3D approach procedures as required by PBN-IR*.

4.5 Overall conclusion on the environmental impact of the Solution

Noting to add

5 References

[1] SESAR Performance Framework (2019), Edition 01.00.01, Dec 2019

https://stellar.sesarju.eu/?link=true&domainName=saas&redirectUrl=%2Fjsp%2Fproject%2Fproject.jsp%3FobjId%3Dxrn%3Adatabase%3Aondb%2Frecord%2F16414675

[2] Methodology for the Performance Planning and Master Plan Maintenance, Edition 0.13, Dec 2017

[3] SESAR, Environment Assessment Process (2019), PJ19.4.2, Deliverable D4.0.080, Sep 2019.

https://stellar.sesarju.eu/servlet/dl/DownloadServlet?downloadKey=xrn%3Adatabase%3Aondb%2Frecord%2F14665451&resuming=true&zip=true&disposition=attachment&domainName=saas&domainName=saas

[4] ICAO CAEP – "Guidance on Environmental Assessment of Proposed Air Traffic Management Operational Changes" document, Doc 10031. https://www.icao.int/publications/pages/publication.aspx?docnum=10031

[5] VLD 01 W2 DREAMS, DEMOR – Part I, D1.4

Appendix A Noise benefits principle linked to overall geometrical effects – *Ciampino Use Case*

The SESAR 2020 Very Large Demonstrator (VLD) VLD.01-W2 DREAMS Project encompasses three different SESAR operational solutions enhancing the approach procedure (EAP) operations to reduce NOISE and, parallelly linked with the Enhanced implementation, some possibly Wake Turbulence Separations integrated in flow of traffic for Airports with a medium traffic OE.

The Project will focus on advanced GNSS navigation technologies (GBAS/SBAS), aiming at progressing solution maturity and demonstrating the feasibility in operational environment through a proof of concept (PoC) with flight trials, tests and preparations for the necessary changes in standardization and regulations.

It will cover the following EAPs:

- ✓ Increased Second Glide Slope (ISGS)
- ✓ Second Runway Aiming Point (SRAP), so called double (two) threshold operations
- ✓ Mixed operations with IGS and SRAP, Increased Glide Slope to Second Runway Aiming Point (IGS-to- SRAP) supported by ground and space-based augmentation systems (GBAS & SBAS).

The scope of the NOISE analysis is to assess the feasibility in live operations (Flight Trials) and possibly to obtain a positive NOISE benefit (NOISE dB reduction) surrounding and within the proximity of the Airport landsite by implementing the EAP (both SRAP & IGS Procedures or ISG only). For the purpose and to accomplish the scope of the VLD, some selected AUs (stakeholders) tested the new EAPs and then, from their flight data (when possible and with the available information),

For the scope of the NOISE assessment, the expectation from the 2 EAPs concepts can be summarized as follow:

- ✓ ***The SRAP concept*** is an approach procedure, enabling aircraft to land on a second further runway aiming point (with associated runway ground markers, lights and visual aids). It is designed with a glide slope parallel to the nominal one operated for the first aiming point.
- Enhanced arrival procedures using a *Second Runway Aiming Point (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 (by optimized wake separations).
- ✓ ***ISGS procedures*** are approaches which feature a glide slope between the published one (commonly *3 degrees*) and *4.49 degrees* (limit above which steep approach concept applies).
- Enhanced arrival procedures using *Increased Glide Slope (ISGS*) will allow inbound aircraft to *reduce noise footprint (environmental benefit)*.
- ✓ ***IGS to SRAP procedures*** This *Enhanced Arrival Procedure*, applying an *Increased Glide Slope* (above the approach angle in use to the considered runway threshold and up to 4.49°) to an *Aiming Point* further down the runway threshold (as specified in the published chart), will enable inbound aircraft to reduce *noise footprint (environmental benefit)*.

The demonstrations focus on business jet, mainline aircraft (with Airbus and Boeing aircraft) and other Airspace Operators (two airlines).

Taking considerations that not all the new *EAPs* will be able as feasible or possible to be planned by all the stakeholders (AUs), mainly depending on the length of the main Runway (*SRAP*) in particular those of General Aviation and wide body aircraft[1], AUs have been involved and all the EAPs have been tested with live operations and by live trials with the aim to estimate if these new ARR Procedures might be implement some cases to improve, for instance, the RWY Capacity throughput or similar cases where they might be involved in some flight efficiencies [2].

Having assessed the scene, the project scenario can be completed assuming that both in *Twente* and in *Ciampino* all the flight tests have been completed as planned; and the tasks, the scopes of the flight trials have been accomplished as scheduled and as expected.

Main Environmental Sustainability expectation are:

- ✓ Reduction in environmental impact affects both fuel consumption and operating restrictions coming from NOISE limits.
- ✓ Communities around airports are interested into environmental benefits, especially Noise
- ✓ Manufacturing Industries are interested in assessing the impact on the NOISE benefits
- ✓ EC is interested into improving the main KPA related the ATM, particularly Environment KPA's possible benefits (NOISE & FEFF) coming from the Solution's implementation.

[1] Cargo wide body and other similar typology of AUs, also the ones with passengers onboard, and 2 type of AUs (DLH & TUI) participated to the flight trials too, in particular to test the IGS to SRAP and all the EAPs as well in Twente.

[2] ROT resulted to be one of the positive effects of the implementation of the SRAP and IGS-to-SRAP that combines the two previous uses from ISGS and SRAP, for instance.

SRAP & IGS to SRAP demonstration at Twente

This Project has been planned as a Live Flight Trial placed at V4-V5, with the aim and the target to demonstrate, in the real operating environment, the operational feasibility of ISGS (*Increased Second Glide Slope*) concept with dual PAPI system.

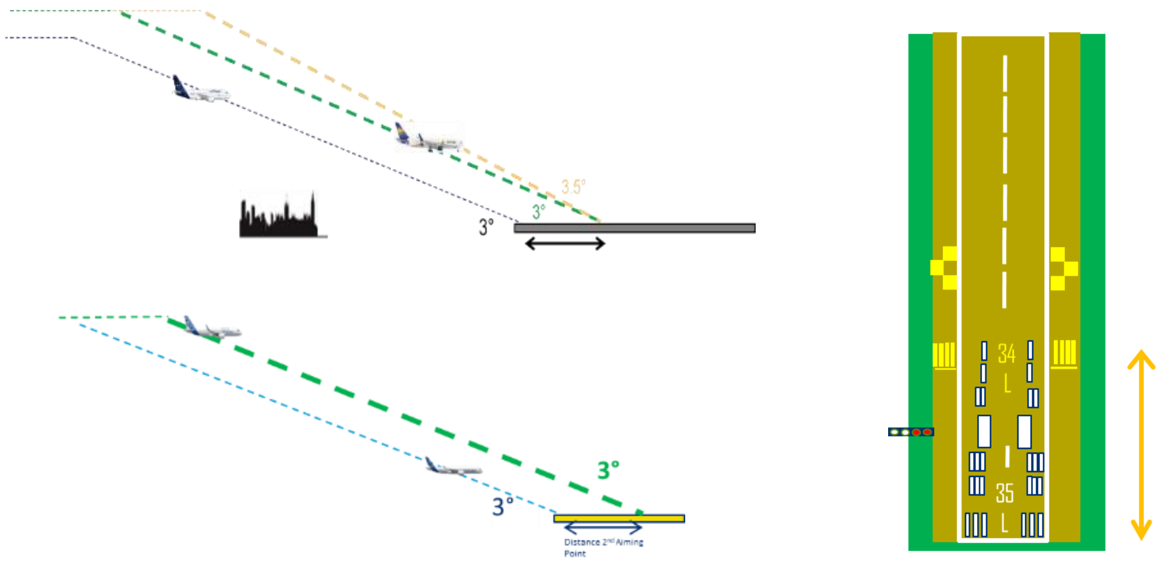
The proposed demo configuration for RWY 05 is the following one:

- ✓ SRAP 3.0° deg (SBAS) - Reference Scenario
- ✓ SRAP 3.0° deg (SBAS) -
- ✓ IGS 3.5° to SRAP (SBAS) - full PAPI configuration)
- ✓ IGS 4.0° to SRAP (SBAS) - full PAPI configuration)
- ✓ IGS 4.49° to SRAP (SBAS) - full PAPI configuration)

(IGS-to-) SRAP approaches can be safely and confidently performed without any difficulties. The APP procedures are straightforward and well within the capabilities of any current crew; the 4.0° and 4.49° IGS-to-SRAP approaches, although within normal approach design criteria for all aircraft types and even if with the limited traffic categories that approach to Twente Airport, may require careful energy management for larger aircraft.

What we were able to demonstrate with this flight trial campaign, mainly starting from the Airspace design project phase and following with the operational post analysis of the flight trajectories, is that both the *Enhanced Approach Procedures* (the one with different and improved descent angles (*3,5° – 3,9° – 4,5°*) and the second IGS and *SRAPtoIGS Approach*), provide surely some identifiable NOISE benefits for each of the new APP Procedures.

Each one of the Scenario demonstrates that, both on the papers/theory (Airspace Design) and on the inflight phases, the improved angles will increase both the Approach speed and the NOISE contour. So, concluding the first section, what we can establish at the end of the post analysis is the validity and the feasibility of the EAPs on that Airport/OE and at the meantime the operational convenience to operate the APP with the Enhanced procedures; what we aren't able to validate is the operational concept to implement the ARPs within a valid traffic sequence by approaching an Airport.



And the above due to:

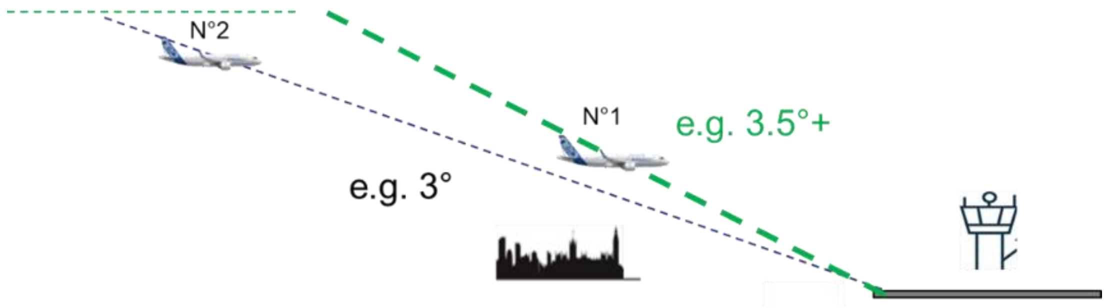
- ✓ In Twente Airport, because it is an airport where there is no scheduled IFR traffic, or better, not enough IFR traffic to insert the Test Flight within the planned arrival sequence and to test the new ARPs with a minima separation 3 NM or a few more, we weren't able to demonstrate and validate with the flight results the benefits to have a threshold moved ahead that allow to improve the RWY Capacity (or Capacity throughput);
- ✓ In Twente Airport the APP procedure starts at 2000ft, that is an altitude where it is difficult to demonstrate that an Advanced APP Procedure can change or can be the additional value to improve any benefit within a traffic sequence. That APP altitude cannot be handled by ATC because it is too low and the pilot has already set the aircraft for the low altitude of approach and the APP/distance is too "minima" to allow a sequence (the first landing aircraft won't be able to vacate the RWY when the second in sequence needs the clearance for landing before the DA/DH);
- ✓ There are also limitations regarding the approach profiles (Go-Around and the standard Twente approach from 2000ft, while an interception from 4000ft or above might be much preferable). In any cases, there are restrictions raised on the use of ANP data for the IMPACT noise modelling tool in case of single events and also for that reason AIRBUS conducted their own assessment for the Lufthansa flight, and a direct analysis by BOEING or CESSNA was not possible and the post analysis has been focused based on the expert judgement and on the reports released by AUs;
- ✓ Having defined the operational situation, the airport layout and the IFR APP Procedures, the expected benefits for NOISE reductions can be easily demonstrated and validated, but for a single Approach/aircraft that perform the new EAP as a single and not for more than one within a traffic sequence or as an Increased Second Glide Slope (ISGS) approach integrated in a flow of traffic;
- ✓ Positive NOISE benefits will be possible and can be demonstrated but limited, qualitative assessment, to the scenario and the Operational Environment where it has been tested. Another similar Environment (airports and EAPs as the ones designed for Twente) can surely feedback the same results but none other OE different from that one.
- ✓ The possibility to move ahead the RWY threshold, associated with an incremented descent angle from 3.0° to 3.5° or more since 4,49°, demonstrated that the APP can be handled with a reduced speed (Kt) thanks to the possibility to maintain the levelled segment at 2000ft longer and to start the descent ahead from the standard FAF. This benefit allows the pilots to set the TRHUST at the minimum and so to reduce the NOISE contour surrounding the original area around THR RWY 05 because the new descent point has been moved ahead (about 0.5/0.7 NM) and, summed with the reduced APP speed, for this reason we can demonstrate that the NOISE contour will be reduced (see image below with red/yellow colors) due to the reduced TRUST effect and the new THR RWY 06 moved ahead towards the RWY centerline;
- ✓ In detail, the Aircraft operational setting will consider the major influence of FLAP configuration, the Deceleration delayed for one SRAP and the *IGStoSRAP* and, as mentioned, Conventional Speed approach vs TAS evolution, all as positive benefits from the EAP implementations that allow an Environmental Benefit assessed as NOISE reduction.

IGS demonstration at Ciampino

This flight trials campaign in Roma Ciampino airport was aimed at demonstrating, also here in this *real operating environment,* the potential benefits derived by the IGS (*Increased Glide Slope*) concept implementation, assessing parallelly NOISE benefits and other potential impacts on Human Performance and Safety KPA.

More in detail, the objectives and the scopes expected by the Ciampino's Trials were:

- ✓ Designing, coding and validating of different ISGS (SBAS-based) approach procedures and then;
  - ➢ Evaluation of need to indicate into the procedure chart the approach path (e.g., angle) and related supporting navigation guidance;
  - ➢ Specifically highlight of the glide path angle in case it's significantly different compared to the conventional one (e.g., more than 3.5° to 3.9° and to 4.49°)
- ✓ Evaluation of NOISE reduction ascribable to the implementation of the new ISGS approach procedures



The proposed demo configuration for Roma Ciampino were the following one:

- ✓ *Solution Scenario #1*: IGS 3.9° with current PAPI installed as-is (3 white lamps and 1 red lamp).
- ✓ *Solution Scenario #2*: IGS 4.4° without PAPI

The operative setup configuration, which was prearranged for the live trial's activity, to allow the management of the ARR traffic to Ciampino airport (LIRA) with new IGS approach procedures in the real operating environment, it is the ***LIRA RWY 33 ARR/DEP***. As backup procedure, it has been planned that in case of availability of ***LIRA RWY 15 ARR/DEP***, in specified slots and traffic scenario permitting, the "Trial" activities could be managed as well on ***RWY 33***.

As well as for the Twente's operational scenario, also for Roma Ciampino the same operational factors were considered as being equal, exception made for the FAF altitude of the EAPs that are set at 5000 ft. To summarize and setup the scene where and how the post analysis has been conducted, these common factors are:

- ✓ type of aircraft: Piaggio A180, Dassault Falcon 8X, Embraer E170 (no airline Operators),
- ✓ dedicated arrival operations on RWY 33 and limited interaction with other arrival aircraft due to minimum separation of 15 NM between approaching traffic on sequence,
- ✓ only executive/business aircraft or in any case aircraft with mass not exactly consistent with the type of commercial/General aviation traffic as those that planned the operations for Twente Airport.

Continuing, in Ciampino Airport other additional integrations might be proponed:

- ✓ the IFR Approach Procedures for RWY 33 (also the EAPs for all the different improved APP angles) start at 5000ft and there is a RADAR service that provide vectors (or RADAR monitoring for the Approach) and also a set of different setups that allow to join the APP Procedures from different directions;
- ✓ the limitation of the distance for traffic sequence is due to the IFR APP procedure that is allocated on the VOR beacon (10 NM as standard separation or 15 NM in case of Departure from RWY 33) and that does not allow to manage a traffic sequence, so be defined. Even if it might be considered an improved Operational scenario compared with the Twente's one thanks to the higher APP FAF, also for Ciampino the positive benefits calculated for the NOISE reduction surrounding the THR RWY 33, as we can see in the images below, can be considered as "stand alone", that means that we can validate and quantify the operational benefit but by considering it as a single situation and within the contest (OE) where it has been deployed only.

Given the above and the element that the FMS data were received from the Piaggio and Honeywell E-170 only, for this airport and for the Validation Exercises carried out, it will certainly be possible to evaluate a qualitative post analysis, as it has been done for Twente Airport, and however trying to provide a parallel quantitative evaluation based on the available flight data. To complete the scene, Dassault send its own Noise Report based of Flight Data too and the output has been reported within the chapters of this DEMOR.

It is important to highlight also within this paragraph, as already mentioned within other parts of the document, that the VALUES obtained, the OUTPUTS registered and all the other DATA here reported too, *are valid and limited to the Demonstration where they have been tested and for the type/configuration of the Aircraft that stated the NOISE Assessment and the other values*. Further details or similar assumptions are not valid for other similar analysis and cannot be compared with the ones here reported!

By completing, even considering that the ANP parameters for the Noise assessment of the PIAGGIO aircraft are not available within the ANP Database, the data present in the EASA database are related to a proxy aircraft, Bombardier CRJ Series CRJ-700, and those parameters might be used for this purpose of the NOISE Assessment, for the quantitative assessment.

So, concluding the section, what can be underlined at the end of the post analysis is the validity and the feasibility of the EAPs on Ciampino Airport too and at the meantime the operational convenience to operate the APP with the Enhanced procedures; as well as for Twente, also for Ciampino Airport what it wasn't able to validate is the operational concept to implement the ARPs within a valid traffic sequence by approaching an Airport, even if the sequence has been followed by using the standard separation as published.

The post analysis assessment for the Ciampino's Validation flight trials, that has been planned to assess the performance analysis on Flight Efficiency (NOISE) SAF & HP KPA, starts by analyzing and going through the feedbacks provided by all the flight crew of ENAV, DASSAULT and Honeywell.
They offered, all of them, very positive feedbacks on the investigated IGS operations at Ciampino airport for both the experimented angles of descent at 3.9° and 4.4° respect to the reference at 3.5° and also respect to the standard approach of 3.0° (feedbacks based on the flight crew's daily experience).
The overall perception was that the tested *Enhanced APP Procedures have no specific difficulties respect to the day-to-day operations*, so defined the *Reference Scenario*, and that *there are even improving the final approach phase respect to the current/actual approach procedure available for RWY 33 at Ciampino airport*.
ENAV flight crew also performed, parallelly and for their own needs, some stress tests of the approach procedures to experiment different speed, aircraft configuration and conditions and final approach phase was always smooth and easy.

Looking at the other expected Performance's post analysis and analyzing the feedbacks received, all the flight crews stated that Safety was not impacted at all from their perspective and the overall perception was very good as the today operations. The perceived level of Safety was as the today operations.

Once that the *crew's feedbacks* have been analyzed and *the positive results* have been obtained both for the *SAF KPA and the operational feasibility*, the final step is the post analysis of the "static" (Airspace Design) and "dynamic" results (the flight data) for the Flight Efficiency scope (NOISE reduction).

The implementation of the new EAPs under the point of view of the Airspace Design has already been analyzed and validated when the Twente's analysis has been done.

Regarding Ciampino Airport too, given the different FAF altitude that is fixed at 5000 ft, the analyzed results are based assessment of the improved APP Design and the new glide paths (3.5° - 3.9° - 4.49°) on the subjective experience (expert judgement).
The new published (on test only) EAPs are able to provide an improvement on the final approach phase respect to the actual published and available Standard Approach for RWY 33.

The results and the FMS data have been collected (provided by ENAV and Honeywell Teams) in an accurate manner and there is a high confidence on the provided feedback too, even if all the actors involved underlined that the results are strictly dependent on the condition and context of Ciampino Exercise. The only difference that was underlined by all the flight crew was in relation to the energy management and configuration that might be more critical for aircraft types of bigger size respect to the ones involved with the flight tests and might slightly affect the energy management workload.

Having described the IFR APP Procedures, the crews' feedbacks and the operational situation, the expected benefits for NOISE reductions can be easily demonstrated and validated.

But before introducing the Flight Efficiency's post analysis linked with the NOISE assessment, it is appropriate to strict considered that the positive results have been obtained by analyzing a single Approach at a time, a single aircraft that performed the new EAP allocated on the new Increased Glide Slope (IGS) approaches.

To better clarify the concept, as already mentioned within the other sections of the Report, the flight operations in Ciampino didn't test in a dedicated time window and stand alone. The flight activities have been conducted, for all the 3 flight crews, during the normal activities and within the live traffic scenarios of Ciampino DEP/ARR traffic. That to underline that, even if a positive result can be validated, it didn't be possible to test within a traffic sequence that is less than the standard available for Ciampino, that means 10 NM separation between traffic approaching RWY 33 that will be incremented at 15 NM in case of departure from RWY 33.

For this reason, as done for Twente Airport, any positive NOISE benefits will be possible and can be demonstrated but limited, qualitative assessment, to the scenario and the Operational Environment where it has been tested. As it has been demonstrated for Twente, also for Ciampino similar Environment can surely feedback the same results but none other OE different from that one.

Assumed that the incremented descent angle from 3.0° and until 4,49° validate the operational concept that APP can be handled with a reduced speed (Kt) thanks to the availability to maintain the levelled segment at 5000 ft longer that the actual IFR Standard Arrival Procedure for RWY 33, the possibility to start the descent for landing on the new glide path (moved ahead from the standard Final Approach Fix as it is today within the STAR published on the Italian AIP) allows the option to set the aircraft with an improved flap angle and with a value of TRHUST and TAS evolution at the minimum setting.

The new approach configuration above described allows to reduce the NOISE contour surrounding the original area around THR RWY 33 (as visible in the following images) by:

✓ LPV -3.9° - 1dB below the glide path

✓ LPV -4.4° - 1 to 3dB below the glide path

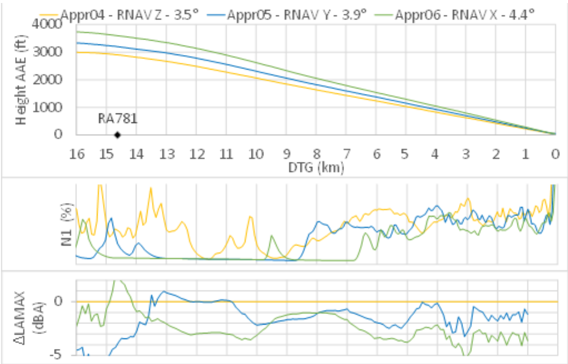
based on a Noise benefit assessment (ΔLAMAX)

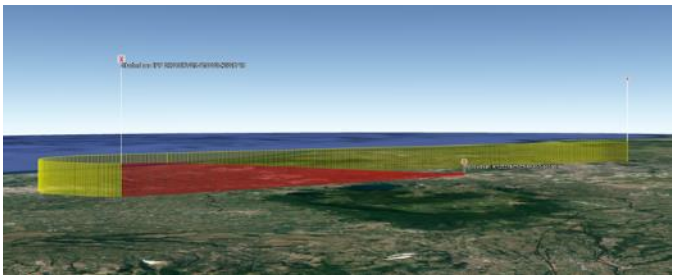
even if it is, actually, limited as reported above, it represents a positive result for the people that live surrounding the Airport and so that can help them to have a NOISE reduction and mainly a "cleaner" air to breath.

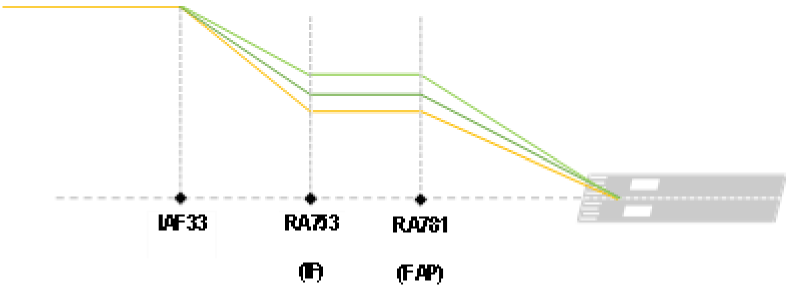
And parallelly the NOISE post analysis arranged with the original cockpit flight data, elaborated by using the IMPACT TOOL released by Eurocontrol, provided by Honeywell at the end of their Flight trial Campaign in Ciampino, acted the same results, as below reported as it was for the Dassault one.

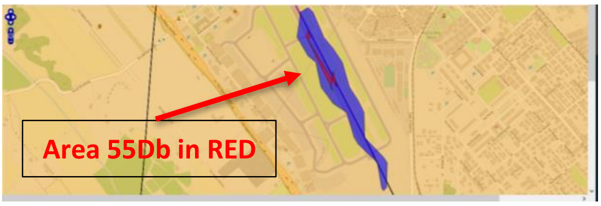
The HWL data also show a marked reduction of the affected area by 60 dB vs 55 dB between the 3.5 ° procedure and the new 3.9 ° and even a lack of detection of the same area 60 dB with the 4.49 ° procedure, in addition to that obviously a reduction of the area affected by the 55 bD which is clearly visible from the following images.

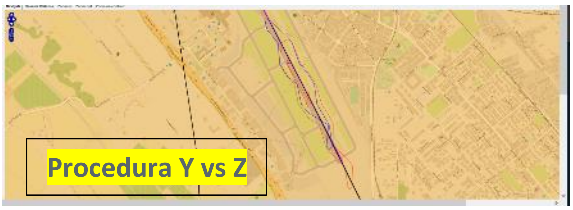
The final recommendation that is available from the above post analysis is to present, parallelly to the performance results in terms of flight efficiency and flight performances, to SJU the possibility to have the same results also at ECAC level, but both the results and the benefits might be considered absolutely in similar Operational contexts.



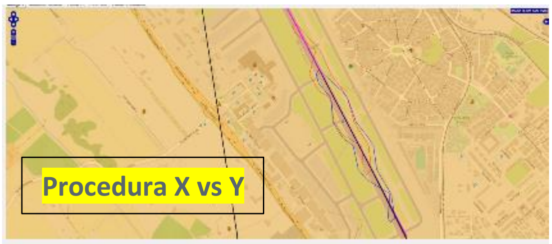




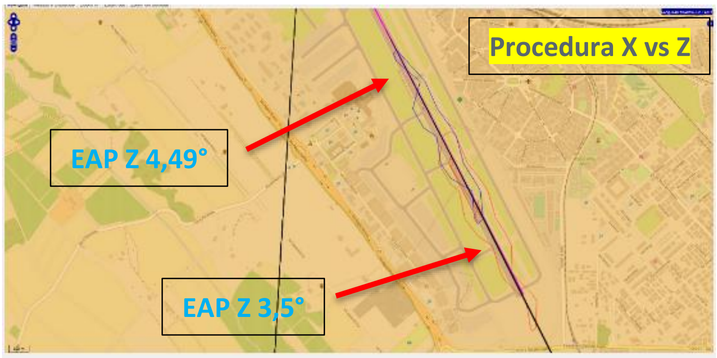

Area 55Db in RED


Procedura Y vs Z


Area 55Db in RED


Procedura X vs Y


NO Area 55Db


Procedura X vs Z
EAP Z 4,49°
EAP Z 3,5°

-END OF DOCUMENT-