

D1.4 - SESAR 2020-W2-VLD3 SORT DEMO Report - Part IV - Environment Assessment Report - WP2

Deliverable ID:	D1.4
Dissemination Level:	PU
Project Acronym:	SORT
Grant:	874520
Call:	H2020-SESAR-2019-1
Topic:	SESAR-IR-VLD-WAVE2-16-2019
Consortium Coordinator:	NLR (AT-One)
Edition Date:	24 May 2023
Edition:	00.03.00
Template Edition:	02.00.05

Authoring & Approval

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NATS	17/04/2023
HAL (SEAC2020)	17/04/2023

Rejected By - Representatives of beneficiaries involved in the project

Beneficiary	Date
None	17/04/2023

Document History

Edition	Date	Status	Beneficiary	Justification
00.01.01	14/04/2023	Partners Approved first edition	NATS	Version for WP2
00.01.02	17/04/2023	Reviewed draft	NLR (AT-One)	Reviewed draft
00.02.00	17/04/2023	Issue approved for submission	NLR (AT-One)	Submitted second D1.4 version to SJU
00.02.01	09/05/2023	Updated version	NATS	Final corrections
00.03.00	24/05/2023	Final SJU approved issue	NLR (AT-One)	Version approved by all project partners and SJU.

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SORT

SAFELY OPTIMISED RUNWAY THROUGHPUT

This VLD3-W2-SORT DEMO report - Part IV Environment Assessment Report (ENVAR) for WP2 is part of a project that has received funding from the SESAR3 Joint Undertaking under grant agreement No 874520 under European Union's Horizon 2020 research and innovation programme.



Abstract

This document constitutes the DEMO Report-Part IV Environment Assessment Report for WP2, hence is part of the contractual deliverable D1.4 (DEMOR). It is the Environment Assessment Report (ENVAR) for the Solution VLD-03-001C. It provides a synthesis of essential information (qualitative and quantitative) related to the assessment of the impact on the environment that Solution VLD-03-001C could have when implemented.

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1 Executive Summary

This document constitutes the Environment Assessment Report for WP2, hence is part of the contractual deliverable D1.4 (DEMOR). It consists of part IV of the DEMOR for the VLD-03-001C Exercise (held under WP2). The purpose of this document is to present the results with focus on Environmental Performance aspects of the Very Large Demonstration (VLD).

2 Introduction

2.1 Purpose of the document

The purpose of this document is to present the results from assessing the integrated runway sequence functions environmental impact.

2.2 Intended readership

The intended audience for this document is the team members of the DEMO VLD-03-001C under investigation.

Environmental practitioners at the level of the transversal areas are also expected to have an interest in this document.

Other stakeholders that may be interested in this document are to be found among:

- ANS providers
- Airport owners / providers
- Airspace users

2.3 Scope of the document

The operational scope of this demonstration was to utilise the Intelligent Approach (IA) Platform in a simulation of Heathrow Final approach, using the Separation and Spacing Indicators generated to position aircraft against.

2.4 Environment work schedule within the Solution

The environmental focus is to demonstrate the increase of fuel efficiency through reduced holding as a result of increased runway throughput.

2.5 Structure of the document

This document is structured as follows:

- **Section 1** provides an executive summary of the document.
- **Section 2** (this section) introduces the document.
- **Section 3** provides an overview of the Environment assessment process.
- **Section 4** presents the activities performed and the findings obtained from the Environment assessment steps conducted and completed to date.
- **Section 5** lists the documents referenced in this document.

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 CO₂) Fuel burnt is also of concern for the environment because of the direct relationship between fuel burnt and CO₂.

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 1: Terminology

2.7 Acronyms

Term	Description
ANSP	Air Navigation Service Provider
ATCO	Air Traffic Controller
ATM	Air Traffic Management
CO	Carbon Monoxide
CO ₂	Carbon Dioxide
DEMOP	DEMOstration Plan
DEMOR	DEMOstration Report
DMAN	Departure MANager
ECAC	European Civil Aviation Conference
EIA	Environmental Impact Assessment
ENV	ENVironment
ENVAR	Environment Assessment Report
FEFF1	Fuel Efficiency average Fuel Flow (1= per flight)
ICAO	International Civil Aviation Organization
IMPACT	EUROCONTROL web portal for the analysis of aircraft noise and emissions
IRSF	Integrated Runway Sequence Function
JU	Joint Undertaking
KPA	Key Performance Area
KPI	Key Performance Indicator
LAQ	Local Air Quality
NO _x	Oxides of Nitrogen, including nitrogen dioxide (NO ₂) and nitrogen oxide (NO).
OSD	Operational Service and Environment Definition
PAR	Performance Assessment Report
PM	Particulate Matter
PU	PUBlic

PWS	Pairwise Separation
RNP AR	Required Navigation Performance Authorization Required
RTS	Real Time Simulation
SEL	Sound Exposure Level
SESAR	Single European Sky ATM Research programme
SPR	Safety Performance Requirements
S3JU	SESAR3 Joint Undertaking (Agency of the European Commission)
SORT	SAFELY OPTIMISED RUNWAY THROUGHPUT
SO _x	Oxides of Sulphur
SPR	Safety and Performance Requirements
TS	Technical Specification
VALP	VALidation Plan
VALR	VALidation Report
VLD	Very Large Demonstration
VOC	Volatile organic compounds
WG	Working Group
WP	Work Package

Table 2: 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.

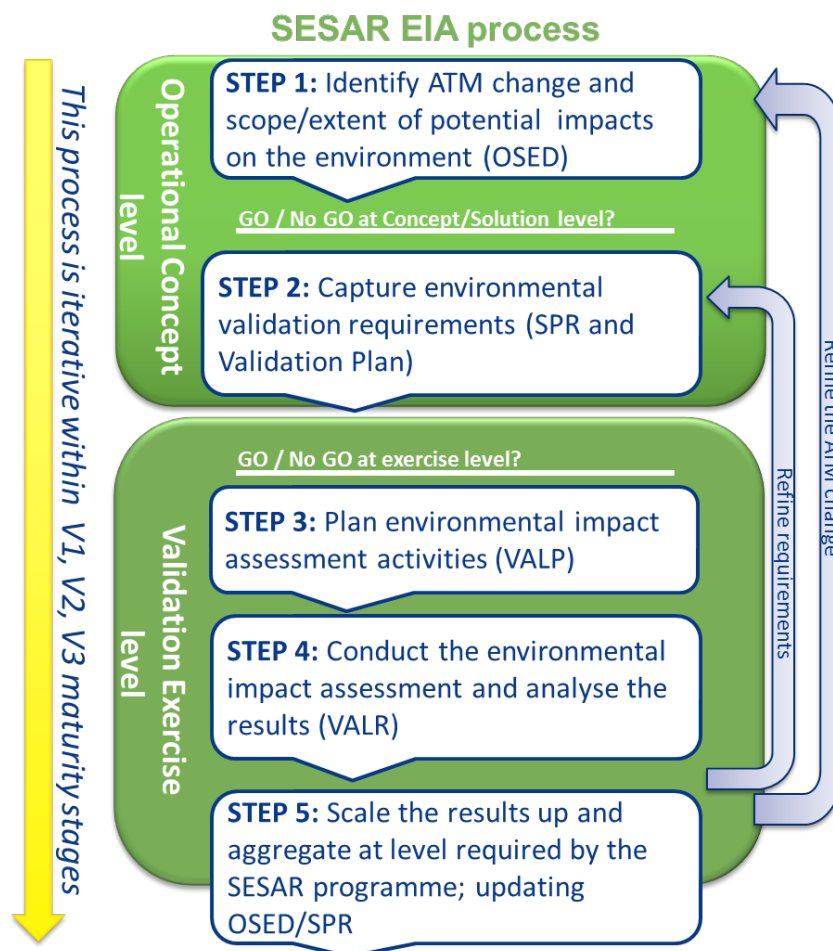


Figure 1: SESAR environmental impact assessment process.

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

Previous Validation Exercises (pre-SESAR2020 Wave 2, etc.) relevant for this assessment are listed below.

Organisation	Document Title	Publishing Date
PJ.02-01 members	D1.1.04 – Final PJ02-01 VALR – 00.01.01 [20]	31/01/2020
PJ.02-03 members	PJ02-03 VALR – 01.00.00 [21]	14/02/2020
PJ.02-08 members	SESAR Solution 02-08 D6.1.13 Validation Report (VALR) for V2 – v00.01.01 [22]	03/08/2018
PJ.02-08 members	SESAR 2020 PJ02-08 D6_1_23 V3 VALR 00.04.00 [23]	31/02/2020

Table 3: Pre-SESAR2020 Exercises

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

Exercise ID	Exercise Title	Release	Maturity	Status
EXE-VLD-03-001C	Demonstrate the feasibility and benefits of implementing Pairwise TBS, reduced MRS and improved ROT management in an RTS pre-deployment trial for London Terminal Control Centre.	R12	V4	Complete

Table 4: SESAR2020 Validation Exercises

Demonstration

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

Exercise	OI Step	Exercise scenario & scope	Performance Results	Notes
EXE-VLD-03-001C	AO-0328 AO-0306 AO-0309	The operational scope of this demonstration is to utilise the Intelligent Approach (IA) Platform in a simulator of Heathrow approach, using the Separation	Capacity: Under this exercise, the arrival throughput was assessed under a range of wind	EXE-VLD-03-001C

	AO-0337	and Spacing Indicators generated to position aircraft against. Valid Heathrow Approach controllers participated in all exercises and followed procedures defined for the solution concept. The national regulator will have visibility of the simulation activity as part of the validation and assurance evidence ahead of full operational deployment.	samples. However, the data set and the consistency of seating configurations for the matched run pairs was constrained. Depending on the wind profile and runway direction, a segregated runway capacity impact of - 0.2 to 3.4 movements/hour (- 0.44-8.11%) was identified. Note: values in red indicate a performance reduction. Fuel Efficiency: Applied to 2019 traffic, an average saving of 14 seconds per flight which corresponds to an average of 14.84kg of fuel saving was achieved. Using the direct link between fuel burn and the amount of CO₂ produced (3.15 times the mass of fuel burnt), this equates to 46.73kg of CO₂ saving per flight during the year 2019. Human Performance: The overall conclusion drawn from the evidence gathered is that the concept is feasible but requires further refinements being made to some
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			components of the ATM system (i.e., technology, system design and people) and reassessing the impact on HP to improve confidence that the results are accurate and reliable. Safety: Based on post-analysis, it can be determined that the delivery of aircraft to separation minima is acceptable under the Pairwise solution, as no technical losses of MRS were reported (11 were reported during eTBS runs).	
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Table 5: Summary of Validation Results.

4.2 Conditions / Assumptions for Applicability

The solution are expected to be applied in Medium to Very Large Airports with runways operated in mixed mode or having other dependencies between arrivals and departures between the runways. The solution is expected to provide benefits in all conditions but especially when runways are used in mixed mode operations.

The following table 6 summarises the applicable operating environments in accordance with 2019 SESAR 2020 airports classification provided by PJ20 sWP2.2 WG.

OE	Applicable sub-OE	Special characteristics
Airport	Very Large	Multiple runways: EDDF Flughafen Frankfurt/Main EDDM Munich Airport EGKK Gatwick Airport EGLL Heathrow Airport EHAM Amsterdam Airport EKCH Copenhagen Airport LEBL Aeropuerto de Barcelona-El Prat LEMD Aeropuerto de Adolfo Suárez Madrid-Barajas LFPG Aéroport de Paris-Charles de Gaulle

		LIRF Aeroporto di Roma-Fiumicino LSZH Flughafen Zürich ENGM Oslo-Gardermoen Airport LOWW Vienna International Airport LTBA Atatürk International Airport
Large		<u>Single runways:</u> EGSS Stansted Airport LSGG Genève Aéroport <u>Multiple runways:</u> LFPO Aéroport de Paris-Orly ESSA Stockholm-Arlanda Airport EBBR Brussels Airport EDDL Düsseldorf International Airport EIDW Dublin Airport LEPA Aeropuerto de Palma de Mallorca EGCC Manchester Airport LIMC Milano Malpensa LPPT Lisbon Airport EFHK Helsinki-Vantaa Airport EPWA Warsaw Frederic Chopin Airport LKPR Prague Airport
Medium		<u>Single runways:</u> EVRA Riga International Airport <u>Multiple runways:</u> LFMN Aéroport Nice Côte d'Azur EDDB Schönefeld Airport LROP Henri Coanda International Airport UKBB Boryspil State International Airport

Table 6: Applicable Operating Environments.

4.3 Environment: Fuel Efficiency / CO₂ emissions

4.3.1 Performance Mechanism

4.3.2 Assessment Data (Exercises and Expectations)

To compute the benefit of PWS in terms of fuel efficiency, it is assumed that the change in movements per hour due to PWS implementation can be translated into the total number of holding minutes saved.

The six sets of real time simulations provided hourly throughput values for eTBS and PWS. The average throughput increase for PWS over eTBS across these six sets was 0.44 movements per hour.

The simulations were based on two one-hour traffic samples (10:00 – 11:00 and 21:00 – 22:00), therefore, the average increase of 0.44 movements per hour has been assumed to apply to all hours from 06:00 UTC onwards, which will exclude the first hour of TEAM operations from the analysis. The base year for the analysis is 2019, since this is the last full year which is not impacted by Covid-19.

The total number of holding minutes saved as a result of PWS is calculated in two parts, the reduction in average holding time and the reduction in the number of flights that hold.

The reduction in average holding time for an hour is calculated as the number of extra movements multiplied by the average holding time per holding flight in the hour. This was calculated for all hours (06:00 UTC onwards) in which holding occurred throughout 2019. Summing these gives the total holding minutes that could be saved for flights that hold.

In addition, it is assumed that a reduction in holding time will reduce queue lengths, leading to a reduction in the number of flights holding. The introduction of eTBS at Heathrow delivered a theoretical 1.1 movements per hour and resulted in a 13% reduction in the proportion of flights holding. It is assumed that the reduction in the number of flights holding at Heathrow under PWS can be estimated as a direct proportion of that the benefit observed for eTBS i.e. PWS will deliver a 5.2% reduction in the number of flights holding because $\frac{0.44}{1.1} \times 13\% = 5.2\%$. The estimated reduction in the number of flights holding is multiplied by the number of arrivals in 2019 (238,818) and the average holding time per arrival flight (3.32 minutes) to estimate the number of minutes holding saved by reducing the number of flights in the stacks.

Combining the two values gives the total holding minutes that could have been saved for 2019, which can then be converted to fuel savings on the assumption that the average fuel burn per minute of holding is 63.8kg/min across all Heathrow arrivals (based on airborne holding at FL80 and a typical Heathrow aircraft fleet mix).

Table 7 shows the estimated fuel and CO₂ savings due to PWS implementation.

	Average
Total Holding Saved in 2019 (minutes)	55,534
Average Holding Saving Per Flight (seconds)	14
Holding Fuel Saved per flight (kg)	14.84
Holding CO₂ Saving per flight (kg)	46.73
Total Fuel Saving in 2019 (Tonnes)	3,543

Total CO₂ Saving in 2019 (Tonnes)	11,161
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Table 7: Fuel and CO₂ impact of Pairwise

Recommendation

4.3.2.1 Assumptions

The following assumptions were made in order to provide the Fuel/CO₂ impact:

- Results are based on the data provided from the real-time simulation which is a small sample size, and this was scaled up by assuming that each hour of a day has the same number of movements as the corresponding hour of every other day.
- The duration of the simulations were not full hours and varied slightly between scenarios, so the number of movements of each scenario were individually scaled to a full hour (also ensuring that each eTBS/PWS pair were matched in terms of run time) to ensure a like for like comparison between scenarios.
- Any aircraft landing outside of the given time frame provided (clock on/off time) was not included in this analysis
- Any aircraft that did not have an estimated landing time were assumed to have not landed within the simulation period and were therefore not included in the throughput calculations
- Extra movements were assumed to have a direct saving on time in the Hold
- Due to loss of indicators aircraft MEA201 and KLM1009 were excluded from the analysis in both eTBS and PWS data sets of the affected scenarios. The time between aircraft was not able to be calculated as their position in the sequence was not provided.
- There is less confidence in the accuracy of 7 of the PWS landing times included in the scenario 3 throughput calculations. Due to missing tracks data the estimated landing times were calculated based on an aircraft position that was further away than the rest of the aircraft
- It is assumed that traffic samples fall within Daylight saving time.
- Assumed average fuel burn per minute of holding is 63.8kg/min across all Heathrow arrivals based on ENVAR PJ.02-W2-14.6b.

4.3.3 Extrapolation to ECAC wide

An average of 14.84kg of fuel could be saved per flight arriving at Heathrow airport. As the common assumption [5] for average fuel burn per flight is of 5280kg, a saving of 14.84kg represents 0.28% (14.84kg / 5280kg) of fuel consumption reduction per flight.

However, as only flights arriving at Very Large and Large airports will reap the benefits, the benefit of the improvement at ECAC level will concern only 46.2% of the ECAC traffic in 2035 (common assumption of Traffic at Very Large (71.1%) and Large (21.3%) airports, from which only 50% (arriving traffic) is affected) and results in 0.13% of fuel reduction (0.28% * ((71.1% + 21.3%) * 50%)).

	Very Large Airports	Large Airports
Fuel Burn Savings	0.10%	0.03%
Fuel burn savings per flight (kg)	5.27	1.58
CO₂ Savings per flight (kg)	16.61	4.98

Table 8: Split of ECAC extrapolation into very large and large airports

4.3.4 Discussion of Assessment Result

Real-time simulations were run to compare the difference between eTBS and PWS arrivals at EGLL. The difference in numbers of aircraft arriving were compared each hour and scaled up to a year. The limited availability of real-time sim data (two 45-minute intervals) should be considered when looking at the resultant figures. It may be advisable to repeat this with a much larger dataset.

4.3.5 Additional Comments and Notes

No additional comments

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

N/A.

4.4.1 Performance Mechanism

N/A.

4.4.2 Assessment Data (Exercises and Expectations)

N/A

4.4.3 Extrapolation to ECAC wide

N/A.

4.4.4 Discussion of Assessment Result

N/A.

4.4.5 Additional Comments and Notes

No additional comments

4.5 Overall conclusion on the environmental impact of the Solution

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