D5.1 Exploratory Research Plan (ERP)

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Abstract

This document is the SESAR ASTAIR Exploratory Research Plan (ERP). It describes the exploratory research plan which will guide the preparation and execution of the validation exercises of the ASTAIR solution for TRL1 (Basic principles observed).

The SESAR ASTAIR Solution is a support tool to fully automate the supervision of airport ground operations. ASTAIR introduces automated taxiing to improve operational efficiency and reduce delays. It leverages the A-CDM (Airport Collaborative Decision Making) and A-SMGCS (Advanced Surface Movement Guidance and Control System) frameworks to create more predictable ground operations and alleviate operator workloads. The ASTAIR tool will consist of an interface that will make use of algorithms to autonomously manage vehicle movements on the airport surface, providing the controller with enough flexibility to locally tweak the algorithm rules to cope with operational events.

ASTAIR aims to promote a cohesive operational environment that integrates manual and autonomous functionalities, enhancing mainly operational efficiency and sustainability in managing engine-off and conventional taxiing operations across major European airports, thus augmenting the capacity of airport ground operations while reducing the impacts on human workload and the environment.

The use of a human-centred approach promotes a coordinated collaboration between human-controlled and automated processes, drawing on operators' expertise to control and engage with the automation (AI) at varied levels, thereby ensuring the optimisation of the collaboration between humans and AI within the complexities of taxi management and control operational tasks.

The ERP will be interrelated with the Exploratory Research Report (ERR) that will consolidate the results obtained from the ASTAIR validation exercises. The ERR will follow the ERP validation exercises in 2025.

Authoring & approval

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ASTAIR

AUTO-STEER TAXI AT AIRPORT

ASTAIR

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Table of contents

List of figures

List of tables

1 Executive summary

The Exploratory Research Plan (ERP) document describes the preparation of the validation activities to achieve ASTAIR solution at Technology Readiness Level (TRL) 1 (Basic principles observed). Hereafter are provided a summary of the information, and elements contained in the ERP.

The validation exercises focus on evaluating the ASTAIR solution across mainly the following Key Performance Areas (KPAs): Human Performance, Environmental sustainability, Cost Efficiency, Safety, Operational feasibility, Performance, Acceptability, Liability. The validation shall follow an iterative Human-Centred approach aimed at demonstrating and validating both the algorithmic tool and the Human-Machine Interface (HMI) concept, thereby supporting the solution's development from concept to functional prototype level.

ASTAIR will deliver a novel HMI solution for supporting human operator in the use of the tool. The project is set to progress from its current Technology Readiness Level (TRL) 0, to developing its knowledge base, defining a technology concept, and advancing to TRL1 (Basic Principles Observed).

The validation approach encompasses three targeted exercises designed to (1) evaluate the scope and use cases of the ASTAIR solution with the aid of the project's stakeholders, (2) evaluate the ASTAIR solution's design and its implementation based on prototypes demo, and (3) evaluate and validation the ASTAIR solution through Human-in-the-loop Real Time Simulation (HITL RTS), Fast-Time Simulation (FTS) and a final workshop.

The ASTAIR project will validate the concept through three validation exercises:

- **Validation exercise #01:** involves three workshops where ASTAIR's stakeholders will validate the scope and use cases of the project. The exercise outputs the set of use cases and updates the scope for the solution.
- **Validation exercise #02:** involves two workshops where ASTAIR's end-users evaluate the ASTAIR's solution design and its implementation. The exercise output the results to improve the solution's HMI design and algorithm.
- **Validation exercise #03:** involves a Human-in-the-loop Real Time Simulation where ASTAIR's end-users and stakeholders will evaluate the ASTAIR's solution. It also involves Fast Time Simulation for more technical objectives evaluation. Finally, workshops will be organised to deal with operational deployment and safety issues. These activities will output the results of the project, which will be checked against the ASTAIR's validation objectives.

2 Introduction

2.1 Purpose of the document

This ASTAIR Exploratory Research Plan (ERP) document describes the preparation of the validation activities to achieve ASTAIR solution for TRL1.

The ERP identifies the context of the experimental research plan in terms of scope, Key R&I needs, expected performance contributions, and initial and exit maturity levels.

The ERP presents the experimental research plan approach, the stakeholders' expectations and involvement, validation objectives, validation assumptions, validation exercise list, and validation exercise planning.

2.2 Intended readership

This document is intended for various stakeholders in the Air Traffic Management (ATM) community at large, especially those involved in the SESAR Programme. These include:

- ASTAIR consortium members who prepare and execute the validation activities.
- SESAR 3 JU programme management, and related SESAR 3 projects (CODA, TRUSTY, etc.).
- Academic research and Industry research who wish to learn about the validation activities behind the ASTRA solution.

2.3 Background

The project ASTAIR is not a direct continuation of its previous stage, as the starting maturity level is TRL0. Nevertheless, it does consider the concepts, tools and results from the following projects[3]:

Project Title	Project Description
SESAR EXPLORATORY RESEARCH PROJECT AEON - Advanced Engine Off Navigation (*completed*)	AEON defined a new concept of operations to make best use of green taxiing techniques; specifically, TaxiBots, WheelTugs, e-Taxi, and single-engine taxiing were investigated to address airport ground operations at long to medium-planning and execution phases. ASTAIR is building on AEON Path planning algorithms.

[3] More details on the relevant projects and concepts are defined in ASTAIR D3.1 Initial Concept Outline, Chapter 3.2.2.2 Integration with other solutions [15].

Project Title	Project Description
SESAR CODA - Controller adaptative Digital Assistant	The CODA project aims at developing a system in which hybrid human-machine teams collaboratively perform tasks. ASTAIR and CODA do not share the same approach on Human Automation Teaming, especially in the use on neurophysiological measures, nevertheless some questions on delegation strategies may be addressed similarly.
EVOLVE: Motion planning and control in the safety-critical situations (NWO Open Technology Programme, project 18484 (*completed*)	EVOLVE proposes to use an enhanced physics and data-based learning approach to the control of automated driving hazardous driving scenarios known as “edge cases” where representative data are statistically rare. The developed control algorithms will handle and guarantee safety during evasive manoeuvres for collision avoidance, something that current automated driving cannot guarantee. Motion planning and control models that were implemented in AEON and eventually in ASTAIR.
OWHEEL: Benchmarking of Wheel Corner Concepts Towards Optimal Comfort by Automated Driving (EU H2020-MSCA-RISE-2019 OWHEEL, project 872907)	The project OWHEEL aims at the development and evaluation of new concepts of automotive wheel corners as crucial elements of future vehicle architecture tailored to provide an optimal comfort during automated driving. The main goal of the OWHEEL project is to perform a deep analysis and provide on its basis the recommendations for future automated vehicle architecture.
SESAR 2020 exploratory research project Take Control (TaCO)	TaCo aims to define an automated system sufficiently powerful to both accomplish complex tasks involved in the management of surface movements in a complex airport and self-assess its own ability to deal with non-nominal conditions. TaCo allows Air Traffic Controllers to progressively create and tune automation with visual constructs that also assist them in understanding the behaviours, hence facilitating the handover if required. The concept of human automation teaming in ASTAIR project is developed upon the results of Take Control (TaCO)
SESAR TAM - Total Airport Management (PJ04 TAM, grant 733121)	TAM is interesting for ASTAIR development at several levels. First because centralization and automation of ground movement promoted in ASTAIR follows the same philosophy as PJ04 TAM, but also because PJ04 investigated the usage of AI for routing. The developed models proposed to the operational solutions and decision-makers decided whether the proposed solution will be applied. This corresponds to the level 1B (in reference to EASA level of automation). ASTAIR will go further into looking for conflict-free routing.
SESAR TRUSTY – TRUStworthy inTellingent sYstem for remote digital tower	The overall goal of TRUSTY is to provide adaptation in the level of transparency and explanation to enhance the trustworthiness of AI-powered decisions in the context of Remote digital towers (RDT). TRUSTY and ASTAIR will most probably share some problematics concerning human centric AI and human AI teaming, thus staying closely in touch will be fruitful for the project.

Table 1: Relevant results from previous projects that will be fed into the ASTAIR project

2.4 Structure of the document

Section 1 describes the executive summary of the ERP.

Section 2 describes the purpose of the document, the intended readership, background, structure of the document and glossary of terms, and the list of acronyms.

Section 3 describes the scope, Key R&I needs, expected performance contributions, and initial and exit maturity levels.

Section 4 describes the experimental research plan approach, the stakeholders' expectations and involvement, validation objectives, validation assumptions, validation exercise list, and validation exercise planning.

Section 5 describes the three validation exercises in detail.

Section 6 includes the list of references used in developing the ERP.

2.5 List of acronyms

Acronym	Description
A-CDM	Airport Collaborative Decision Making
AEON	Advanced Engine Off Navigation
A-SMGCS	Advanced Surface Movement Guidance & Control System
AI	Artificial Intelligence
ASTAIR	Auto-Steer Taxi at AIRport
ATCO	Air Traffic Controller
ATM	Air Traffic Management
CAP	Capacity
CBA	Cost-Benefit Analysis
CRT	Criterion
CTOT	Calculated Take Off Time
DES	Digital European Sky
EASA	European Union Aviation Safety Agency
ECAC	European Civil Aviation Conference
ENV	Environment
EPC	Estimated Performance Contribution
ERP	Exploratory Research Plan
ERR	Exploratory Research Report
EXE	Exercise
FRD	Functional Requirements Document

FTS	Fast Time Simulation
GA	Grant Agreement
GDPR	General Data Protection Regulation
GND ATCO	Ground Controller
HCD	Human-Centred Design
HCI	Human-Computer Interaction
HE	Horizon Europe
HITL	Human In The Loop
HMI	Human-Machine Interface
HP	Human Performance
ID	Identifier
KPA	Key Performance Area
KPI	Key Performance Indicator
MAS	Multi-Agent System
OSED	Operational Service and Environment Description
PI	Performance Indicator
R&I	Research & Innovation
RDT	Remote Digital Tower
RTS	Real-Time Simulation
SAF	Safety
SART	Situation Awareness Rating Technique
SESAR	Single European Sky ATM Research
SESAR 3 JU	SESAR 3 Joint Undertaking
SUS	System Usability Scale
TA	Transversal Area
TRL	Technology Readiness Level
TVAL	Test Validation
TWR ATCO	Tower Controller
UC	Use Case
OBJ	Objective

Table 2: list of acronyms

3 Context of the exploratory research plan

3.1 Exploratory research plan context

The ERP presents the plan for the three validation exercises that aim to assess and refine the scope and the selected use cases, assess the design and implementation based on prototypes demo, and validate the ASTAIR solution in general.

The experimental research is supported by a User-Centred Design approach to the development of the ASTAIR solution. Validation exercises are planned at the end of cycles of design going from the initial concept definition up to a Human-In-The-Loop (HITL) RTS that will address the operational side of the solution, while Fast-Time simulation (FTS) will address the ASTAIR technical side.

The operational environment in which the ASTAIR solution will be assessed within the scope of major European airports, focusing on the apron and ground operations and end users. The concept considers Paris-Charles de Gaulle Airport (CDG), Amsterdam Schiphol (AMS) and Frankfurt (Fraport) airports for the use cases development and assessments. These are the primary airports studied since their current working methods and future strategy, including mix of engine-off taxiing techniques versus full towing, and thus, shall provide interesting automation use cases. However, the project will overlook other European airports for potential interesting use cases and try to create high level automation categories for design and development activities that will be illustrated in the validation scenarios.

3.2 Scope

The present ERP focuses on the ASTAIR solution as described in D1.3 Initial Concept Outline [15].

The proposed solution will consist of a tool to fully automate the supervision of airport ground operations. The project will prototype an HMI that will make use of algorithms to autonomously manage vehicle movements on the airport surface, by providing the airport operators (including ATCOs, ground handlers, airport management...) with enough flexibility to locally tweak the algorithm rules to cope with operational events.

The solution will be evaluated in a cohesive operational environment that integrates manual and autonomous functionalities, enhancing efficiency, safety, and sustainability in managing engine-off and conventional taxiing operations across major European airports.

Through interactive tools and adaptive AI algorithms, the solution will aim at augmenting the predictability of airport ground operations while reducing the impacts on human workload and the environment.

The use of a human-centred approach will promote a coordinated collaboration between human-controlled and automated processes, drawing on operators' expertise to control and engage with the automation at varied levels, thereby ensuring the optimisation of the collaboration between humans and AI within the complexities of taxi management and control operational tasks.

The main high-level research questions that are planned to be answered with the validation activities are described in section 3.3 Key R&I Needs.

The three validation exercises related to the high-level research questions are described in section 4.5 Validation exercises list.

3.3 Key R&I needs

The validation activities foreseen in the present ERP will address the following R&I needs:

- Collaboration between human-controlled and automated processes/AI within the complexities of taxi management and control operational tasks
- Operator's controlling and engaging with the automation at diverse levels.
- Employ a Human-Centred Design (HCD) approach to ensure that the automated system effectively integrates with human-controlled processes and meets the needs of airport operators and controllers. The design activities will focus on providing usable interactions for operators to adjust algorithm rules as needed.
- HMI / interactive tools and adaptive AI algorithms:
    - The concepts from TaCo project for programming or representing automation explicitly on top of the airport map could be reused for certain tasks such as giving a priority to specific areas or creating safety nets according to the supervisor preferences. We will also explore how these concepts will still be relevant for high level of automation as envisioned within ASTAIR.
    - Adapt intelligent systems to operators' mode of operation.
    - Ensure logical consistency across manual and automated control.
- Path planning: It will be explored how the motion planning and control models developed in EVOLVE project can be used to extend the path planning algorithms developed in AEON project, which will be used in ASTAIR.
- Improve the manoeuvrability of tugs and tug-aircraft combinations: the models developed in OWHEEL project will used studied and reused.

The project's Use Cases should portray the concept and provide solutions for the R&I needs.

3.4 Estimated performance contributions

ASTAIR will improve the managing of engine-off and conventional taxiing operations across major European airports, as well as ensuring the optimisation of the collaboration between humans and AI within the complexities of taxi management and control operational tasks.

ASTAIR concept falls inside a future airport operation scenario and aim to help increase the general predictability of airport turnaround operations and cope with the additional complexity induced by engine-off taxiing techniques.

The main expected performance outcome in the ASTAIR can manage and perform engine-off and conventional airport surface movement operations at a major European airport by designing a seamless partnership between AI. ASTAIR will demonstrate a significant contribution to the realization of the Digital European Sky vision (SESAR Phase D) towards high and full automation (level 4/5). ASTAIR will have a significant contribution (Estimated Performance Contributions – EPCs) to the following outcomes:

- **Environment (including Fuel Efficiency):** Beyond engine-off taxiing, ASTAIR will move towards more sustainable operations (noise, emissions). Optimised operations due to improved route planning contribute to the optimisation of fuel-burn and therefore to reduced CO2 emissions per flight. Average taxiing duration is also expected to be reduced, having a positive impact on fuel efficiency. As such, ASTAIR will make its contribution to establishing Europe as the most environmental-friendly continent to fly in the world.
- **Punctuality:** ASTAIR is expected to have a positive influence on punctuality of departure flights through increased level of automation, leading in turn to more efficient and more predictable ground operations.
- **Capacity**: ASTAIR will have a positive contribution on operational efficiency while ensuring a high quality of control. Increased level of automation will reduce controller (end-user) workload and increase capacity on the ground, as automated functions work regardless of traffic load and complexity. With automation support & virtualisation it is expected to have scalable capacity at the airport.
- **Safety**: Automation level introduced by ASTAIR (at minimum, level 2B AI - machine performs a function / Human monitors) is expected to have a positive impact on safety. Human errors are expected to be reduced or eliminated, as the computer is much faster and more accurate that the human brain. As in the future humans will work close to the capacity limit, automation of tasks will contribute to reducing stress-related accidents. Some new alerts will be added to the A-SMGCS Airport Safety Support Service to improve Safety.
- **Human Performance**: If automation is a reliable source for more capacity and efficiency, the importance of human factors and ergonomics in system design focusing on automation is prominent for increasing confidence in technology. ASTAIR will adopt a human-centric approach and user-cantered design, supported by algorithms for efficient and conflict-free route of aircraft, tugs and vehicles. Coupled with strategies to deal with human cognitive demand, ASTAIR will bring a significant contribution to human performance.
- **Security**: ASTAIR will identify the potential risks deriving from having a more interconnected and automated ATM system such as component malfunctions or malicious interference; an increased level of automation generally means that extra care should be taken in order to prevent unauthorised intervention. The introduction of automation will need to be carefully shielded from unwanted external interference.
- **Liability:** One of the integral aspects of the project is to prove its feasibility in terms of liability implications across stakeholders. Therefore, one of the ASTAIR validation objectives is to ascertain that the ASTAIR does not introduce unacceptable liability risks for actors and stakeholders. In order to address any potential risks, the following preliminary success criteria were developed:
    - Identification of key new liability risks for all actors and stakeholders involved in defining, developing, and implementing the concept, according to the level of definition achieved at various validation stages.
    - Identification of suitable measures in design, organisation, and policy to mitigate identified risks.
    - Positive feedback from AB stakeholders on the proposed concept or suggestions for alternative enhancements.
    - Ensuring that the concept does not introduce unacceptable liability risks for actors and stakeholders.

- **Cost benefits/economic** aspects will be assessed and discuss with stakeholders:

- Better utilization of resources (human and equipment).
- Improved (time and cost) efficiency in taxiing operations.
- New market for AI/ML specialists
- New tools to support automation
- New rules to support harmonization in future implementation.

3.5 Initial and exit maturity levels

As stated in the ASTAIR's Grant Agreement [101114684], the ASTAIR solution is at TRL0 at the beginning of the project and is expected to reach TRL1 (Basic principles observed) by the end of the project.

Project/ Proposed SESAR solution(s) ID	Proposed SESAR solution(s) title	Initial maturity level	Exit maturity level	Reused validation material from past R&I Initiatives
SESAR solution	ASTAIR	TRL0	TRL1	The ASTAIR's solution will build on previous R&D projects, especially: AEON for the path planning algorithm; EVOLVE for the motion planning and control models; TaCo for the concepts of programming or representing automation explicitly on top of the airport map; and finally, OWHEEL for the manoeuvrability of tugs and tug-aircraft combination models.

Table 3: maturity levels table

4 Experimental plan

4.1 Exploratory research plan approach

This section provides the description of the exploratory research plan approach.

The planned validation exercises are listed below. The exercises will utilise ASTAIR use cases as defined in the D1.3 Initial Concept Outline, v.01.01 [15]:

- TVAL.01.0-ASTAIR-TRL1: Initial assessment and review of expectations;
- TVAL.02.0-ASTAIR-TRL1: Intermediate assessment;
- TVAL.03.0-ASTAIR-TRL1: Final assessment.

The initial maturity level for all exercises is TRL0 and the exit maturity level is TRL1. For all validation exercises, the KPAs/KPIs of interest are listed in 3.4 Estimated performance contributions.

All the validation exercises are inserted in the overall design approach, which is human-centred and iterative. HCD is a subset of Human-Computer Interaction (HCI), a field of study that focuses on the interaction between people and machines. Following the HCD approach, the three validation exercises were generated to support the development of the solution from a low maturity (concept) to a higher one (functional prototype).

Validation exercise #01: Initial assessment and review of expectations

ASTAIR's stakeholders will be presented with the ASTAIR concept with the aim to ask for feedback on the solution scope and use cases, as well as providing expectations in terms of expected benefits and possible issues generated by the solution. This validation exercise is structured in two distinctive workshops and are described as below.

- **Paris CDG Workshop:** this workshop consists of interviews, observation and discussion on ASTAIR concept with stakeholders to better understand the current procedures, identify automation opportunities and gather important requirements for the project. Paris CDG airport concept-relevant situations were discussed, for which the identification of level of automation was discussed. Consequently, a potential impact of ASTAIR concept on airport's operations was discussed.
- **Fraport Airport Workshop**: this workshop consists of interviews, observation and workshops with stakeholders to better understand the current procedures, identify automation opportunities and gather important requirements for the project. Several use cases will be described, including envisioned levels of automation associated and thus discuss the identified challenges on human automation teaming, path planning and liability.
- **Expert Group Workshop:** this workshop will build on the previous workshop of Validation exercise #01 and will consist in a judgment analysis performed by the ASTAIR's expert group to better understand the current procedures, identify automation opportunities and gather important requirements for the project. The refined use cases will be described, including envisioned levels of automation associated and thus discuss the identified challenges on human automation teaming, path planning and liability.

Merging the results of the three workshops provide evidence on the ASTAIR's concept, scope and use cases and will allow the progress of the project towards Validation Exercise #02.

Validation exercise #02: Intermediate assessment

This activity will enable ASTAIR's end-users to experience how the solution will work, providing an interactive mock-up of the solution's interface. Interacting with prototype demos following the relevant use case scenarios, they will be able to provide feedback on the HMI's design, the quality of the information provided and any pain points or missing functions/aspects. This validation exercise, performed through a workshop, will allow the progress of the project towards Validation exercise #03.

Validation exercise #03: Final assessment

This validation exercise will be spread throughout the following three validation activities whereas each using a different validation technique:

1. **Human-in-the-loop Real Time Simulation (HITL RTS)**, in which end-users will interact with the ASTAIR's solution in a realistic environment. In this activity, more detailed quantitative and qualitative results will be gathered.
- **Fast time simulations (FTS)**, which shall validate the technical side of the ASTAIR concept; e.g., MAS (Multi-Agent System) algorithm.
2. **Final workshop**: to gather feedback from the ASTAIR end-users mainly on the concept's operational and technical feasibility, safety and human performance.

The output of this validation activity will allow the project to check the results against the validation objectives to assess the output and the TRL of the ASTAIR's solution.

The following table summarises the validation exercises that will be performed during the ASTAIR project.

ID	High-level validation objective	Rationale	Validation method	Related exercise
1	Validate concept, scope and use cases	Form the basis for the design and development tasks	Workshop with stakeholders	TVAL.01.0-ASTAIR-TRL1
2	Validate solution design and implementation	Develop the final solution design and implementation procedures of ASTAIR. Refine the Use Cases.	Workshops with users	TVAL.02.0-ASTAIR-TRL1
3	Validate ASTAIR solution	Compare results against the validation objectives	HITL RTS, FTS, Final Workshop	TVAL.03.0-ASTAIR-TRL1

Table 4: ASTAIR Experimental Research Plan Approach

These research activities implicitly include the integration of human performance in the exploratory process, as requested in the SESAR Project Handbook [12]. Therefore, a separate human performance assessment is not needed in this project. Furthermore, it is not necessary to carry out a cost benefit assessment, a safety assessment, a security assessment, and/or an environmental impact assessment for the ASTAIR project.

4.2 Stakeholders' expectations and involvement

Stakeholder	Involvement	Why it matters to the stakeholder
Airport	Participants in the validation exercises. AEROPORTS DE PARIS SA (ADP) are part of the consortium.	The ASTAIR concept is expected to have an impact on operations and airport's operational staff: ground handlers. Airports may benefit from improved predictability of the departure sequence based on the speed profiles and centralized routing (UC1). Reducing congestion on airport surface movement which would reduce delays in aircraft departure and have positive impact on the environment in a scenario where taxiing operations are handled by taxibots efficiently. Better environmental performances due to use of taxibot.
ANSPs (Air Navigation Service Providers) End-users: Air Traffic Controllers	Participants in the validation exercises. EUROCONTROL are part of the consortium.	The ASTAIR concept is expected to have an impact on operations and operational staff: Ground Controller (GND ATCO), Tower Controller (TWR ATCO). Impact mainly portrayed in following ASTAIR UCs: • Improved predictability of the departure sequence based on the speed profiles and centralized routing. • Less workload for the GND ATCO supervising the taxiing for the departure. • Better service quality (contact parking rate), better resilience of the system and possibly better fuel efficiency and predictability as other routes could be further optimized. Less workload on the GND ATCO to adapt to the situation. • Reduced workload for the GND ATCO. Better predictability. • Reduce cognitive workload for the GND ATCO, improved resilience of the system.
Airline Operator	Possible participants in the validation exercises.	The ASTAIR concept is expected to have an impact on airlines operations, Cost Efficiency, and operational staff – pilots; mainly portrayed in ASTAIR UC - Better service quality (contact parking rate), better resilience of the system and possibly better fuel efficiency and predictability as other routes could be further optimized.
Ground Handling End-users: Taxibot Operators	Participants in the validation exercises.	The ASTAIR concept is expected to have an impact on Airside Operations, specifically to Ground Handling operations, specifically the end-users: Taxibot Operators. Impact mainly portrayed in ASTAIR UC3: Reduce congestion around the predetermined parking area, improve fluency of ground movement and processes.

Table 5: stakeholders' expectations and involvement

4.3 Validation Objectives

This section lists the validation objectives required for the Exploratory Research Plan.

Validation objectives (OBJs) and success criteria (CRTs) have been developed to cover the R&I needs that will be validated through the project's validation exercises. Each objective and success criterion has an identifier for better traceability.

Key environment conditions applicable for all the objectives is within medium to large airports with complex layout.

Target maturity TRL applicable for all objectives is TRL1, that shall be achieved based on the results from the final third validation exercise.

Objective 1

Identifier	OBJ-ASTAIR-ERP-01
Objective	To assess the operational feasibility of the ASTAIR concept.
R&I Need	Adapt intelligent systems to operators' mode of operation
Title	Operational Feasibility
Category	<safety>, <operational feasibility>, <human performance>

Identifier	Success Criterion
CRT-ASTAIR-TRL1-ERP-01.01	Assess that the new ASTAIR procedures and tools are operationaly feasible in regards to **pilot's** operating methods based on the feedback.
CRT-ASTAIR-TRL1-ERP-01.02	Assess that the new ASTAIR procedures and tools are operationaly feasible in regards to **ATCO**'s operating methods based on the feedback.
CRT-ASTAIR-TRL1-ERP-01.03	Assess that the new ASTAIR procedures and tools are operationaly feasible in regards to **Ground Operator**'s operating methods based on the feedback.

Objective 2

Identifier	OBJ-ASTAIR-ERP-02
Objective	Evaluate the collaboration between human-controlled and automated processes/AI.
Title	Human-Machine Collaboration
R&I Need	Collaboration between human-controlled and automated processes/AI
Category	<performance>, <safety>, <operational feasibility>, <human performance>, <acceptability>, <liability>

Identifier	Success Criterion
CRT-ASTAIR-TRL1-ERP-02.01	Degree of Collaboration - **Teamwork**: Measure the effectiveness of interaction between human operators and the automated system during taxi management tasks based on the operators' feedback.
CRT-ASTAIR-TRL1-ERP-02.02	Integration Flexibility - **Task distribution**: Assess the system's ability to accommodate diverse operator preferences and operational requirements through flexible integration options based on the operators' feedback.
CRT-ASTAIR-TRL1-ERP-02.03	Assess that the **logical consistency** across manual and automated control is ensured based on the operators' feedback.
CRT-ASTAIR-TRL1-ERP-02.04	**Assess the Liability** impact of innovations.*

*Liability CRT supported by the following sub-criteria/metrics:

CRT-ASTAIR-TRL1-ERP-02.**04.01**	**Liability** impact of innovations: Identification of key new liability risks for all actors and stakeholders involved in defining, developing, and implementing the concept, according to the level of definition achieved at various validation stages.
CRT-ASTAIR-TRL1-ERP-02.**04.02**	**Liability** impact of innovations: Identification of suitable measures in design, organisation, and policy to mitigate identified risks.
CRT-ASTAIR-TRL1-ERP-02.**04.03**	**Liability** impact of innovations: Positive feedback from AB stakeholders on the proposed concept or suggestions for alternative enhancements.
CRT-ASTAIR-TRL1-ERP-02.**04.04**	**Liability** impact of innovations: Ensuring that the concept does not introduce unacceptable liability risks for actors and stakeholders.

Objective 3

Identifier	OBJ-ASTAIR-ERP-03
Objective	Assess the operators' controlling and engaging with the automation at diverse levels.
Title	Interaction with different automation levels
R&I Need	*Operator's controlling and engaging with the automation at diverse levels.*
Category	<performance>, <human performance>

Identifier	Success Criterion

CRT-ASTAIR-TRL1-ERP-03.01	**Level of Operator Engagement**: Assess the extent to which operators actively interact with the automated system and utilise its features to enhance operational efficiency.[4]
CRT-ASTAIR-TRL1-ERP-03.02	Customisation options - **Ability to effectively control and engage with the automation** before and during the operation: Measure the range and effectiveness of customisation features available to operators for adjusting system behaviour and settings.[5]

Objective 4

Identifier	OBJ-ASTAIR-ERP-04
Objective	Assess the HMI / interactive tools and adaptive AI algorithms supporting the operators.
Title	Usable HMI and Interactive Tools
R&I Need	*HMI / interactive tools, adaptive AI algorithms*
Category	<performance>, <safety>, <operational feasibility>, <human performance>, <acceptability>

Identifier	Success Criterion
CRT-ASTAIR-TRL1-ERP-04.01	**HMI Usability:** Assess the usability of the HMI and interactions with the interactive tools, based on operators' ability to quickly understand and navigate the interface.
CRT-ASTAIR-TRL1-ERP-04.02	**Decision-making support**: Measure the effectiveness of interactive tools in providing operators with relevant information and assistance for making real-time decisions during ground operations.
CRT-ASTAIR-TRL1-ERP-04.03	**Tools performance:** Evaluate the tools performance and the impact on the efficiency of operators' interactions with the HMI and interactive tools.

[4] The level and number of interactions may depend on the operational constraints, workload and other factors. These factors will become metrics for measuring this CRT. Other factors are the ability to complete the senario, number of overrideen AI decisions and number of performed actions. User Engagement Scale score will provide further insights.

[5] Questions regarding the adequacy and relevance of the customizations offered to the user to finely tune the AI before and during the operation.

Objective 5

Identifier	OBJ-ASTAIR-ERP-05
Objective	Assess the Optimized Path & Motion Planning for Efficient Ground Operations.
Title	Optimised Path & Motion Planning
R&I Need	Path Planning
Category	<performance>, <safety>, <environmental sustainability>, <capacity>

Identifier	Success Criterion
CRT-ASTAIR-TRL1-ERP-05.01	Assess that the **airport capacity** is maintained or increased with the new ASTAIR concept based on the operators' feedback and the Fast-Time Simulation results.
CRT-ASTAIR-TRL1-ERP-05.02	**Conflict-free routing:** Evaluate the safety implications of optimised taxi routes, including collision avoidance measures and adherence to operational regulations and guidelines. Conflict-free routing (Conflict detection & resolution) to ensure safety levels remained based on the operators' feedback and simulations data analysis.
CRT-ASTAIR-TRL1-ERP-05.03	Assess that the **manoeuvrability of tugs and tug-aircraft combinations** is improved based on the Fast-Time Simulation results**.**
CRT-ASTAIR-TRL1-ERP-05.04	Assess that the **tugs resource management** is improved through the capacity utilisation of the tugs based on the Fast-Time Simulation results

4.4 Validation assumptions

The following table provides the validation assumptions to perform the three validation exercises.

Assumption ID	Assumption title	Assumption description	Justification	Impact Assessment
VA-ASTAIR-TRL1-VALP-01	A-CDM	The ASTAIR's solution will be a standalone tool and will assume that Airport collaborative decision making (A-CDM) is more likely to be benefiting from more automation on ground with engine off taxiing techniques. Airports already have dedicated data sharing infrastructure.	This approach is likely to provide the best balance of scalability, cost-effectiveness, performance, manageability, operational advantages.	To be evaluated

VA-ASTAIR-TRL1-VALP-02	A-SMGCS	The ASTAIR solution will be a standalone tool and will assume that Advanced Surface Movement Guidance & Control System (A-SMGCS) is more likely to be benefiting from more automation on ground with engine off taxiing techniques.	This approach is likely to provide the best balance of scalability, cost-effectiveness, performance, manageability, operational advantages.	To be evaluated

Table 6: validation assumptions overview

4.5 Validation exercises list

The following traceability table specifies the common elements of the ASTAIR for all validation exercises. Thus, the exercise traceability table will specify only the relevant validation objectives.

[ASTAIR EXEs Trace]

Linked Element Type	Identifier
<SESAR Solution>	0501
<Project>	ASTAIR
<Sub-Operating Environment>	Medium to large airports
<Validation Objective>	To be filled in per exercise.

[EXE]

Identifier	TVAL.01.0-ASTAIR-TRL1
Title	Initial assessment and review of expectations
Description	This exercise involves a series of workshops to refine the concept, the scope and the use cases of ASTAIR together with its stakeholders: Paris CDG Workshop: 18-19/12/2023 Fraport Airport Workshop: 19/04/2024 Expert Group Workshop: 24/05/2024
KPA/TA addressed	All
Addressed expected performance contribution(s)	N/A
Maturity level	TRL1
Use cases	Three ASTAIR Use Cases, addressing the following topics: Arrival without parking, High level taxi strategy tuning, Automation Failure.
Validation technique	Expert Group (Judgement Analysis)
Validation platform	N/A

Validation location	Online
Start date	01/09/2023
End date	24/05/2024
Validation coordinator	ENAC
Status	<completed>
Dependencies	N/A

Table 7: Validation Exercise #01 description

[EXE #01 Trace]

Linked Element Type	Identifier
<Validation Objective>	OBJ-ASTAIR-ERP-01 OBJ-ASTAIR-ERP-03

Table 8: Validation exercise #01 layout

[EXE]

Identifier	TVAL.**02.0**-ASTAIR-TRL1
Title	Intermediate assessment
Description	Workshops to work on solution design and implementation based on prototypes demo. This exercise is for purposes of enabling users to experience how the ASTAIR's system may work, providing prototypes demo of the solution. End-users provide feedback on the solution design, the quality of the information provided and any pain points or missing functions/aspects.
KPA/TA addressed	All
Addressed expected performance contribution(s)	N/A
Maturity level	TRL1
Use cases	Main ASTAIR Use cases: 1,2,3
Validation technique	Expert Group (Judgement Analysis)
Validation platform	N/A
Validation location	ENAC Toulouse
Start date	01/06/2024
End date	30/06/2024
Validation coordinator	ENAC
Status	<completed>

Dependencies	N/A

Table 9: Validation Exercise #02 description

[EXE #02 Trace]

Linked Element Type	Identifier
<Validation Objective>	OBJ-ASTAIR-ERP-01 OBJ-ASTAIR-ERP-03 OBJ-ASTAIR-ERP-04

Table 10: Validation exercise #02 layout

[EXE]

Identifier	TVAL.**03.0**-ASTAIR-TRL1
Title	Final assessment
Description	This exercise represents the execution of the Human-in-the-loop Real time simulation (HITL), Fast-Time simulation (FTS) and the final workshop on the defined use cases scenarios. During the test campaign, all the data will be gathered using a mixed approach using quantitative and qualitative methodologies (questionnaires, observations, structured-interviews, debriefing, etc.), also including Human Performance evaluation tools addressing HMI usability, user workload and situational awareness. The data gathered will be analysed using standardised research practice to ensure data reliability. Two types of experimental runs will be conducted - one with the system and one without it (baseline/reference), to evaluate the benefits and impacts of implementing the new tool by comparing system performance and user experience across both simulation scenarios.
KPA/TA addressed	All
Addressed expected performance contribution(s)	N/A
Maturity level	TRL1
Use cases	All ASTAIR Use Cases
Validation technique	Human-in-the-loop Real Time Simulation Fast-Time Simulation (FTS) Final Workshop
Validation platform	ASTAIR platform
Validation location	ENAC simulation facilities
Start date	01/05/2025
End date	31/05/2025
Validation coordinator	DEEP BLUE SRL (ENAC, TUD)

Status	<To be started>
Dependencies	N/A

Table 11: Validation Exercise #03 description

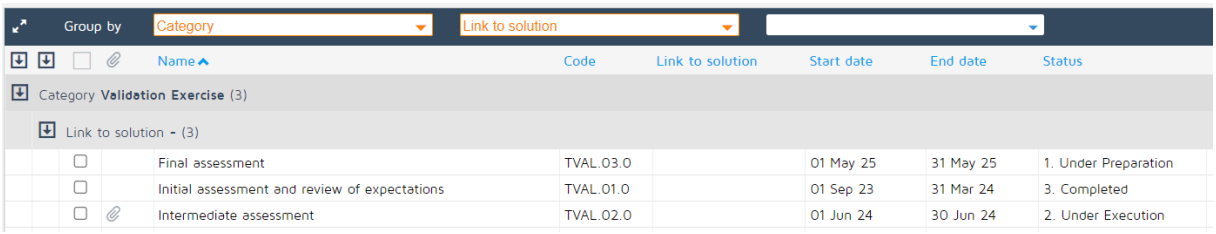
[EXE #03 Trace]

Linked Element Type	Identifier
<Validation Objective>	OBJ-ASTAIR-ERP-01 OBJ-ASTAIR-ERP-02 OBJ-ASTAIR-ERP-03 OBJ-ASTAIR-ERP-04 OBJ-ASTAIR-ERP-05

Table 12: Validation exercise #03 layout

4.6 Validation exercises planning

This ERP includes the validation plan for the TRL1 validation exercises. The screenshot below reports all the validation exercises scheduled in STELLAR, and which are under scope of this ERP.



4.7 Deviations with respect to the SESAR 3 JU project handbook

This Exploratory Research Plan is compliant with the approach to validate/demonstrate SESAR Solutions, as described in the SESAR 3 JU project handbook.

5 Validation exercises

5.1 Validation exercise #01 plan - Initial Assessment and review of expectations

5.1.1 Validation exercise description and scope

This section outlines Validation Exercise #01 - TVAL.01.0-ASTAIR-TRL1: *Initial Assessment and review of expectations*, to refine the concept, the scope and the use cases of the ASTAIR solution. This exercise consists in the initial assessment and review of the expectations of the ASTAIR's Stakeholders.

This exercise in part of a comprehensive process of workshop with stakeholders. The process involves gathering end user feedback, conducting workshops and reviewing documentation to refine and finalise the ASTAIR solution's scope and use cases.

This exercise shall provide results from the interviews and workshops with ground operations stakeholders at three major European major airports: Paris CDG, Amsterdam Schiphol (AMS) and Frankfurt (Fraport) airports. The stakeholders included airport operation and innovation managers, a ground handling quality and sustainability manager, an A-SMGCS and autonomous ground movement expert and an apron controller.

The Validation exercise #01 consists of three workshops, namely:

- **Paris CDG Workshop**: this workshop consists of interviews, observation and discussion on ASTAIR concept with stakeholders to better understand the current procedures, identify automation opportunities and gather important requirements for the project. Paris CDG airport concept-relevant situations were discussed, for which the identification of level of automation was discussed. Consequently, a potential impact of ASTAIR concept on airport's operations was discussed.
- **Fraport Airport Workshop:** this workshop consists of interviews, observation and discussion on ASTAIR concept with stakeholders to better understand the current procedures, identify automation opportunities and gather important requirements for the project. Major use cases were briefly discussed, including envisioned levels of automation associated and thus discuss the identified challenges on human automation teaming, path planning and liability.
- **Expert Group Workshop:** this workshop builds on the previous workshop of Validation exercise #01 and will consist in a judgment analysis performed by the ASTAIR's expert group to better understand the current procedures, identify automation opportunities and gather important requirements for the project. The refined use cases will be described, including envisioned levels of automation associated and thus discuss the identified challenges on human automation teaming, path planning and liability.

This validated scope and use cases definition will form the basis for further concept development.

The results from the three workshops, as part of the EXE#01, are detailed in the ASTAIR D1.2 Workshops Report deliverable [14].

5.1.2 Stakeholder's expectations and benefit mechanisms addressed by the exercise

The following Table 13 identifies the relevant stakeholders for Validation exercise #01.

Stakeholder	Involvement	Why it matters to the stakeholder
Airport	Airport operations experts present in the validation exercise.	The ASTAIR concept is expected to have an impact on operations and airport's operational staff: ground handlers. Airports may benefit from improved predictability of the departure sequence based on the speed profiles and centralized routing (UC). Reducing congestion on airport surface movement which would reduce delays in aircraft departure and have positive impact on the environment in a scenario where taxiing operations are handled by taxibots efficiently. Better environmental performances due to use of taxibot.
Ground Handling End-users: Taxibot Operators	Involved in the validation exercise - *Taxibot programme manager*	The ASTAIR concept is expected to have an impact on Airside Operations, specifically to Ground Handling operations, specifically the end-users: Taxibot Operators. Impact mainly portrayed in ASTAIR UC: Reduce congestion around the predetermined parking area, improve fluency of ground movement and processes.
ANSPs (Air Navigation Service Providers) End-users: Air Traffic Controllers	Not involved in this exercise.	The ASTAIR concept is expected to have an impact on operations and operational staff: Ground Controller (GND ATCO), Tower Controller (TWR ATCO). Expected benefits for the Ground and Tower Controllers due to better predictability on the taxiways and thus it is expected to have a positive impact on the human performance. Impact mainly portrayed in following ASTAIR UCs: - Improved predictability of the departure sequence based on the speed profiles and centralized routing. - Less workload for the GND ATCO supervising the taxiing for the departure. - Better service quality (contact parking rate), better resilience of the system and possibly better fuel efficiency and predictability as other routes could be further optimized. Less workload on the GND ATCO to adapt to the situation.UC6: Reduced workload for the GND ATCO. Better predictability. - Reduce cognitive workload for the GND ATCO, improved resilience of the system.

Table 13: stakeholders' expectations - exercise #01

5.1.3 Validation objectives

SESAR solution validation objective	SESAR solution success criteria	Coverage and comments on the coverage of SESAR solution validation objective in exercise #01	Exercise validation objective	Exercise success criteria
OBJ-ASTAIR-ERP-01	CRT-ASTAIR-TRL1-ERP-01.01; CRT-ASTAIR-TRL1-ERP-01.02; CRT-ASTAIR-TRL1-ERP-01.03.	Partially covered, since partial and full functionalities of the ASTAIR solution will be available respectively at validation exercise #02 and #03	Validate concept, scope, and use cases of ASTAIR.	Positive feedback from the ASTAIR's stakeholders.
OBJ-ASTAIR-ERP-03	CRT-ASTAIR-TRL1-ERP-03.01	Partially covered, since partial and full functionalities of the ASTAIR solution will be available respectively at validation exercise #02 and #03	Validate concept, scope, and use cases of ASTAIR.	Positive feedback from the ASTAIR's stakeholders.

Table 14: validation objectives addressed in validation exercise #01

5.1.4 Validation scenarios

Validation exercise #01 approach the scope and operational scenarios and use cases with the ASTAIR stakeholders to validate their definition from a theoretical point of view. Validation scenarios aim to validate the ASTAIR Solution and shall portray both the process' and tool's usefulness and usability and the expected benefits for the relevant stakeholders. The solution scenario enabled to receive the results towards the Use Cases benefits when compared to the reference scenario. The scenarios utilised the main chosen project's researched Use Cases (UC1, UC2).

5.1.4.1 Reference scenario(s)

The reference scenario is considered the current operations and tools, as described in the D1.3 Initial Concept Outline, v.01.01 [15], as the stakeholder's assessed the ASTAIR scope and use cases against their knowledge and experience.

5.1.4.2 Solution scenario(s)

Solution scenario is defined as the ASTAIR Solution and its operations and tools, as described in the D1.3 Initial Concept Outline, v.01.01 [15].

5.1.5 Exercise validation assumptions

Assumption ID	Assumption title	Assumption description	Justification	Impact Assessment
AS-EXE1-01	User/Stakeholder Expertise	It is assumed that the solution's end-users/domain experts involved in the exercise workshops possess sufficient knowledge and experience to assess the concept and its use cases.	If absent, this may negatively affect results from the solution scenario (the solution may not appear as beneficial, or it may appear too beneficial due to inexperience on the current procedures and their limitation within certain airport environments).	High

Table 15: validation exercise #01 assumptions

5.1.6 Limitations and impact on the level of significance

In terms of expected limitations and impact on the level of significance, Validation exercise #01:

- May introduce new terms and definitions that may generate confusion among the stakeholders. These shall be clearly defined in the Concept Outline document.
- May incur the risk of varying levels of proficiency among the stakeholders.
- May incur the risk for consistency of the validation across different evaluators and time periods.
- The qualitative feedback from the workshops will provide only qualitative results towards the validation objectives.
- Scope of discussed use cases is limited due to time constraints. Not all Use Cases were discussed in the workshop in detail.
- Validity[6]:
  - Validity of results may be limited due to the limited number of stakeholders and end-users present at the workshops
  - Validity of results may be limited due to the limited number of ASTAIR Use Cases discussed during the workshops.

5.1.7 Validation exercise platform / tool and validation technique

5.1.7.1 Validation exercise platform / tool characteristics

The Validation exercise #01 activities were held online. No validation platform was used, as the ASTAIR concept, scope and use cases were presented through the presentation.

[6] A degree to which the experiment permits correct conclusions about the environment it studies (includes statistical (conclusion) validity; internal validity and external validity.

The Validation exercise #01 validate the outcome through the stakeholder's judgment analysis validation. The outcomes were fed to the Validation exercise #02.

5.1.7.2 Validation exercise technique

The main technique was a workshop style of the discussion between the domain experts and the project members.

The project's scope and use cases were reviewed and assessed against the workshops' attendees' knowledge and experience. This technique is effective in ensuring that the arguments under analysis are accurate, complete, and aligned with the project's scope and objectives.

5.1.8 Data collection and analysis

5.1.8.1 Data and data collection methods

Data collection and analysis methodology:

Task 5.3 Data collection and analysis concerns the collection and analysis of the data that are necessary for the validation of the ASTAIR concept and associated tools. Coherently with the validation strategy and plan produced in Task 5.1, different methodologies and techniques will be used to collect the relevant data.

The workshops attendees were asked to express their feedback on the ASTAIR scope and use cases definition. The meeting will be recorded through the appropriate function. ASTAIR stakeholders **qualitative** feedback will be collected and reported in the D5.2 Exploratory Research Report (ERR). Initial results on the concept are collected in the SESAR ASTAIR D1.2 Workshops Report [14].

As there were three workshops during this validation exercise, this has provided valuable feedback that was utilised for the further concept development. Thus, it can be said, that after each workshop a new concept development cycle started. New concept ideas, requirements were initiated and moreover, the Use Cases has been shaped thanks to these workshops and the stakeholders' feedback.

5.1.8.2 Analysis methods

The qualitative data collected from the ASTAIR stakeholders' feedback will be analysed through thematic analysis.

Task 5.3 Data collection and analysis concerns the collection and analysis of the data that are necessary for the validation of the ASTAIR concept and associated tools.

5.1.9 Exercise planning and management

5.1.9.1 Activities

Preparatory phase

- Paris CDG workshop, Fraport expert workshop, Expert group workshop preparation by consortium members.

Execution phase

- Introduce the stakeholders to ASTAIR's concept, scope and use cases.

- Stakeholders' feedback was collected by the consortium members into the minutes' documents – one document per each workshop.

Post-execution phase

- The stakeholders' feedback was analysed through thematic analysis.
- Results were coordinated in the minutes document and elaborated in more detail in the SESAR ASTAIR D1.2 Workshops Report [14].
- Further results towards the Validation Objectives will be reported in the ASTAIR D5.2 Exploratory Research Report (ERR).

5.1.9.2 Roles and responsibilities in the exercise

This subsection describes the roles and responsibilities of the ASTAIR consortium in preparing, conducting and analysing the validation exercise #01.

- ENAC managed the involvement of the stakeholders;
- ENAC managed the organisation of the three workshops, collection and analysis of data.
- Deep Blue collected the feedback and elaborated on it within the minutes document; and reviewed the SESAR ASTAIR D1.2 Workshops Report [14].
- Deep Blue will report the validation exercise #01 results in D5.3 Exploratory Research Report (ERR).
- ENAC and Deep Blue presented the ASTAIR concept, scope (including expected benefits or potential issues) and use cases.
- EUROCONTROL provided verification and validation expertise.
- TUD coordinated interviews in the preparatory stage (prior to Paris CDG workshop) for shaping the initial concept.
- ADP provided expertise and participated in the workshops.

5.1.9.3 Time planning

Preparatory phase of Validation exercise #01 started in September 2023 (M1) with the Fraport Airport Workshop.

The following Table 16 indicates the start and end date of the preparatory, execution and post-execution exercise phases.

Activity	Description	When
Paris CDG Workshop - preparation	Coordination with project partners on the workshop objectives.	Sep-Dec 2023
Paris CDG Workshop - execution	This workshop consists of interviews, observation and discussion on ASTAIR concept with stakeholders to better understand the current procedures, identify automation opportunities and gather important requirements for the project. Paris CDG airport concept-relevant situations were discussed, for which the identification of level of automation was discussed. Consequently, a potential impact of ASTAIR concept on airport's operations was discussed.	18/12/2023

Fraport Airport Workshop - preparation	Coordination with project partners on the workshop objectives.	Dec-Apr 2024
Fraport Airport Workshop - execution	his workshop consists of interviews, observation and discussion on ASTAIR concept with stakeholders to better understand the current procedures, identify automation opportunities and gather important requirements for the project. Major use cases were briefly discussed, including envisioned levels of automation associated and thus discuss the identified challenges on human automation teaming, path planning and liability.	19/04/2024
Expert Group Workshop - preparation	Coordination with project partners on the workshop objectives.	Apr-May 2024
Expert Group Workshop - execution	This workshop builds on the previous workshop of Validation exercise #01 and will consist in a judgment analysis performed by the ASTAIR's expert group to better understand the current procedures, identify automation opportunities and gather important requirements for the project. The refined use cases will be described, including envisioned levels of automation associated and thus discuss the identified challenges on human automation teaming, path planning and liability.	24/05/2024
All workshops – post execution	To be reported in the ERR.	May 2025

Table 16: detailed exercise #01 time planning

5.1.9.4 Identified risks and mitigation actions

The following table presents the identified risks and mitigation actions for validation exercise #01.

Risks	Impact (1-low, 2-medium, 3-high)	Likelihood (1-low, 2-medium, 3-high)	Criticality (calculated based on likelihood and impact)	Mitigation actions
The ASTAIR concept, scope and use cases get negative reviews from the stakeholders. This could have a negative effect on the successful concept development.	3	1	3.00	(1) ASTAIR adopts a HCD approach from the beginning of the project. (2) Validate concept, scope and use cases with stakeholders and end-users early in the development phases.

Table 17: exercise #01 risks and mitigation actions

5.2 Validation exercise #02 plan - Intermediate assessment

5.2.1 Validation exercise description and scope

The Validation exercise #02 aims to enable end users to experience how the ASTAIR's system may work, providing prototypes demo of the solution. End-users, ATCOs, will be able provide feedback on the solution design, the quality of the information provided and any pain points or missing functions/aspects.

During the session, ENAC demonstrated mock-ups and prototypes with specific scenarios to gather feedback and co-design solutions to identified limitations.

Upon successful completion of Validation exercise #02, the ASTAIR's prototype designs will be considered validated and will form the basis for the development tasks that follow, namely the Human-in-the-loop Real Time Simulation performed in Validation exercise #03.

5.2.2 Stakeholder's expectations and benefit mechanisms addressed by the exercise

The following table identifies the relevant stakeholders for Validation exercise #02.

Stakeholder	Involvement	Why it matters to the stakeholder
Air Traffic Controllers	End-users	Relevant ASTAIR Use Case: Reduce congestion around the predetermined parking area, improve fluency of ground movement and processes.

Table 18: stakeholders' expectations - exercise #02

5.2.3 Validation objectives

The following section reports the validation objectives related to validation exercise #02.

SESAR solution validation objective	SESAR solution success criteria	Coverage and comments on the coverage of SESAR solution validation objective in exercise #02	Exercise validation objective	Exercise success criteria
OBJ-ASTAIR-ERP-01	CRT-ASTAIR-TRL1-ERP-01.01; CRT-ASTAIR-TRL1-ERP-01.02; CRT-ASTAIR-TRL1-ERP-01.03.	Partially covered, since full functionalities of the ASTAIR solution will be available at validation exercise #03	Assess the operational feasibility of the ASTAIR concept.	Positive feedback from the ASTAIR's stakeholders.
OBJ-ASTAIR-ERP-02	CRT-ASTAIR-TRL1-ERP-02.01;	Partially covered, since full	Assess the collaboration	Positive feedback from the

	CRT-ASTAIR-TRL1-ERP-02.02; CRT-ASTAIR-TRL1-ERP-02.03.	functionalities of the ASTAIR solution will be available at validation exercise #03	between human-controlled and automated processes/AI	ASTAIR's stakeholders.
OBJ-ASTAIR-ERP-03	CRT-ASTAIR-TRL1-ERP-03.02	Partially covered, since full functionalities of the ASTAIR solution will be available at validation exercise #03	Assess the operators' controlling and engaging with the automation at diverse levels.	Positive feedback from the ASTAIR's stakeholders.
OBJ-ASTAIR-ERP-04	CRT-ASTAIR-TRL1-ERP-04.02 CRT-ASTAIR-TRL1-ERP-04.03	Partially covered, since full functionalities of the ASTAIR solution will be available at validation exercise #03	Assess the HMI / interactive tools and adaptive AI algorithms supporting the operators.	Positive feedback from the ASTAIR's stakeholders.

Table 19: validation objectives addressed in validation exercise #02

5.2.4 Validation scenarios

Validation exercise #02 will adopt the use cases defined in validation exercise #01 to create corresponding scenarios. The scenarios identified will be used as validation scenarios. Due to time constraints, there could be a sub-selection of scenarios, leading to a reduction in the number of scenarios adopted for the simulation.

5.2.4.1 Reference scenario(s)

The reference scenario is considered the current operations and tools, as described in the D1.3 Initial Concept Outline, v.01.01 [15], as the stakeholder's assessed the ASTAIR scope and use cases against their knowledge and experience.

5.2.4.2 Solution scenario(s)

Solution scenario is defined as the ASTAIR Solution and its operations and tools, as described in the D1.3 Initial Concept Outline, v.01.01 [15]. The following specific scenarios were validated during the design walkthrough session:

1) Normal Operation:
- situation awareness elements (identify necessary information)
- interactions to understand and monitor the situation (level 2 et level 3)
- understand the ai level, future inspection
- interactions level 2B when engines need startup approval during taxiing
- Teamwork and task distributions

2) With re-scheduling:
- situation awareness of the changes

- interaction to understand and validate a new plan

3) Without parking:
- understand the situation
- decision making support
- add information/knowledge to AI to system performance

5.2.5 Exercise validation assumptions

N/A. No additional assumptions compared to the ones presented in section 4.4.

5.2.6 Limitations and impact on the level of significance

Assumptions made in sub-section 5.1.5 may have an impact on the significance of the validation results. This sub-section reports the limitations of the validation exercise and the potential impact on the level of significance of the results that may be obtained.

The prototype demo of validation exercise #02 is characterised by the limitations that are characteristic of a simulation. First of all, there will be a lack of realism, both in terms of visual representation and interactivity. The functionalities could be limited, and complex interactions will be avoided. Therefore, the engagement as well as the user experience could be limited. Despite those limitations, the exercise is not focused on the functionality but on the clarity and usability of the HMI and AI. For this reason, the limitations should not affect the scope of the simulation. This is acceptable due to the level of concept's target maturity - TRL1.

5.2.7 Validation exercise platform / tool and validation technique

5.2.7.1 Validation exercise platform / tool characteristics

The workshops were conducted face-2-face in a meeting room with a wide screen and a simulator of the ASTAIR system. After a short introduction using the ASTAIR system to illustrate A-SMGCS based ground control and presenting engine-off taxiing we started demonstrating interfaces and interactions. We presented prototypes made with the Figma prototyping tool using specific scenarios defined in deliverable SESAR ASTAIR D1.2 Workshops Report [14]. Following a design walkthrough methodology, we stopped after each interaction to collect reaction and ask specific questions related to situation awareness such as visibility of information teamwork (with and without AI) and task distribution with the system among other elements.

5.2.7.2 Validation exercise technique

Prototype simulation is the technique used in this exercise. This lower fidelity brings researchers to plan, design, and execute the simulation with less effort, compared with more high-fidelity simulations (such as HITL simulations).

5.2.8 Data collection and analysis

5.2.8.1 Data and data collection methods

During and after the exercise qualitative data were collected.

The workshops attendees were asked to express their feedback on the ASTAIR scope and use cases definition. The meeting will be recorded through the appropriate function. The results from this exercise in not collected in the SESAR ASTAIR D1.2 Workshops Report [14], the **qualitative** feedback will be collected and reported in the D5.2 Exploratory Research Report (ERR).

As there were two workshops during this second validation exercise, this has provided valuable feedback that was utilised for the further concept development. Thus, it can be said, that after each workshop a new concept development cycle started. New concept ideas, requirements were initiated and moreover, the Use Cases has been shaped thanks to these workshops and the stakeholders' feedback.

The outcome will feed the Validation exercise #02.

5.2.8.2 Analysis methods

The qualitative data collected from ASTAIR stakeholders' feedback will be analysed through thematic analysis.

Task 5.3 Data collection and analysis concerns the collection and analysis of the data that are necessary for the validation of the ASTAIR concept and associated tools.

The analysis is the feedback from the workshop will be analysed based on the expert judgement and the results towards the EPCs and validation objectives will be reported in the ERR.

5.2.9 Exercise planning and management

5.2.9.1 Activities

In the scope of exercise 2, there were two workshops with the relevant stakeholders that followed a similar structure.

The following phases are relevant to both activities (workshops).

Preparatory phase:

We prepared demonstrations, slides and prototypes to explain the interaction and information presented as well as the intended behaviour of the AI.

Execution phase:

We started by presenting the goals of the project and demonstrated a simulation of engine off taxiing on ground operations at CDG airport. We then presented our prototypes using a design walkthrough process to gather feedback from participants and discuss possible solutions to raised issues or questions.

The minutes from the two workshops have been written by ENAC.

Post-execution phase:

The results to be analysed and reported in the ERR.

5.2.9.2 Roles and responsibilities in the exercise

This subsection describes the roles and responsibilities of the ASTAIR consortium in preparing, conducting and analysing the validation exercise #02.

- ENAC managed the involvement of the end users (ATCOs).
- Deep Blue provided discussion topics suggestions in the preparatory stage.
- ENAC prepared the minutes of the workshop.
- ENAC provided the end users and facilities for the ASTAIR solution.
- Deep Blue and ENAC will analyse the results in the ASTAR D5.2 ERR.

5.2.9.3 Time planning

The following indicates the start and end date of the preparatory, execution and post-execution exercise phases.

Activity	Description	When
Design Walkthrough Workshop - preparation	ENAC prepared the design walkthrough objectives and validation scenarios.	May-Jun 2024
Design Walkthrough Workshop - execution	The Validation exercise #02 aims to enable end users to experience how the ASTAIR's system may work, providing prototypes demo of interface and interactions. End-users, ATCOs, will be able provide feedback on the solution design, the quality of the information provided, and any pain points or missing functions/aspects related to the HMI. During the sessions, ENAC demonstrated mock-ups and prototypes with specific scenarios to gather feedback and co-design solutions to identified limitations.	20/06/2024 and 23/07/2024
Design Walkthrough Workshops - post-execution	The results were reported and analysed in minutes and will be further reported in the ERR in regard to the Validation Objectives (Exercise OBJs).	Jun 2024 - 2025

Table 20: detailed exercise #02 time planning

5.2.9.4 Identified risks and mitigation actions

The following table presents the identified risks and mitigation actions for validation exercise #01.

Risks	Impact (1-low, 2-medium, 3-high)	Likelihood (1-low, 2-medium, 3-high)	Criticality (calculated based on likelihood and impact)	Mitigation actions

The ASTAIR concept, scope and use cases get negative reviews from the stakeholders. This could have a negative effect on the successful concept development.	3	1	3.00	(1) ASTAIR adopts a HCD approach from the beginning of the project. (2) Validate concept, scope and use cases with stakeholders and end-users early in the development phases.

Table 21: exercise #02 risks and mitigation actions

5.3 Validation exercise #03 plan

5.3.1 Validation exercise description and scope

This third (and last) ASTAIR validation exercise, TVAL.**03.0**-ASTAIR-TRL1, will be spread throughout the following three validation activities whereas each using a different validation technique:

1. Human-in-the-loop Real Time Simulation, in which end-users will interact with the ASTAIR's solution in a realistic environment. In this activity, more detailed quantitative and qualitative results will be gathered. During the test campaign, all the data will be gathered using a mixed approach using quantitative and qualitative methodologies (questionnaires, observations, structured-interviews, debriefing, etc.), also including Human Performance evaluation tools addressing HMI usability, user workload and situational awareness. The data gathered will be analysed using standardised research practice to ensure data reliability.
2. Fast time simulations (FTS): shall validate the technical side of the ASTAIR concept; e.g., MAS algorithm.
3. Final workshop: to gather feedback from the ASTAIR end-users mainly on the concept's operational and technical feasibility, safety and human performance, and in general for the EPCs. This workshop will focus on gathering the feedback mainly towards the OBJ-ASTAIR-ERP-01 - the operational feasibility of the ASTAIR concept. It shall provide the next steps for exploring the concept in the next maturity level, i.e., the outputs should be fed into the project final report and not necessarily in ERR.

The output of this final validation exercise will allow the project to check the results against the validation objectives to assess the output and the TRL of the ASTAIR's solution.

The scope of this exercise includes:

- Simulation of real-time engine-off taxiing scenarios at one of the target airports: Paris-Charles de Gaulle, Amsterdam Schiphol, or Frankfurt.
- Assessment of AI support for ground operations, particularly for the allocation of Taxibots, routing, and remote holding procedures.
- Focus on interactions between AI, human operators (e.g., air traffic controllers, ground handlers), and automated systems (e.g., Taxibots) during normal and disrupted operations.

5.3.2 Stakeholder's expectations and benefit mechanisms addressed by the exercise

Stakeholder	Involvement	Why it matters to the stakeholder
Airport	Airport operations experts present in the validation exercise.	The ASTAIR concept is expected to have an impact on operations and airport's operational staff: ground handlers. Airports may benefit from improved predictability of the departure sequence based on the speed profiles and centralized routing. Reducing congestion on airport surface movement which would reduce delays in aircraft departure and have positive impact on the environment in a scenario where taxiing operations are handled by taxibots efficiently.

		Better environmental performances due to use of taxibot.
Ground Handling End-users: Taxibot Operators	Involved in the validation exercise - *Taxibot programme manager*	The ASTAIR concept is expected to have an impact on Airside Operations, specifically to Ground Handling operations, specifically the end-users: Taxibot Operators. Impact mainly portrayed in ASTAIR UC: Reduce congestion around the predetermined parking area, improve fluency of ground movement and processes.
ANSPs (Air Navigation Service Providers) End-users: Air Traffic Controllers	Involved in the validation exercise.	The ASTAIR concept is expected to have an impact on operations and operational staff: Ground Controller (GND ATCO), Tower Controller (TWR ATCO). Expected benefits for the Ground and Tower Controllers due to better predictability on the taxiways and thus it is expected to have a positive impact on the human performance. Impact mainly portrayed in following ASTAIR UCs: • Improved predictability of the departure sequence based on the speed profiles and centralized routing. • Less workload for the GND ATCO supervising the taxiing for the departure. • Better service quality (contact parking rate), better resilience of the system and possibly better fuel efficiency and predictability as other routes could be further optimized. Less workload on the GND ATCO to adapt to the situation.UC6: Reduced workload for the GND ATCO. Better predictability. • Reduce cognitive workload for the GND ATCO, improved resilience of the system.

Table 22: stakeholders' expectations - exercise #03

5.3.3 Validation objectives

SESAR solution validation objective	SESAR solution success criteria	Coverage and comments on the coverage of SESAR solution validation objective in exercise #03	Exercise validation objective	Exercise success criteria
OBJ-ASTAIR-ERP-01	CRT-ASTAIR-TRL1-ERP-01.01, CRT-ASTAIR-TRL1-ERP-01.02, CRT-ASTAIR-TRL1-ERP-01.03	Fully	Assess the operational feasibility of the ASTAIR concept.	Positive feedback from the ASTAIR's stakeholders, and achievement of success criteria based on qualitative and quantitative data.

OBJ-ASTAIR-ERP-02	CRT-ASTAIR-TRL1-ERP-02.01, CRT-ASTAIR-TRL1-ERP-02.02, CRT-ASTAIR-TRL1-ERP-02.03, CRT-ASTAIR-TRL1-ERP-02.04	Fully	Evaluate the collaboration between human-controlled and automated processes/AI.	Positive feedback from the ASTAIR's stakeholders, and achievement of success criteria based on qualitative and quantitative data.
OBJ-ASTAIR-ERP-03	CRT-ASTAIR-TRL1-ERP-03.01, CRT-ASTAIR-TRL1-ERP-03.02	Fully	Assess the operators' controlling and engaging with the automation at diverse levels.	Positive feedback from the ASTAIR's stakeholders, and achievement of success criteria based on qualitative and quantitative data.
OBJ-ASTAIR-ERP-04	CRT-ASTAIR-TRL1-ERP-04.01, CRT-ASTAIR-TRL1-ERP-04.02, CRT-ASTAIR-TRL1-ERP-04.03	Fully	Assess the HMI / interactive tools and adaptive AI algorithms supporting the operators.	Positive feedback from the ASTAIR's stakeholders, and achievement of success criteria based on qualitative and quantitative data.
OBJ-ASTAIR-ERP-05	CRT-ASTAIR-TRL1-ERP-05.01, CRT-ASTAIR-TRL1-ERP-05.02, CRT-ASTAIR-TRL1-ERP-05.03, CRT-ASTAIR-TRL1-ERP-05.04	Fully	Assess the Optimized Path & Motion Planning for Efficient Ground Operations.	Positive feedback from the ASTAIR's stakeholders, and achievement of success criteria based on qualitative and quantitative data.

Table 23: validation objectives addressed in validation exercise #03

5.3.4 Validation scenarios

The applicable sub-operating environment that relates to the reference and solution validation scenarios selected for the validation exercise is within medium to large airports with complex layout. ASTAIR concept targets large airports with high congestion levels or long average taxi times, implementing A-CDM and A-SMGCS.

As the automation is expected to be implemented at airports with high traffic and complexity where capacity issues are to resolve, very large and large airports are concerned by the results and outcome of the project.

5.3.4.1 Reference scenario(s)

The reference scenario is considered the current operations and tools, as described in the D1.3 Initial Concept Outline, v.01.01 [15].

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5.3.4.2 Solution scenario(s)

Solution scenario is defined as the ASTAIR Solution and its operations and tools, as described in the D1.3 Initial Concept Outline, v.01.01 [15].

The validation runs will be based on the ASTAIR Use Cases. All/most of the Use Cases from the following list will be validated. These UCs are the most important one that aim to respond to the Key R&I needs:

- Normal operations with rescheduling (with or without taxibots)
- Arrival without parking
- Automation failure
- Arrival with technical issue
- Departure remote holding
- High level strategy
- Runway mode change

A series of high-traffic scenarios will be simulated, representing various operational conditions such as runway mode changes, remote holding requirements, and automation failures.

The AI will autonomously manage routes for aircraft and Taxibots, while human operators will monitor and provide inputs as required.

Traffic levels to be validated: medium to high.

The precise number of runs and target UCs will be defined closer to the validation date.

5.3.5 Exercise validation assumptions

This sub-section lists the assumptions under which the exercise is done. The assumptions captured in this table are those that may have an impact on the validation results for experiment/validation exercise #03.

Assumption ID	Assumption title	Assumption description	Justification	Impact Assessment
VA-ASTAIR-TRL1-VALP-EXE03-01	Simulated weather conditions	Simulation runs will be conducted with neutral weather conditions, without the influence of factors such as wind or precipitation.	At TRL1 maturity, it is not deemed necessary to include the impact of weather conditions for concept evaluation.	Low
VA-ASTAIR-TRL1-VALP-EXE03-02	Restrictions on controller	A limited number of end-users will participate in the validation exercise – RTS validation activity.	Only a limited number of end-users will be available (e.g., ATCO available for release from the operation) in order to assess the ASTAIR concept. Thus, the results will not be analysed through advanced statistical methods. It is not deemed necessary at TRL1 maturity to assess the concept with	Low

			all/numerous relevant stakeholders/end-users.	
VA-ASTAIR-TRL1-VALP-EXE03-03	Restrictions on supporting systems	The participants will not have access to 'live' data on support information systems (e.g., weather, runway changes, etc.).	Due to the nature of simulations end-users will not have access to 'live' information that would typically be displayed on support information systems. This will instead be provided as static information. It is not deemed necessary at TRL1 maturity.	Low
VA-ASTAIR-TRL1-VALP-EXE03-04	Separation standards, speed limitations at the airport	Participants will adhere to the current operational speed and separation standards specific to the airport environment being simulated.	Operational standards are set according to the airport involved, and participants will use expert judgement.	Low
VA-ASTAIR-TRL1-VALP-EXE03-05	Traffic levels	Traffic samples will be representative of high traffic of the high complexity airports (from the available input from 2024 or older).	In order for the participants to adequately assess the ASTAIR concept, the traffic samples must be representative of a variety of future traffic environments.	Medium
VA-ASTAIR-TRL1-VALP-EXE03-06	Training attendance	All RTS participants are familiar with the platform operational environment and relevant procedures of chosen airport.	A sufficient training for all participants is key to collecting reliable data on the ASTAIR concept and that the results are not influenced by unfamiliarity with the operational environment. The RTS participants must be familiar with the measured airport environment in order to make full use of the ASTAIR concept during solution scenario runs.	High

Table 24: validation exercise #03 assumptions

5.3.6 Limitations and impact on the level of significance

Assumptions made in sub-section 5.1.5 may have an impact on the significance of the validation results.

This sub-section reports the limitations of the validation exercise and the potential impact on the level of significance of the results that may be obtained.

The simulation environment may not be fully representative of medium to large airports with complex layout. In order for the participants to adequately assess the ASTAIR concept and its full potential (as intended by all Use Cases), the simulation environment shall be representative of the designated operational environment. But, at this stage of the project's maturity level it is not required.

5.3.7 Validation exercise platform / tool and validation technique

5.3.7.1 Validation exercise platform / tool characteristics

The exercise platform is ASTAIR platform that will be validated at ENAC simulation facilities.

The detailed description of the exercise platform and tool characteristics will be specified in deliverable - *D4.1 - Description of the validation platform*[7].

ASTAIR will propose interactive tools and adaptative AI algorithms that take advantage of operators' expertise for controlling and engaging with the automation at diverse levels.

The objectives are to:

- Characterize levels of automation and identify pathways to full automation. For instance, the decisional routing support technologies developed in AEON can be used to shift toward an automated routing clearance system under operators' supervision. We will identify all other automation opportunities and be targeting the 2B level according to EASA's AI Roadmap as shown in below.
- Design of interactive tools in collaboration with the operators (air traffic controllers - ATCOs and ground handling operators) to allow them and computers to contribute to what is the best suited at the most appropriate time. These tools will allow to supervise, predict, and gradually takeover or give the control in ASTAIR automated concepts at diverse levels of automation.
- Design human-centred AI algorithms able to perform optimized path planning and fleet formation- controlled routing tasks. These algorithms will be highly adaptative to the level of automation required by the operators and will offer input and output that match operators' approach to taxi management and control operational tasks. This is in line with the Human-Centred approach described in the EASA Artificial Intelligence Roadmap 2.0 document [18] to create effective Human-Automation Teaming and improve AI systems performances by explicitly designing such systems from stakeholders' expertise.
- Implement an ASTAIR simulation and demonstration platform to demonstrate the potential of sustainable autonomous taxi operations and assess the new ASTAIR concepts at major European platforms with two different configurations introduced in the AEON project. These platforms are Amsterdam Schiphol, where all aircraft are tugged to the parking stands and to the runways, and Paris Roissy-CDG which hosts a mix of engine-off taxiing techniques and dedicated service roads for empty tugs movements. [17]

[7] To be delivered on 28/02/2025.

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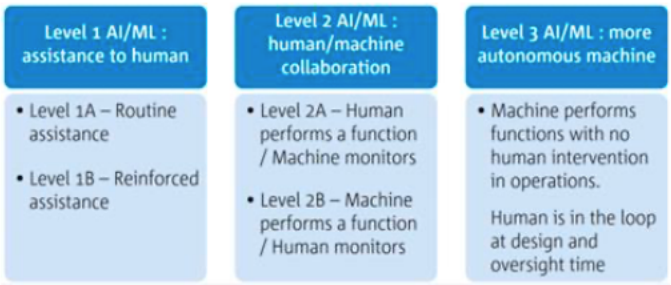

Figure 1: EASA Artificial Intelligence Roadmap: Possible classification of AI/ML applications [18]

Developed functional prototypes will be integrated within the simulation platform to assess the resulting interaction for **supervising and controlling the automation** in realistic situations.

5.3.7.2 Validation exercise technique

Three techniques will be used for the EXE03:

- Human-in-the-loop Real Time Simulation (HITL RTS)
- Fast-Time Simulation (FTS)
- Workshop with ASTAIR concept's end users (e.g., Ground Handling, Tower/Ground ATCOs) and other domain experts.

The validation techniques encompass a range of methods to validate the functionality, accuracy, usability and acceptability of the ASTAIR concept as well as compliance and reliability in real-world scenarios (using UCs of the project). The main technique includes user testing of the ASTAIR tool and relevant procedures.

5.3.8 Data collection and analysis

5.3.8.1 Data and data collection methods

Based on the previous concept development iterations through the previous two validation exercises, this exercise will build on the top of the results of these exercises and will aim to validate the concept through the user-tool interaction rather than only through the discussions. Thus, it is expected the concept has matured prior doing the final exercise.

Both qualitative and quantitative data will be collected during the validation days of the three validation activities.

The three validation activities will use the following data collection methods:

Human-in-the-loop Real Time Simulation (HITL RTS)**:**

- Quantitative data:
    - Quantitative data will be collected from the questionnaires, which will contain question on the ASTAIR KPIs, and the answers shall provide results towards all five Validation Objectives.

- Qualitative data:
    - Qualitative feedback on the ASTAIR concept will be collected from the users, from debriefs with the ASTAIR platform users.
    - Observations of users' interaction with the ASTAIR tool, observed by the ASTAIR project team during the validation.

Fast-Time Simulation (FTS):

- Quantitative data will be collected from the FTS data logs.
- Flight schedules and Calculated Take Off Time (CTOT) times, as well as historic track data from year 2019 will be taken into account.

Final Workshop:

- Qualitative data will be collected based on the discussions with ASTAIR end users (e.g., Ground Handling, Tower/Ground ATCOs) and other domain experts.

5.3.8.2 Analysis methods

RTS activity:

- Expert judgement analysis of the qualitative feedback and specialists' observations preset at the validation. Analysis for Estimate Performance Contributions will be done by the project's specialists, and reported on by the validation lead in the ERR.
- Data logs analysis. Example of data logged: users' interactions with HMI, aircraft taxi times, radio communication between operators and pseudo pilots.
- Qualitative and quantitative results analysis of Human Performance using the evaluation tools addressing HMI usability, user workload and situational awareness.

Fast Time Simulations (FTS) activity:

- The analysis shall provide the results towards the MAS algorithm.
- A number of operational scenarios identified in ASTAIR will be modelled and implemented in the developed FTS tool. The implemented scenarios will be simulated under different operational conditions, and relevant KPIs will be analysed statistically and visually.

Final Workshop activity:

- Expert judgement analysis of the qualitative feedback, towards the EPCs and OBJs.

The Legal Case methodology will be used to study the possible implications of the ASTAIR concept and tools with reference to liability risks of the concerned actors.

5.3.9 Exercise planning and management

5.3.9.1 Activities

This exercise will be performed through the already mentioned three validation activities:

- RTS

- FTS
- Final Workshop.

The more detailed planning and description of the activities is in Table 25.

5.3.9.2 Roles and responsibilities in the exercise

This subsection describes the roles and responsibilities of the ASTAIR consortium in preparing, conducting and analysing the validation exercise #03.

- ENAC manages the involvement of the end users, as a minimum: ATCOs, Ground Handling, from Schiphol.
- Deep Blue provides questionnaires for the RTS in the preparatory stage.
- ENAC/Deep Blue prepares the observation sheets for the RTS observers.
- Groupe ADP acts as an observer and prepares the minutes of the RTS validation.
- Consortium will provide the end users and facilities for the ASTAIR solution.
- Deep Blue and ENAC will analyse and report on the results from RTS in the ASTAR D5.2 ERR.
- TUD will verify the ASTAIR tool prior conducting FTS.
- EUROCONTROL will provide verification and validation expertise and will analyse the validation results.
- TUD will analyse and report on the results from FTS in the ASTAIR D5.2 ERR.
- Consortium (ADP/EUROCONTROL) will collaborate on ASTAIR Final Workshop preparation and execution.

5.3.9.3 Time planning

Activity phases	Description	When
RTS Verification activity – preparation phase	Verification of the ASTAIR tool and concept by the Consortium members.	Oct 2024 – Mid April 2025
FTS Verification activity – preparation phase	Verification of the ASTAIR tool and concept by the TUD. Objective addressed: OBJ05 and its CRTs. A number of operational scenarios identified in ASTAIR will be modelled and implemented in the developed FTS tool. The implemented scenarios will be simulated under different operational conditions, and relevant KPIs will be analysed statistically and visually.	Sep 2024 – May 2025
RTS – execution phase	Validation of the ASTAIR concept with end-users.	End of April 2025
FTS – execution phase	FTS to validate the algorithms of the ASTAIR tool.	May 2025
Final Workshop - execution phase	Final project workshop to discuss the results gathered from the validation exercises and discuss the overall operational feasibility, HP and Safety and other main KPAs (as defined relevant to this project) with the domain experts.	Q2 2025

RTS and FTS – post-execution phase	The results will be reported in the ERR.	May 2025
Final Workshop – post-execution phase	The results will be reported in the Final Project Report.	Q3 2025

Table 25: detailed exercise #03 time planning

5.3.9.4 Identified risks and mitigation actions

The following table presents the identified risks and mitigation actions for validation exercise #03.

The table below is filled in by extracting data from the project's STELLAR risks register.

Risks	Impact (1-low, 2-medium, 3-high)	Likelihood (1-low, 2-medium, 3-high)	Criticality (calculated based on likelihood and impact)	Mitigation actions
Insufficient involvement of ground operations stakeholders.	2	1	2.00	Engage early with ground operations stakeholders through workshops and regular communication. Establish formal agreements to ensure participation and contribution. Communicate the potential benefits of the ASTAIR solution.
The designed concept may be inapplicable in operational conditions.	3	1	3.00	Conduct thorough operational needs analysis and simulations early in the project. Use iterative design approaches, continuously testing and validating the concept with real-world scenarios to ensure applicability.
Low participation to validation sessions.	3	2	3.00	Increase outreach efforts through targeted invitations and flexible scheduling to accommodate participants' availability. Offer incentives or provide alternative validation methods, such as virtual or remote participation.
Difficulties in reaching the targeted audiences for dissemination, communication & training project results, due to prolonged impact of COVID-19.	2	2	4.00	Leverage online platforms and virtual events for dissemination and training. Develop digital resources, such as webinars, and virtual workshops, to reach a wider audience despite travel or in-person restrictions.
Unclarity about TRL of output(s) reached at the project end, resulting in	2	1	2.00	Regularly assess and document the TRL during the project's lifecycle. Engage experts to review progress and ensure

difficulties in defining appropriate follow-up exploitation activities.				clarity in TRL evaluations. Plan for TRL-specific follow-up activities to align with project outcomes.
Acceptability of the concept by ATCO due the increase of automation level.	3	3	9.00	Involve ATCOs in the design and validation processes through user-cantered design methodologies. Ensure that the system provides sufficient transparency, control options, and safety assurances to build trust in the increased automation.

Table 26: exercise #03 risks and mitigation actions

6 References

6.1 Applicable documents

This ERP complies with the requirements set out in the following documents:

Content integration

[1] Common Taxonomy Description 1.0

[2] SESAR ATM Lexicon

Content development

[3] SESAR Operational Concept Document (OCD 2023)….

Performance management

[4] PJ19 Content Integration, “D4.4 SESAR 2020 Performance Framework.’” Brussels, 2018.

Validation

[5] DES HE requirements and validation / demonstration guidelines (3.0).

Safety

[6] Expanded Safety Reference Material (E-SRM) Core Document, Edition 1.2, November 2023

Human performance

[7] SESAR Human Performance Assessment Process TRL0-TRL8

Environment assessment

[8] SESAR, Environment Reference Material, alias: “Environmental impact assessment as part of the global SESAR validation”, 2014.

[9] ICAO Doc. 10031, “Guidance on Environmental Assessment of Proposed Air Traffic Management Operational Changes.” 2014.

Security

[10] 16.06.02 D103 SESAR Security Ref Material Level.

Project and programme management

[11] Project [101114684] ASTAIR Grant Agreement, [31/05/2023]

[12] SESAR 3 JU Project Handbook – Programme Execution Framework, [11/04/2022], [01.00]

6.2 Reference documents

[13] EUROCAE ED-78A Guidelines for Approval of the Provision and Use of Air Traffic Services supported by Data Communications, December 2020.

[14] SESAR ASTAIR D1.2 Workshops Report

[15] D1.3 Initial Concept Outline, v.01.01

[16] A. Rehmann, Crew Systems Ergonomics/Human Systems Technology Information Analysis Center, and United States. Federal Aviation Administration, “A Handbook of Flight Simulation Fidelity Required for Human Factors Research,” 1995, doi: 10.21949/1403228.

[17] ASTAIR DOA PartB-final - v2

[18] EASA Artificial Intelligence Roadmap 2.0