CODA - D6.2 Description of the final validation platform

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Abstract

This document summarizes the final validation platform for the CODA project, highlighting ESCAPE Light as the core component. It covers key elements and outlines their roles in scenario preparation, simulation execution, and data collection. The document also notes key constraints emphasizing the platform's role in supporting human factors research for the CODA project within the SESAR framework.

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1 Executive summary

This document provides a comprehensive overview of the final validation platform developed for the CODA project, with the ESCAPE Light simulation environment serving as its core component. The platform plays a central role in conducting human factors research and validating operational scenarios within the SESAR framework.

The document highlights how ESCAPE Light replicates real-world air traffic control operations, supporting both operational training and research analysis. It explains the platform's primary components—IPAS Position, Ground Server, Controller Working Positions (CWP), and Pseudo-pilot Positions—each contributing to realistic simulations and accurate data collection.

The platform's functionalities are detailed across key phases: exercise preparation, simulation execution, and post-processing of collected data. These processes are vital for generating insights on controller workload, decision-making, and traffic management performance.

The document briefly presents the mock-ups developed within CODA and the sensors that will used to feed them. These are:

- Controller task prediction mock-up;
- Controller mental states measurement mock-up;
- Controller mental states prediction mock-up;
- Adaptation and human AI interaction strategy mock-up.

Additionally, the document outlines the technical and operational constraints of the platform, such as interface differences from real-world systems, limited position availability, and scenario duration restrictions. Despite these limitations, the platform remains a powerful tool for human factors research, supporting the CODA project's objective of developing predictive models for controller mental states and workload patterns.

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2 Introduction

2.1 Purpose of the document

This document describes the final validation platform used in the CODA project exercise 3 [12], focusing on the ESCAPE Light simulation environment as the primary tool for executing, supervising, and analysing validation exercises, and the mock-ups developed within CODA. The document outlines the platform's components, functionalities, and limitations, highlighting its role in supporting human factors research and air traffic management validations. It aims to provide a clear and structured overview of how the platform contributes to achieving the CODA project objectives within the SESAR framework.

2.2 Intended readership

This document is intended for stakeholders involved in the CODA project and other SESAR research initiatives, including:

- **Researchers and Analysts:** To understand the platform's functionalities and data collection capabilities for human factors and operational research.
- **Validation and Simulation Engineers:** To gain insight into the technical components and their roles during validation exercises.
- **SESAR JU Representatives:** To assess the platform's contribution to achieving project objectives.
- **Air Traffic Management Experts:** To evaluate how ESCAPE Light simulations align with real-world operations and support research on controller workload and performance.

2.3 Background

The simulation platform used for the exercises has been developed by Eurocontrol and is used in several research projects. The mock-ups have been developed on enhanced by CODA partners based on the work performed within the project. For detailed information please refer to the model description deliverables.

- Controller task prediction mock-up [8];
- Controller mental states measurement mock-up [9];
- Controller mental states prediction mock-up [10];
- Adaptation and human AI interaction strategy mock-up [11].

2.4 Structure of the document

This document is organized into the following sections:

Abstract: A concise summary of the document's objectives and key points.

1. Executive Summary: A high-level overview highlighting the platform's role and contributions.

2. Introduction: Includes the document's purpose, target audience, background, structure, and terminology.

3. Overview of the Final Validation Platform: Describes the platform's scope, components, and architecture.

4. Functionalities for Validation Exercises: Details the platform's capabilities for scenario preparation, simulation execution, and data collection.

5. Limitations and Constraints of the Platform: Identifies technical and operational limitations of the platform.

6. Conclusions: Summarizes key points and the platform's contribution to the CODA project.

7. References: Lists applicable and reference documents.

2.5 Glossary of terms

Term	Definition	Source of the definition
CWP	The controller working position (CWP) provides the human-machine interface to air traffic controllers at the air traffic service units	EUROCONTROL [5]
ESCAPE Light	Scalable EUROCONTROL ATM real-time simulation platform supporting small- and large-scale simulations	EUROCONTROL [6]
BADA (Base of Aircraft Data)	An Aircraft Performance Model developed and maintained by EUROCONTROL. BADA is based on a kinetic approach to aircraft performance modelling, which models aircraft forces.	EUROCONTROL [3]
SESAR	SESAR is the technological pillar of the EU's Single European Sky policy and a key enabler of the European Commission's Sustainable and Smart Mobility Strategy. SESAR defines, develops and deploys technologies to transform air traffic management in Europe	SESAR JU [2]

Table 1: glossary of terms

2.6 List of acronyms

Term	Definition
BADA	Base of Aircraft Data
CWP	Controller Working Position
GS	Ground Server
IPAS	Integrated Preparation and Analysis System
SESAR	Single European Sky ATM Research
SESAR 3 JU	SESAR 3 Joint Undertaking

Table 2: list of acronyms

3 Overview of the Final Validation Platform

3.1 Platform Purpose and Scope

The ESCAPE Light simulation environment is the core component of the final validation platform for the CODA project exercise 3 [12], serving as the primary tool for executing, supervising, and analysing validation exercises, [4].

ESCAPE Light replicates real-world air traffic control operations, enabling high-fidelity simulations that support both operational and research objectives. On the operational side, it provides a realistic environment for controllers to practice managing traffic scenarios and handling complex airspace operations. On the research side, ESCAPE collects detailed trace data during simulations, which is essential for post-processing analysis and evaluating performance metrics, such as workload patterns and traffic management strategies.

While ESCAPE Light forms the platform's foundation, external tools add value by enhancing human factors research, providing insights into cognitive load, fatigue, and decision-making processes. Together, these components support the CODA project’s goal of developing predictive models of controller workload and mental states, aligning with SESAR’s vision of safer and more efficient air traffic management through data-driven insights.

The simulation platform is completed with the mock-ups developed by the different partners addressing each of the different components of the CODA system.

3.2 Key Components of the Platform

The final validation platform is composed of several interconnected components that collectively support the design, execution, supervision, and analysis of validation exercises. Each component plays a specific role in enabling realistic simulations and facilitating comprehensive post-exercise analyses.

3.2.1 IPAS Position

The IPAS (Integrated Preparation and Analysis System) Position is the primary interface for creating and managing simulation scenarios within ESCAPE Light. It is responsible for data preparation and scenario configuration prior to the simulation process.

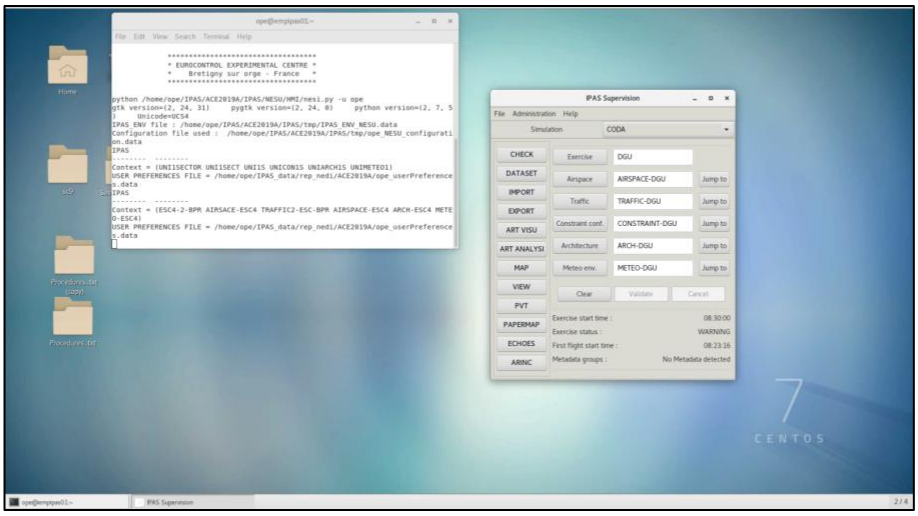

Figure 1. IPAS interface

The IPAS Position provides:

- **Scenario Design and Configuration:** IPAS allows users to define airspace sectors, traffic routes, and operational parameters for simulation exercises.
- **Data Import and Management:** Users upload and organize datasets such as airways, navigation points, and traffic patterns required for scenario creation.
- **Scenario Validation:** The system performs consistency checks on imported datasets to identify and resolve errors before scenarios are transferred to the Ground Server.

In the ESCAPE Light environment, IPAS is dedicated to scenario preparation and validation. It does not execute or supervise simulations. Instead, validated scenarios are handed over to the Ground Server, which manages the simulation process and collects data for post-exercise analysis.

3.2.2 Ground Server

The Ground Server is a key component of the ESCAPE Light simulation environment, responsible for launching, managing, and recording simulation exercises. It acts as the central hub for controlling simulation runs and collecting performance data, making it an essential element for validation exercises within the CODA project.

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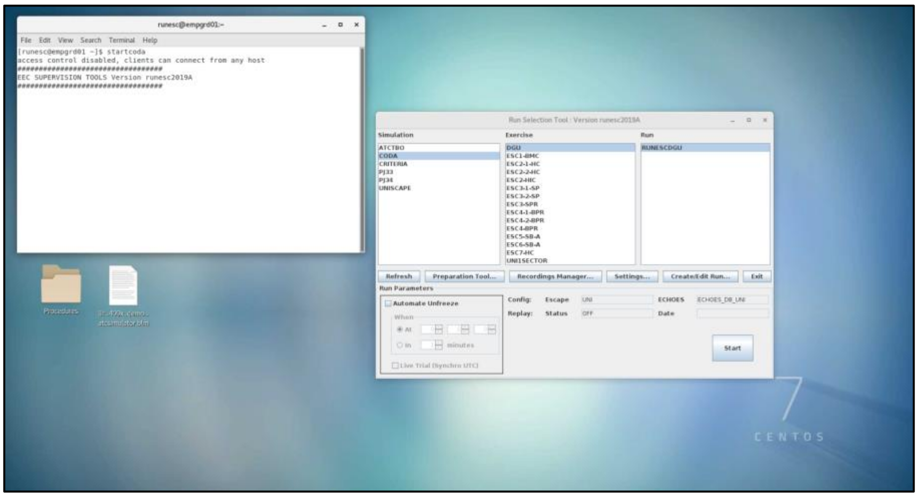

Figure 2. GS interface

The Ground Server oversees the following key operations:

- **Simulation Launch and Control:** It initiates the simulation using validated scenarios from the IPAS Position. During the simulation, users can monitor traffic flows, pause or stop the simulation, and adjust timing settings such as fast-forwarding.

- **Exercise Management:** The Ground Server tracks all simulation activities, including aircraft movements and controller interactions, ensuring accurate logging of events.

- **Data Collection for Post-Processing:** It records trace data from the simulation, including traffic patterns and control responses. This data is essential for CODA's post-simulation analysis, supporting the development of workload models and human factors research.

- **Run Configuration:** Users can create, edit, and save simulation runs with specific parameters, including assigned controller positions and simulation scenarios.

The Ground Server is critical in maintaining the consistency and integrity of the simulation process. While it does not create scenarios (a task performed by IPAS), it ensures their accurate execution and collects vital data for subsequent analysis. This component is fundamental to achieving the research objectives of the CODA project, providing detailed insights for workload modelling and human performance evaluation.

3.2.3 Controller Working Positions

The Controller Working Positions (CWP) are essential components of the ESCAPE Light simulation environment, providing air traffic controllers with the necessary interface to interact with simulated traffic during validation exercises. The CWPs replicate real-world controller tools and workflows, making them fundamental for assessing operational performance within the CODA project.

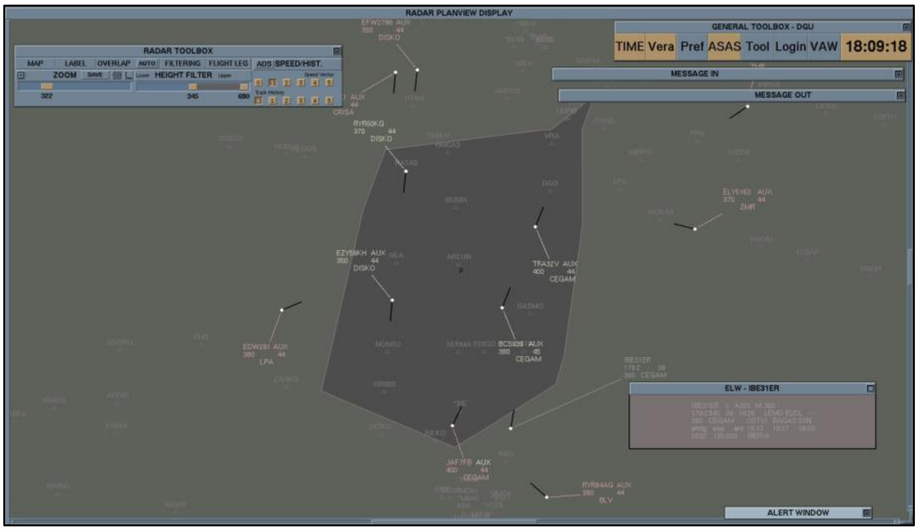

Figure 3. Controller HMI

CWPs are designed to simulate the tasks and responsibilities of air traffic controllers, offering a realistic operational environment. These positions are configured according to the exercise scenario defined in the IPAS Position and launched from the Ground Server.

Key capabilities of the CWPs include:

- **Traffic Visualization:** Controllers can monitor aircraft positions, trajectories, and relevant flight information in real time through radar displays.
- **Sector Management:** Each CWP is assigned a sector defined in the scenario, allowing controllers to manage traffic flow and resolve conflicts.
- **Label Management:** The system displays dynamic aircraft labels containing critical flight data such as callsigns, headings, altitudes, and speeds.
- **Handoff Operations:** Controllers can manage sector handovers by transferring flights to adjacent sectors.

3.2.4 Pseudo-pilot Positions

The Pseudo-pilot Positions responsible for simulating pilot responses and interactions during validation exercises. These positions are essential for creating realistic traffic management scenarios and supporting human factors analysis within the CODA project.

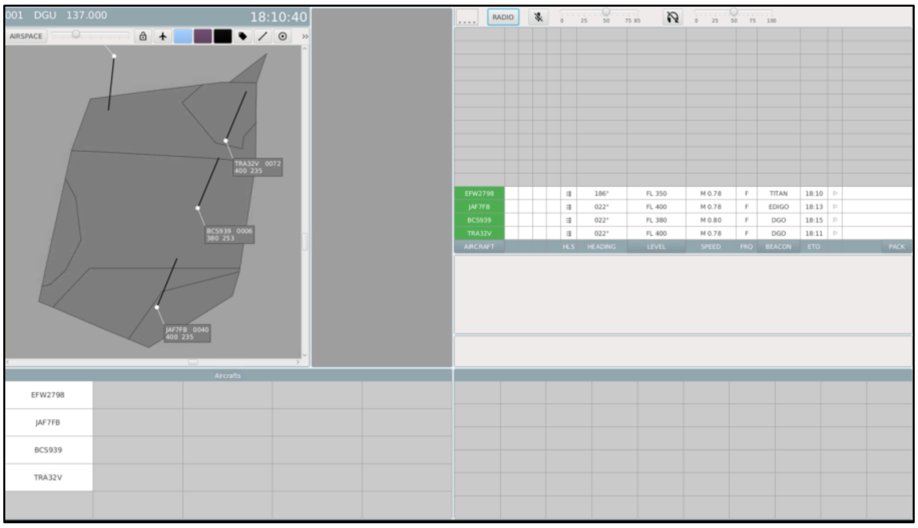

Figure 4. Pseudopilot HMI

Pseudo-pilots replicate the actions of real pilots, responding to instructions issued by controllers from the CWP (Controller Working Positions). Their primary function is to ensure realistic traffic behaviour during simulations, supporting the analysis of controller performance and decision-making processes.

Key capabilities of the Pseudo-pilot Positions include:

- **Aircraft Management:** Pseudo-pilots control multiple aircraft simultaneously, adjusting flight levels, headings, and speeds based on controller instructions.
- **Voice Communications:** Pseudo-pilots use simulated voice channels to communicate with controllers, replicating real-world pilot-controller interactions.
- **Procedure Execution:** They implement manoeuvres such as holds, vectors, and direct routings in response to controller commands.

3.2.5 Task prediction mock-up

To integrate the ATCO task prediction system, based on the algorithms and methods described in[8], in the real-time CODA system for validation, a web server architecture was implemented, and additionally several web apps with different purposes where integrated with it. Given the difficulties in integrating the ESCAPE platform with these models in real time, an alternative mechanism for registering tasks being performed by the ATCO in real-time was developed. This mechanism is essential for ATCO task prediction validation, as task updates directly impact the predicted probabilities. It is based on a tablet web app connected to a server devoted to task registering. Second, another server has been developed whose main role is performing the real time prediction of ATCO tasks. This server publishes an API, enabling external systems (and specifically the CODA adaptation strategy and HMI implementations) to access the prediction data in real time.

Figure 5 illustrates the high-level architecture of the complete system. Both implemented subsystems meet security requirements, enforcing authentication mechanisms and requiring valid credentials for access.

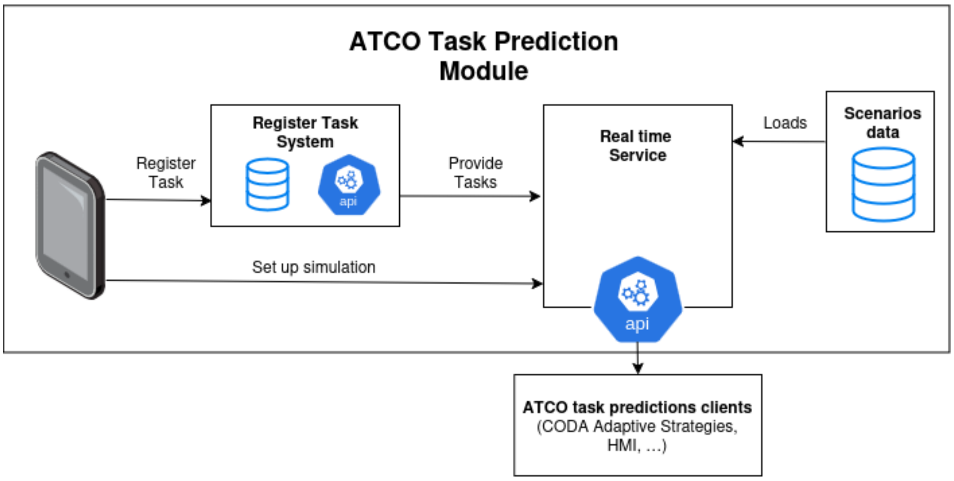

Figure 5. High-level ATCO Task prediction architecture.

3.2.5.1 ATCO Task register application

The first requirement for reliable task prediction is the ability to access the collection of tasks already performed by an ATCO within a given scenario. To achieve this, a web application connected to a database has been developed. This application includes a user-friendly interface, allowing users to interact with the system efficiently. Through the web UI, Figure 6, users can configure the required simulation times and scenario, ensuring synchronization between the ESCAPE platform and the ATCO real-time external system. This implementation ensures that task data is recorded and readily accessible, providing a reliable API used by the real time system.

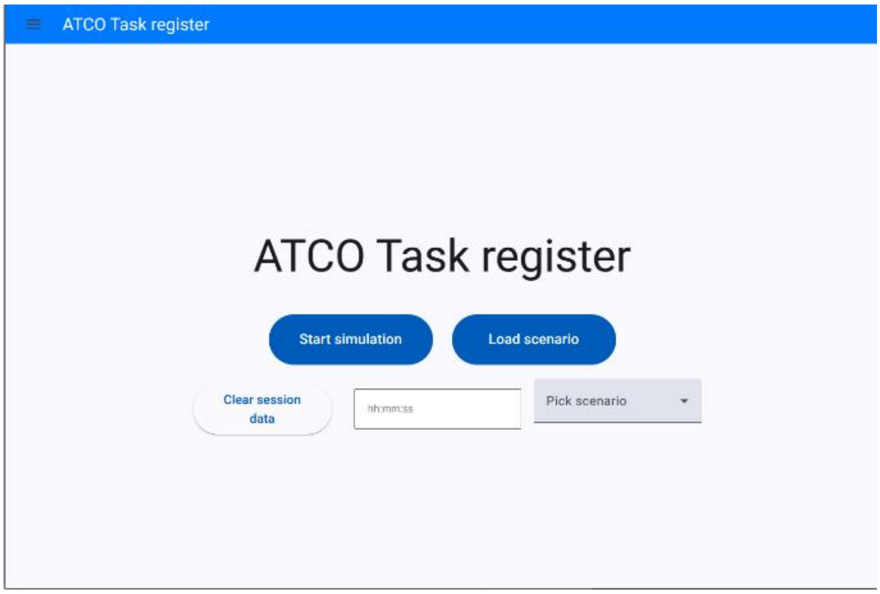

Figure 6. ATCO Task registration app 1.

Once a scenario is running, Figure 7 illustrates the interface available for registering tasks that can be applied to a flight. Each task recorded through user interaction is sent to a backend server, where the system securely stores the information (callsign, the assigned task, and the corresponding timestamp) in a relational database. This stored data plays a crucial role in enabling the calculation of probability predictions requested by the real-time system.

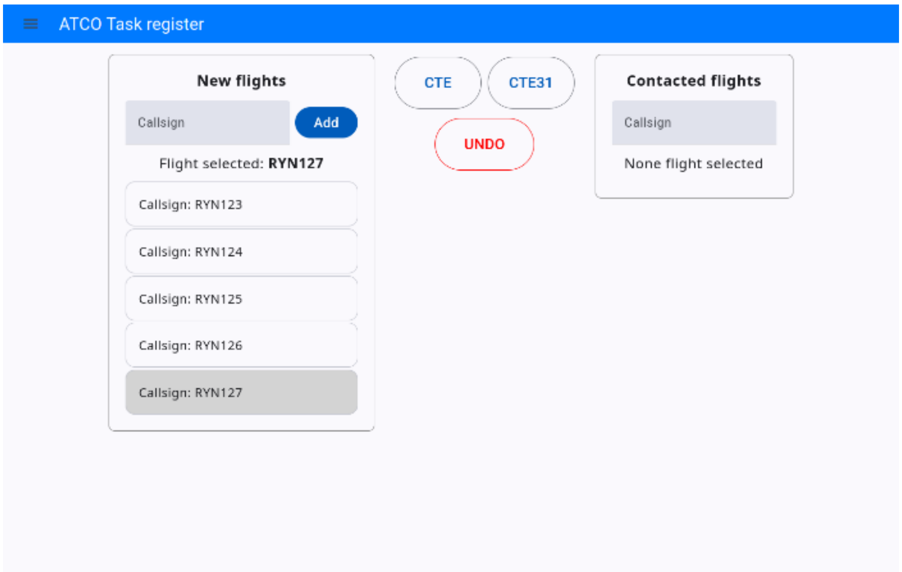

Figure 7. ATCO Task registration app 2.

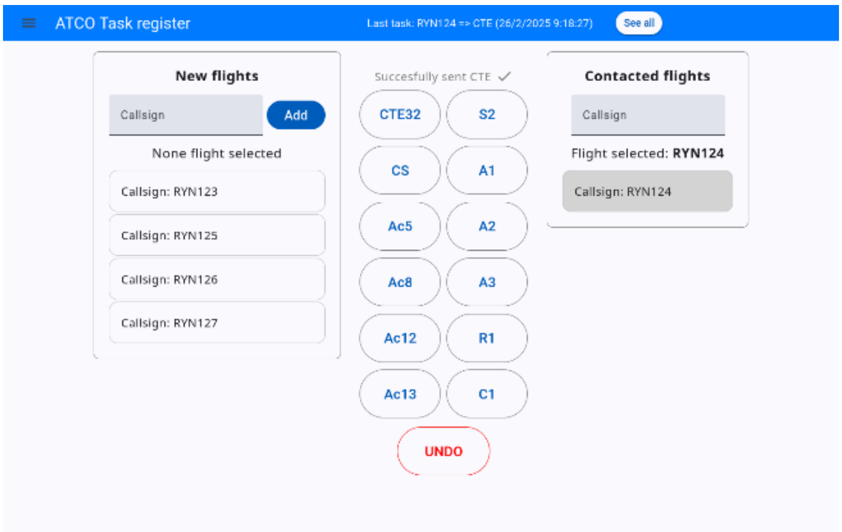

Figure 8. ATCO Task registration app 3.

3.2.5.2 Real time service predictor

The second component in the architecture focuses on deploying the prediction algorithms within a containerized server that encapsulates its full functionality. The aim of this deployment is to ensure an easy and accessible integration of the task prediction system within the broader CODA system architecture. This service includes all necessary components to initialize and execute the prediction algorithms developed in WP3, specifically for ATCO task prediction [8]. The predictors are initialized during the server bootstrap process. At this stage, the system precomputes and prepares the required probability distributions and time histograms, ensuring that the prediction mechanism is immediately operational and efficient. To initialize the prediction, the service also loads flight plan files associated with each scenario. These files are stored on the server and loaded on-demand. Figure 9 depicts a sequence diagram of the setting up process of a simulation using the UI provided by the task registration web application and its communication with this real time system.

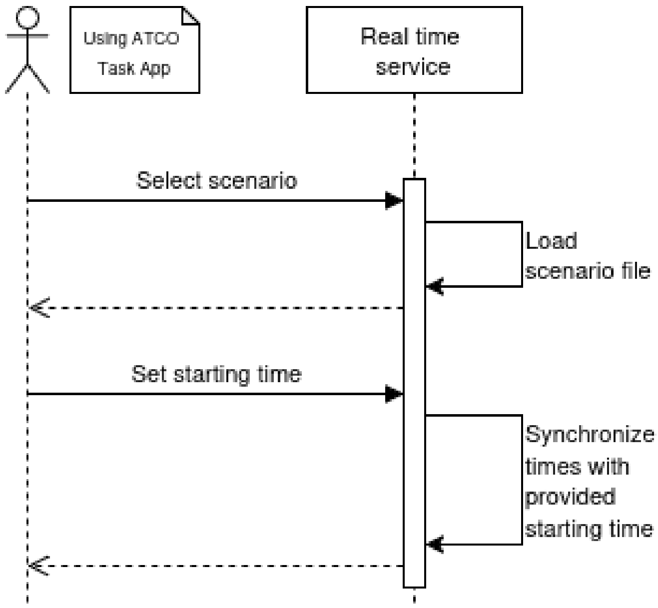

Figure 9. Simulation set up sequence diagram.

Once the simulation start time is set and a specific scenario is selected (which are set also through API requests), the service provides an API that delivers real-time prediction results upon request. Each API call retrieves the computed predictions corresponding to the requested time, with an internal conversion aligning it to the simulator's timeline (ESCAPE Platform). To implement this prediction on each request it consults the task registration system and requests the latest available data regarding the list of already performed tasks to compute the predicted probability. Figure 10 depicts the high-level sequence diagram of the request process. These requests are intended to be performed periodically by the ATCO task predictions clients (CODA Adaptive Strategies, HMI, …), to update their information in real time, although the ATCO tasks prediction module API operates purely on demand.

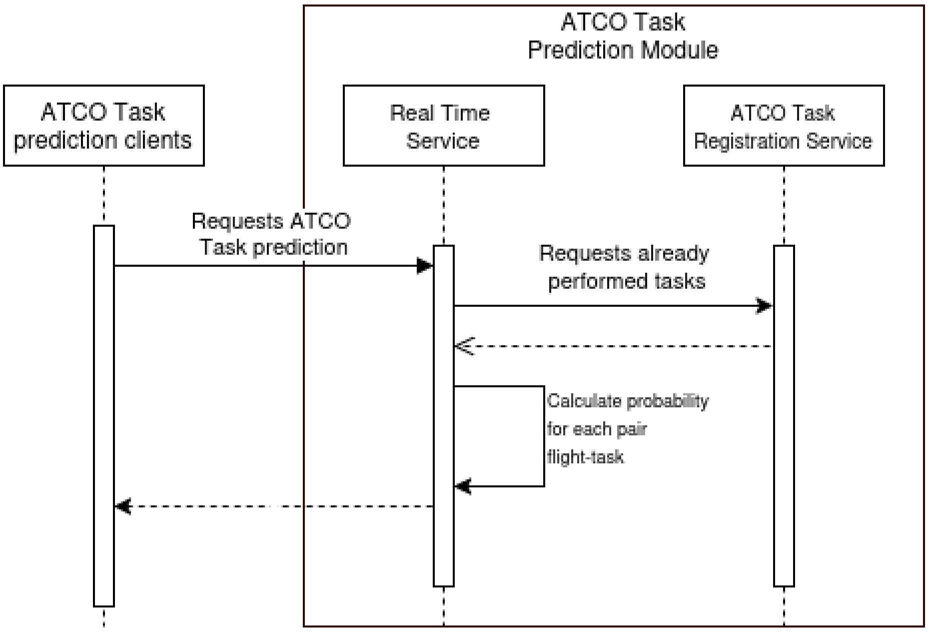

Figure 10. Request predictions sequence diagram.

The data exposed by this API corresponds to a JSON complex object with the probability predictions within the next 5 minutes for each individual flight, as well as an aggregated for all flights, as well as the list of performed tasks in the previous 5 minutes and the number of tasks executed for all flights in the same time interval.

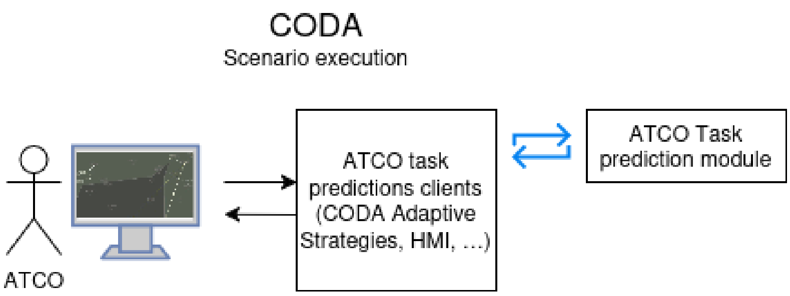

Figure 11. CODA scenario high-level diagram.

Finally, Figure 12 depicts a representation of a technical graphical interface that is used to evaluate in real time the output of the systems to verify that everything is working as expected. This is not the interface that will be exposed to ATCOs, it is an inner functionality so that the development team can evaluate the performance of the system, in terms of real time requirements and prediction quality. The interface enables seeing and filtering individual and aggregated probabilities for different tasks and flights.

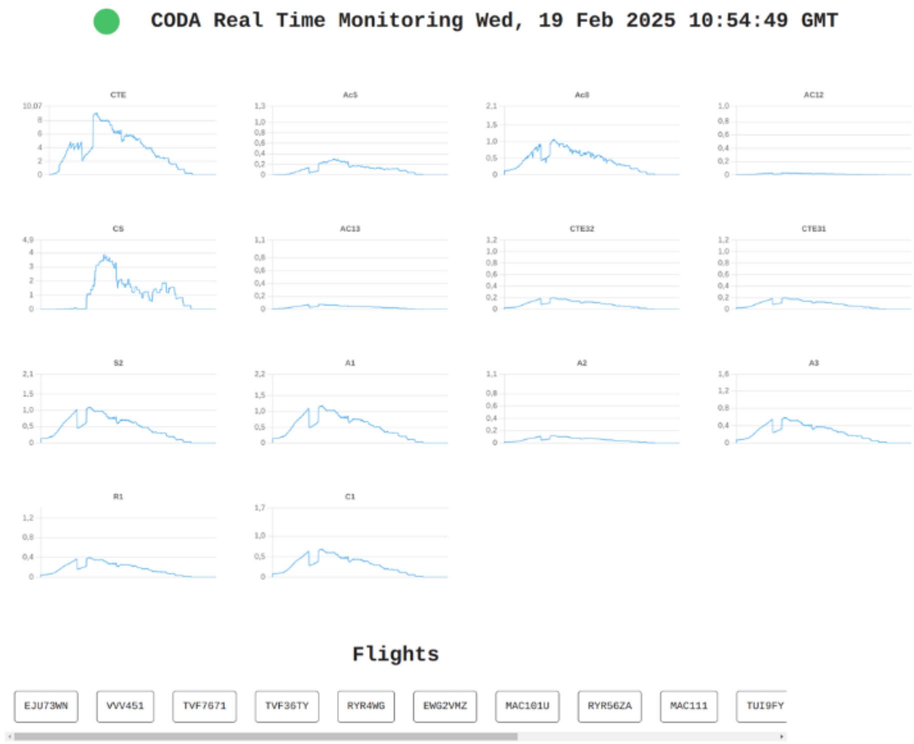

Figure 12. ATCO task prediction monitoring view.

3.2.6 Mental model prediction mock-up

The mental state prediction models developed in [9] have been translated into a software programme that executes the different algorithm identified. The algorithms in the model included a set of parameters that were identified analysing the data obtained during the execution of CODA exercise 002 in November 2024, [12].

The mock-up the algorithm implementation uses as input information the list of flights of the traffic sample, and the simulation time. The output file contains the values for Mental Workload, Fatigue, Stress and Vigilance, in the agreed levels:

- Workload (L/M/H);
- Stress (L/M/H);
- Mental fatigue (L/M/H);
- Vigilance (L/H);

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The mental state prediction algorithm is influenced by the Operational Mode in which the controller is performing their task, thus the mock-up also provides information if the Operational Model changes.

All calculations in the mental states prediction mock-up are set in sliding window-width of 5 minutes every 1 minute as illustrated in Figure 13 .

Figure 13. ATCO Mental States Models calculation granularity

As example, Figure 14 presents the output of the workload and fatigue mental states predicted in the mock-up against the ones measured during one of the scenarios during Exercise 002.

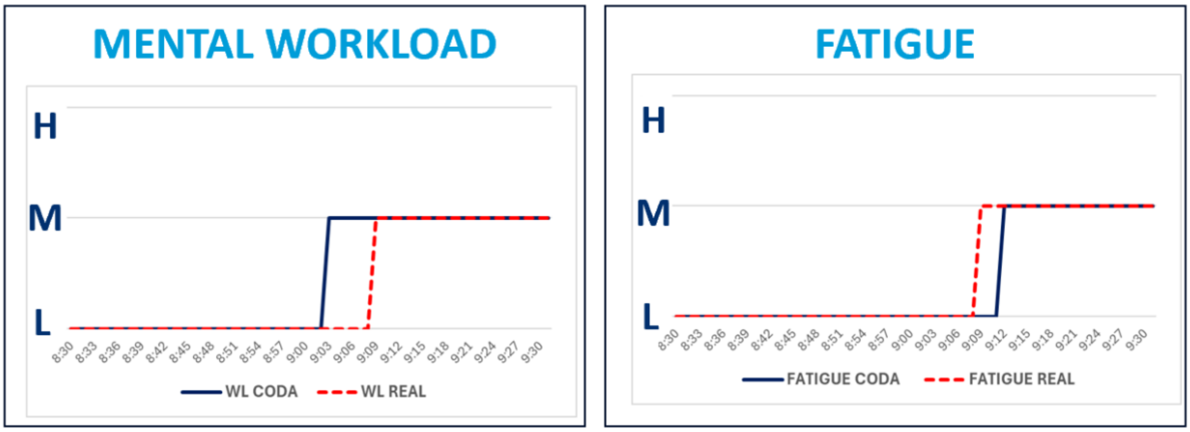

Figure 14. ATCO Workload and Fatigue Mental States prediction parameters

If the traffic to managed by the controller changes i.e. the controller agrees to delegate one flight to the Artificial Intelligence, the input data to the model will change triggering a new calculation and prediction of the mental workload parameters.

The mental states prediction model has been developed using Java. The model will be provided as an executable .jar file to the Adaptation and human AI interaction strategy mock-up. Within the Adaptation and human AI interaction strategy mock-up the different files (traffic update, and mental state predictions) will be exchanged in dedicated folders.

3.2.7 Mental model measurement sensors

The controller's mental states will be collected in real time using two sets of neurophysiological sensors that are wearable, wireless, non-invasive and reliable. A detailed description of the sensors is available in [10].

- The ATCOs' brain (Electroencephalogram – EEG) data will be acquired through the Mindtooth Touch system (https://mindtooth-eeg.com/) with 8 water–-based electrodes (5 frontal and 3 parietal channels) and Bluetooth low-energy (BLE) connectivity.
- For the heart (Photoplethysmography – PPG) activity, and skin (Electrodermal activity – EDA) conductance PPG and EDA data collection, the Shimmer3 GSR+ (https://shimmersensing.com/product/shimmer3-gsr-unit/).

Figure 15. Mindtooth © Touch EEG headset and Shimmer3 GSR+ device

Both sensors were used during the execution of Exercise 002, [12], in November 2024, where data regarding each individual controller was gathered. The data from each controller have been analysed and will be used to ensure that the devices are calibrate to the specificities of each controller.

A simple model will collect the real time information, normalize it according to each controller calibration parameters, and transform it into the agreed mental levels:

- Workload (L/M/H);
- Stress (L/M/H);
- Mental fatigue (L/M/H);
- Vigilance (L/H);

This information will be provided to the adaptation and human AI interaction strategy mock-up for processing using LSL protocol every minute.

3.2.8 Adaptation and human AI interaction strategy mock-up

The adaptation and human AI interaction strategy mock-up uses as baseline the work developed within [11]. The mock-up will receive information from the three previously described mock-ups. A simple algorithm will be used to decide on when to implement the adaptation and human AI strategy and present the outcome together with relevant information to the controller. Due the updated approach in the controllers' task prediction models and Escape platform connectivity limitations next decision have been made:

- The Automation and human AI interaction strategy mock-up will propose to delegate complete flights to the AI.
- Due to the prediction horizon (five minutes) the flight delegation proposal will be done between 5 and 2 minutes before the flight enters the sector.
- The controller will agree or disregard the proposal.

Figure 16 and Figure 17 present the Adaptation and human AI interaction strategy mock-up interface and an example of the algorithm and when the automation would be triggered

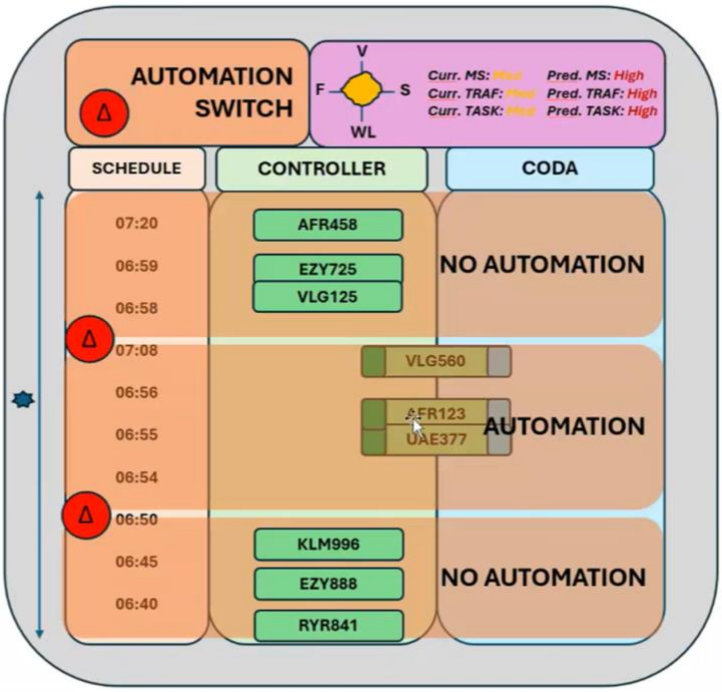

Figure 16. Adaptation and human AI interaction strategy mock-up HMI

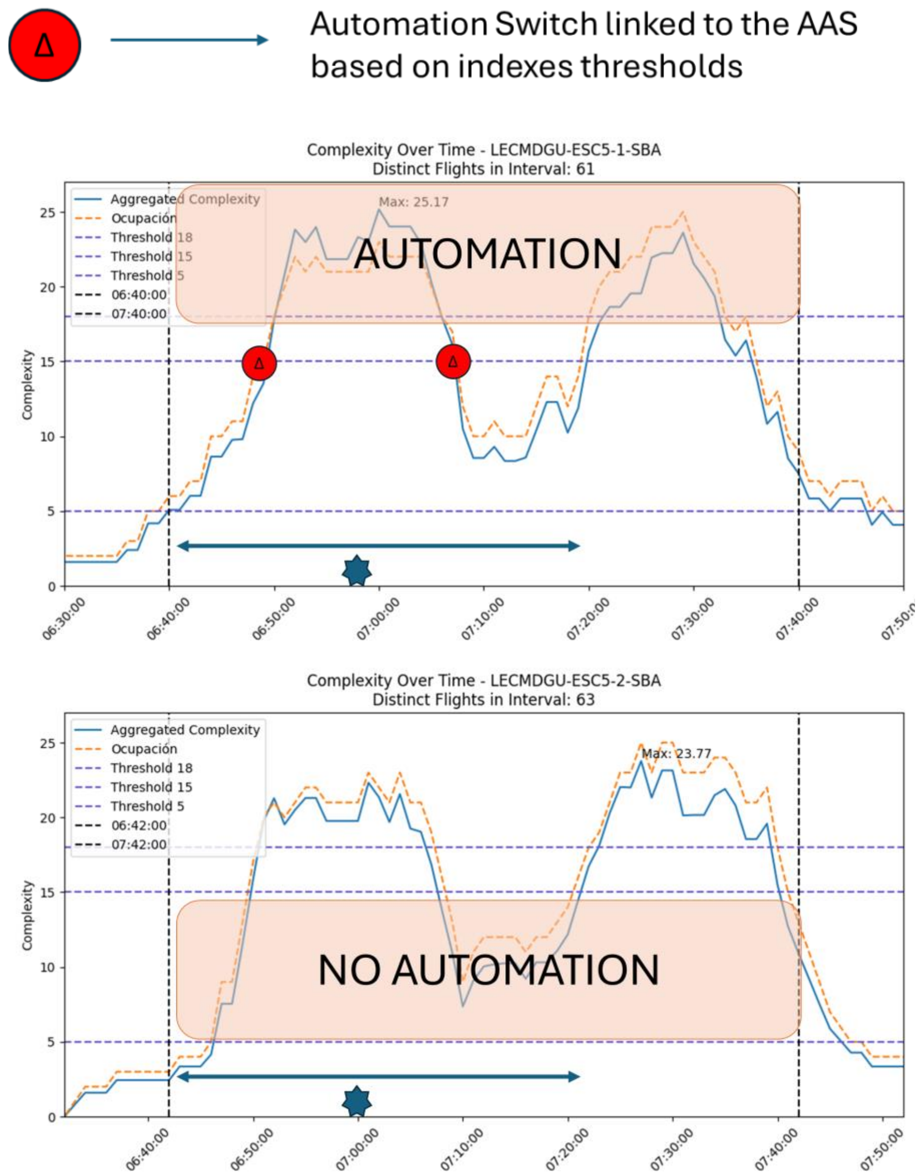

Figure 17. Example of possible task, mental states (current and predicted) relationship with mock-up

A duplication of the HMI will be presented to the controller acting as Wizar of Oz (acting as the AI in another console), so they are aware of the decision made by the controller executing the simulation exercise.

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4 Functionalities for Validation Exercises

The simulation environment offers a range of functionalities that support the preparation, execution, and analysis of validation exercises. These features are essential for achieving the objectives of the CODA project, enabling accurate scenario configuration and comprehensive data collection.

4.1 Exercise Preparation

Exercise preparation is a critical phase in the validation process, during which simulation scenarios are defined, configured, and validated. The preparation phase involves setting up airspace structures, traffic patterns, and operational parameters to support the intended research objectives.

The key steps in exercise preparation include:

- **Scenario Definition:** Using the IPAS Position, users configure the airspace, including airports, navigation points, and sector boundaries. Traffic patterns such as departures, arrivals, and en-route flows are also established.
- **Data Import and Validation:** The IPAS Position imports datasets (e.g., routes, SIDs, STARs) and performs consistency checks to ensure data integrity before delivering the scenario to the Ground Server. This process can also be done manually, but it is typically performed using real flight traffic files.
- **Exercise Parameters:** Users define simulation start times, traffic loads, and weather conditions to replicate operational challenges.
- **CWP Configuration:** Controller Working Positions are assigned specific sectors and physical positions.
- **Automation algorithm launch definition:** a simple algorithm will be defined to be used to determine the best moment to launch the CODA system.
- **Task prediction per flight:** the task prediction mock-up will be launched in advance to select the flights that will be proposed by the CODA system to the controller to be handled by the simulated Artificial Intelligence (AI).

4.2 Simulation Execution and Supervision

Simulation execution involves running the predefined scenario and monitoring its progress to ensure smooth operation. The process is straightforward, focusing on launching the exercise and verifying that the simulation runs without unexpected issues.

The simulation is initiated using the Ground Server, which loads and launches the scenario configured in the IPAS Position.

- **Pseudo-pilots** simulate aircraft behaviour and communicate with controllers through oral exchanges, ensuring realistic interactions.

- **Controllers** engage with the traffic, issuing instructions and managing sector operations.

Figure 18. Photos from Validation Exercise 2

- **CODA Mock-ups** execute the models and algorithms.
- **Neurophysiological sensors** collect information for estimating controller's mental states (workload, stress, vigilance and mental fatigue) in real-time while dealing with ATC scenarios
- **CODA HMI duplicate screen** duplicates the CODA HMI information presented to the controllers to support the controller simulating the AI.

4.3 Data Collection and Post-Processing

Data collection and post-processing are crucial for deriving insights from simulation exercises.

The Ground Server records trace data from every simulation run, capturing various files containing different types of information, including aircraft movements, controller actions, and sector events. These files can be used to derive insights such as airspace occupancy, significant events, aircraft positions, and control actions performed during the simulation. The recorded trace data is exported from the Ground Server for analysis.

The different sensors used in the CODA system will record the information gathered.

5 Limitations and Constraints of the Platform

5.1 Technical Limitations

The ESCAPE Light simulation environment, although effective for validation exercises, presents certain technical limitations due to its research-oriented design and differences from operational systems:

- **Interface Differences:** The ESCAPE Light interface is not the same as the one used by air traffic controllers in their daily operations, which may affect their familiarity and interaction speed.
- **Missing Operational Tools:** Certain tools available in real environments, such as coordination panels or automated warnings, may be simplified or absent.
- **Hardware and Display Limitations:** Display configurations and input devices (e.g., trackballs, specialized keyboards) may differ from those used in real control towers or en-route centres.
- **Simulation Engine Constraints:** The simulation engine, designed for research purposes, may not fully replicate complex airspace behaviours or extreme traffic situations.
- **Speed Modelling Limitation:** Aircraft speeds are derived from BADA, [3], performance models and cannot be adjusted during scenario design, which standardizes traffic behaviour and reduces realism.
- **Connection Limitations:** the live extraction of information from the current version of Escape light platform provokes the instability of the platform. Due to this instability no connection will be performed in real time between CODA mock-ups and the platform. As mitigation measures:
    - an HMI to gather controller's control actions has been developed and will feed the task prediction mock-up.
    - CODA system HMI will be presented in a separate screen to the controller and the simulated AI.

Despite these limitations, ESCAPE Light remains a valuable tool for validation exercises, providing essential trace data for post-processing and supporting human factors research within the CODA project.

5.2 Simulation Constraints

The current version of the ESCAPE Light simulation environment has specific constraints regarding working positions and scenario duration:

- **Limited Positions:** Only two pseudo-pilot positions and two controller working positions (CWPs) are currently available. Expanding the number of positions would require additional hardware.

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- **Scenario Duration Limit:** Long-duration simulations are limited. While exercises up to 90 minutes run without issues, continuous simulations lasting hours are not possible without stopping and relaunching the simulation.

These constraints, while limiting for large-scale validations, can be addressed through hardware upgrades or scenario design adjustments, ensuring the platform remains suitable for CODA project objectives.

Other simulation limitations identified are:

- **Complexity of the adaptation strategy selection**: to demonstrate the benefits of the CODA system an initial simplified algorithm will be used to select when to launch the automation.

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6 Conclusions

The final validation platform for the CODA project, built around the ESCAPE Light simulation environment, provides essential capabilities for supporting human factors research and validating air traffic management scenarios. Through its core components—IPAS Position, Ground Server, Controller Working Positions (CWPs), and Pseudo-pilot Positions—the platform enables comprehensive simulation exercises from scenario preparation to post-simulation analysis.

The platform's ability to generate high-fidelity trace data is vital for post-processing, supporting the development of models that analyse controller workload, traffic management performance, and human factors indicators. Despite its technical limitations, such as differences from real-world operational interfaces, limited working positions, and scenario duration constraints, the platform remains a powerful tool for research and validation.

Different mock-ups have been developed within CODA and will be used in the execution of the exercise. Some simplifications have been performed, and more complex connections and developments could be expected in higher TR levels.

In conclusion, the ESCAPE Light-based platform and the developed mock-ups effectively supports the CODA project's objectives by enabling realistic simulations and producing valuable data for human factors analysis. Its contributions align with SESAR's goals of enhancing air traffic management through data-driven insights, reinforcing the importance of simulation in advancing operational safety and efficiency.

7 References

7.1 Applicable documents

This concept outline complies with the requirements set out in the following documents:

Project and programme management

[1] 101114765 CODA Grant Agreement, 17/05/2023

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

7.2 Reference documents

[3] Angela Nuic, D. P. (2010). BADA: An advanced aircraft performance model for present and future ATM systems. INTERNATIONAL JOURNAL OF ADAPTIVE CONTROL AND SIGNAL PROCESSING, 1.

[4] CRIDA, Medina González, J., & Vaquero Ramos, J. R. (2024). Manual ESCAPE Light.

[5] EUROCONTROL. (n.d.). Controller working position / human machine interface. Retrieved from https://www.eurocontrol.int/project/controller-working-position-human-machine-interface

[6] EUROCONTROL. (n.d.). EUROCONTROL simulation capabilities and platform for experimentation. Retrieved from scalable EUROCONTROL ATM real-time simulation platform supporting small- and large-scale simulations

[7] SESAR JOINT UNDERTAKING. (n.d.). About SESAR Discover SESAR. Retrieved from https://www.sesarju.eu/discover-sesar

[8] CODA D3.1 ATCO Task prediction model. Ed 02.00. 20 December 2024

[9] CODA D3.2 Cognitive prediction model. Ed 01.01. 07 November 2024

[10] CODA D4.1 Indexes description and integration with prediction model. Ed 01.00. 20 October 2024

[11] CODA D5.1 Adaptation and Human AI interaction strategy and teaming playbook. Ed 02.00. 04 February 2025

[12] CODA D6.1 CODA Exploratory research plan (ERP). Ed 02.00. 05 July 2024