EPISODE 3

Single European Sky Implementation support through Validation

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0 EXECUTIVE SUMMARY

Episode 3 is in charge of the initial validation of the operational concept as expressed by SESAR Task 2.2. The initial emphasis is to perform a system level assessment of the concept's ability to deliver the defined performance benefits in the 2020 timeframe. Episode 3 WP6.2 objective is to provide platform and tools on which to perform technical validation.

This document describes the architecture of the technical validation platform, integrating already developed components from ground and airborne systems. It provides the main system capabilities and the adaptation required to cover the technical validation requirements defined in Episode 3 WP6.3.

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1 INTRODUCTION

1.1 PURPOSE OF THE DOCUMENT

This document is produced as part of EP3 WP6.2.

Its purpose is to provide an overall description of these technology validation platform and tools, including listing their capabilities as regards the parts of the SESAR Operational Improvements and Enablers covered, as well as the functionalities needed to actually perform the validation and produce the expected assessments.

As technology validation activities were scheduled in two steps, referred to as "Initial scope" and "Extended scope", this document will include the descriptions related to these steps. An initial version, which will remain internal to the consortium, will describe capabilities related to the "Initial scope"

As per EP3 definition technical validation activities were scheduled in two steps:

- An initial step called "Initial scope" focuses on the Initial 4D concept and the two ASAS S&M manoeuvres that could be tested without requiring FMS modifications, nor the TR6 air traffic simulator use (thanks to the use of EPOPEE traffic generator), and using voice communications since datalink message were not available for that step;
- The final step called "Extended scope" further refines the Initial 4D concept, extends ASAS S&M to all three manoeuvres defined in the RFG ASPA OSED (which include FMS modifications), the use of CPDLC for the ASAS dialogs and the use of TR6 air traffic simulator and then takes a look at the integration of 4D and ASAS, focusing on the transition from one to the other and the impacts on the procedures and systems.

Issue 1 of this document focused on the platform and tools capabilities needed to carry out the "Initial scope" validation. It also gave initial ideas for the "Extended scope". This initial version was not formally made public and delivered to the EC. However, communication outside the consortium for information was possible on request.

This version of the document provides a complete view of the platform and tools capabilities needed to carry out the "Extended scope" validation.

1.2 INTENDED AUDIENCE

This document is to be used:

- As a communication material to the community, including the EP3 consortium and the EC;
- As a reference for technical validation teams to ensure major elements and capabilities of the platform and tools are properly shared and agreed.

Note: This document does not replace the detailed specifications of the platform and tools elements developed by each participating company, which remain internal to these companies.

1.3 DOCUMENT STRUCTURE

Section 2 focuses on the purpose of the platform and tools, providing an overall definition of technical validation, showing the links with technical validation activities in EP3 WP6.4.

Section 3 provides an overall description of the platform, focusing on the different constituting elements.

Section 4 presents the architecture and the capabilities of the validation platform.

Sections 5 and 6 detail which capabilities were modified or developed to support Initial 4D and ASPA S&M functions; respectively for “Initial scope” and “Extended scope”.

The capabilities are identified by a unique number and section 7 provides a traceability matrix between these capabilities and the validation requirements defined in document [1].

1.4 GLOSSARY OF TERMS

Term	Definition
ADS	Automatic Dependent Surveillance
ADS-B	Automatic Dependent Surveillance - Broadcast
ADS-C	Automatic Dependent Surveillance - Contract
AGCG	Air Ground Communication Generator
AGDLS	Air Ground Data Link Server
AIS	Aeronautical Information System
ATC	Air Traffic Control
ATSU	Air Traffic Service Unit
CFMU	Central Flow Management Unit
CPDLC	Controller/Pilot Data Link Communication
DCDU	Data Communication Display Unit
EIS	Electronic Instrument System
EP3	EPISODE 3
ETA	Estimated Time of Arrival
ETA_{max}	Latest ETA achievable at a specific waypoint
ETA_{min}	Earliest ETA achievable at a specific waypoint
FCU	Flight Control Unit
FDPS	Flight Data Processing
FG	Flight Guidance
FMS	Flight Management System
FIR	Flight Information Region
HMI	Human Machine Interface
IFPS	Initial Flight Plan Processing System
MCDU	Multi-purpose Control and Display Unit
MRTS	Multi Radar Tracking System (EUROCAT)
ND	Navigation Display
ODS	Operator Display System
PFD	Primary Flight Display
TBD	To Be Defined
TC	Traffic Computer
TGMS	Trajectory Guidance Management System
UIR	Upper Information Region

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Term	Definition
WP	Work Package
4D	Four Dimensional (LAT, LONG, ALT, TIME)

Table 1: Glossary

Refer also to document [3] for a comprehensive list of acronyms, and their definitions.

2 PURPOSE OF THE PLATFORM

The first objective of the platform is to support the technical validation planned in the EP3 WP6 (refer to document [2]):

- EP3 WP6.4.2 - Air Ground Initial 4D Management (for Initial and Extended scopes);
- EP3 WP6.4.3 - Spacing Performance Validation (for Initial and Extended scopes);
- EP3 WP6.4.4 - Integration of 4D and ASAS (for Extended scope only).

This platform is used to test the functional and performance characteristics of the various components of the air / ground system both individually and together as an integrated system. It will provide the necessary facilities to integrate the actual prototype avionic boxes or development versions, providing the necessary stimuli to exercise the component and the means to measure outputs.

Note: The platform will not address the protocol aspect of datalink between air and ground.

The second objective is, as anticipation to SESAR development phase, to validate the use of such an integrated platform for technical validation of air-ground functions.

3 OUTLINE VIEW OF THE PLATFORM

The platform is composed of several elements already developed (EPOPEE, FMS, EUROCAT…) but that need to be further modified/adapted for the purpose of the EP3 WP6 technical validation.

An outline view of the facility to support EP3 WP6 technical validation of 4D trajectory exchange and ASAS Spacing S&M is presented in the figure below.

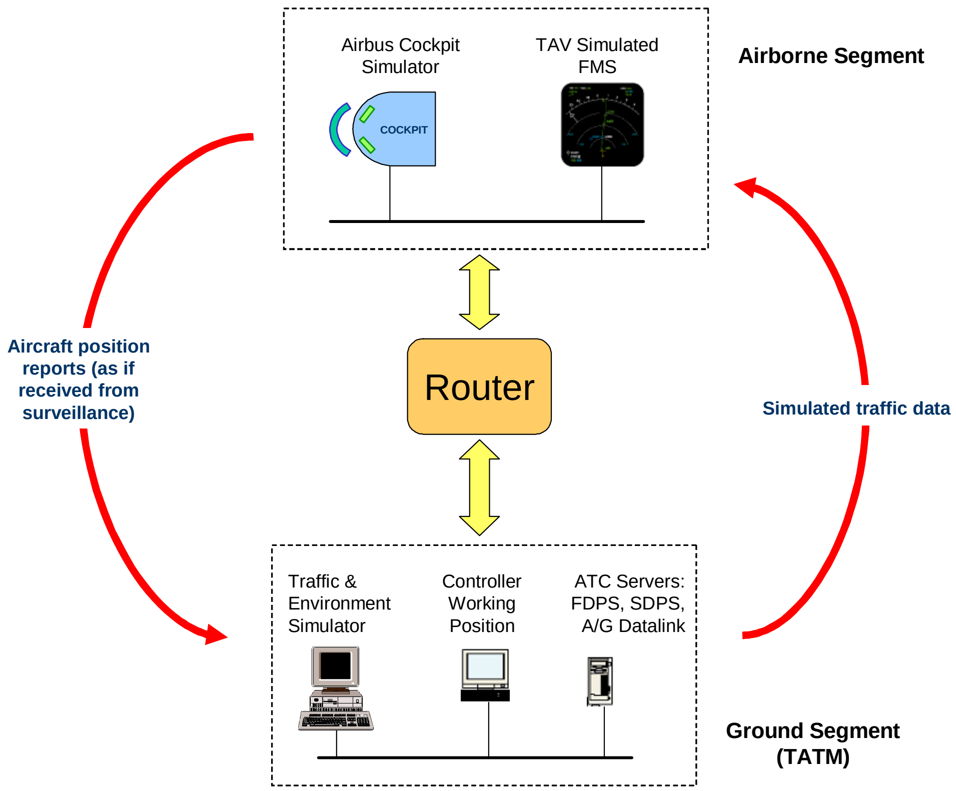

Figure 3-1 – Outline view of the4D trajectory exchange validation platform

This platform is composed of two segments:

- A ground segment, which hosts an industrial operational ATC system, on a compact hardware configuration. The baseline platform, provided by Thales Air Systems, includes the same ATC components as used in European operational ATC systems. This ground segment includes a EUROCAT-E platform including Controller Working Positions, providing operational Human Machine Interface to the system and a air traffic simulator. The main features of the ground segment in respect of the 4D trajectory exchange validation are:
  - o The Flight Data Processing (FDPS). This includes a state of the art Trajectory Predictor and an ATC Constraints Manager;
  - o Air Ground Data Link Server (AGDLS), handling data link communication with the airborne segment of the platform.
- An Airborne segment composed of a cockpit simulator provided by Airbus where FMS and ATSU sub-segments provided by THAV are integrated.

- o The ATSU sub segment is based on a simulated ATSU connected to a simulated FMS enabling aircraft data and trajectory downlink to the ground segment (simulating ADS-C[1]), and CPDLC[2] exchange between the ground and the cockpit via the airborne simulated DCDUs;
- o The FMS sub segment is based on a simulated FMS with appropriate simulated sensors, controls and displays. It contains the FMS functionalities necessary for pilot evaluation, with the advantage over a certified FMS that it can be readily adapted and modified for experimental purposes.

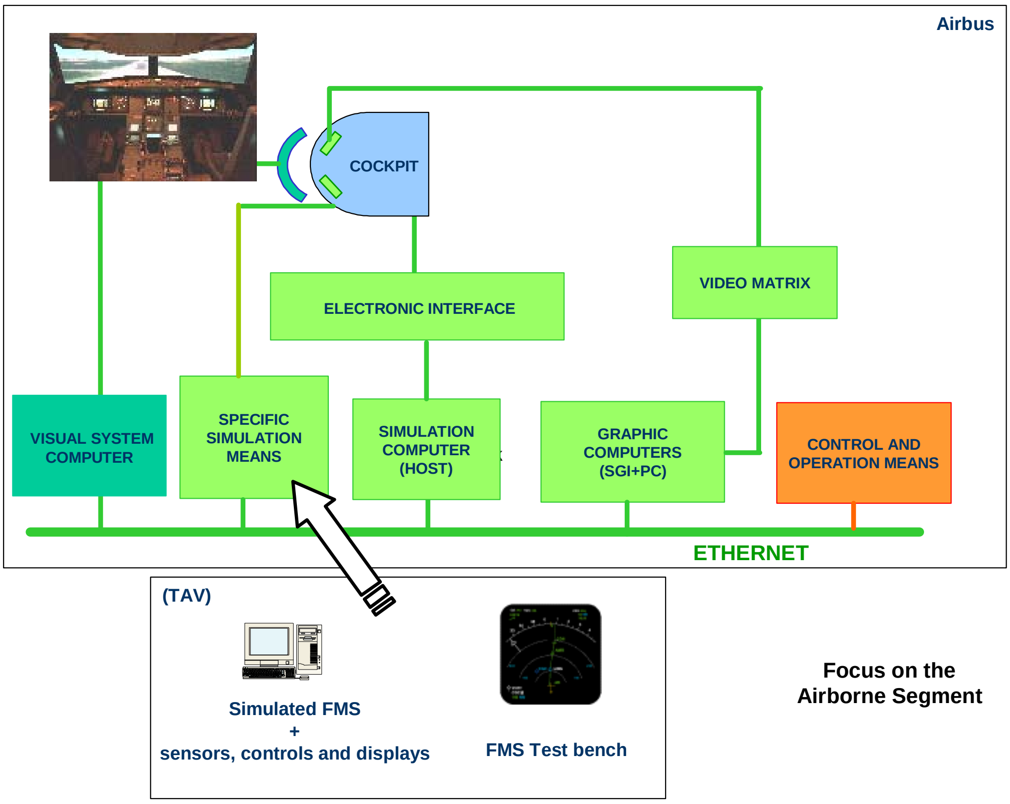

Figure 3-2. – Outline view of the airborne segment of the platform

[1] The 4D trajectory contains only a subset of ADS-C information required for the technical validation (for each point of the trajectory: lat/long; estimated level, estimated time). The transmission is performed using a specific format and is not representative of the ADS-C data flow.

[2] The CPDLC messages are exchanged between the EUROCAT-E and the simulated ATSU in FANS 1/A ED-100A (ref. document [4]) compatible format (for the new messages, not defined in FANS 1/A, free text messages are used). The AGCG, Thales Air Systems (TR6) CPDLC communication test tool, is added as a Gateway between the EUROCAT-E and the simulated ATSU. It allows:

- The EUROCAT-E to exchange CPDLC FANS 1/A message in exactly the same way as in an operational system;
- The simulated ATSU to interface with the EUROCAT-E without having to implement an airborne communication stack (the AGCG plus a PER library used by the simulated ATSU emulate this stack).

For both, the airborne and ground segments, facilities are provided for off-line data preparation (for setting the operational parameters of the validation exercises), supervision and data recording/observation of the experiment.

3.1 EPOPEE MULTI AIRCRAFT-TYPE SIMULATOR

Figure 3-3. – EPOPEE multi-aircraft types cockpit simulator

EPOPEE is a research simulator developed by AIRBUS for multi aircraft R&T activities (Single Aisle, Long Range, A380), which provides:

- A high fidelity aircraft simulation associated to high level of flexibility for evolutions;
- Fully simulated test means;
- Multi AIRBUS aircraft simulations;
- Flexible graphic workshop;
- Capability of integration (or coupling) of external models or simulations from partners or suppliers.

Main objectives of EPOPEE simulator are:

- Cockpit displays and system concepts evaluation with pilot in the loop;
- HMI evaluation in representative operational environment, cockpit operations, crew workload;
- Flight control laws concepts and handling qualities evaluation;
- Development and test platform for new models, simulations and architecture.

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Figure 3-4. – EPOPEE Exploitation Room

EPOPEE provides recording and exploitation capacity such as:

- Centralized monitoring tool (failure activation, data management…);
- Recording and visualisation of simulation data;
- Audio and video recording system.

For the purpose of the EP3 project, EPOPEE will be configured such as to be representative of an Airbus A340-600 with all needed system operative.

EPOPEE includes a Traffic Generator, which is an off-the-shelf software (MAXSIM), which receives the EPOPEE A/C position from the simulation and sends the generated traffic to the simulation. The generator can handle several, ADS-B and/or TCAS only A/C, which can fly or roll at the same time. This traffic is then computed by the TC model, which gives intruders information to all the systems.

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3.2 EUROCAT-E OVERVIEW

3.2.1 Introduction

EUROCAT is the Thales Air Systems product for civilian Air Traffic Control Centres.

It is suited for applications ranging from Approach to En-Route control in a variety of geographic environments, traffic densities and varying operational situations including control for oceanic airspace and high-density traffic areas.

In EPISODE-3, the European version of EUROCAT will be used. This version, **EUROCAT-E,** responds to EUROCONTROL / ECAC needs (ODS HMI, ARTAS tracker, full OLDI, FDP, etc.) More generally it is designed to accommodate the future evolutions towards the Single European Sky.

EUROCAT-E has been specifically designed to cope with:

- En-route traffic handled by an Area Control Centre (ACC) in charge of a Flight Information Region / Upper Information Region (FIR/UIR);
- Terminal Air traffic handled by an Approach Control Centre (APP) and attached Towers (APP/TWR) in charge of a Terminal Manoeuvring Area (TMA).

EUROCAT-E provides functional capabilities for the management of ATC services while:

- **Enhancing safety in the FIR/TMA** through the accurate monitoring of aircrafts positions and routes, short and medium term detection of potential collisions between two aircraft or between an aircraft and a hostile environment;
- **Increasing the flow of air traffic**, by satisfying planned traffic growth while reducing flight delays, thanks to the extensive automation of frequently used tasks and an ergonomic HMI offering fast, efficient access to information and on-line tools;
- **Reducing significantly the controller's workload** through automatic and silent inter-sector and inter-centre coordination thanks to the automatic acquisition and processing of flight plans and flight progress data;
- **Enhancing airspace management**, through real-time and dynamic reallocation of the sectors according to the analysis of the traffic load changes and through the dynamic management of the restricted areas and conditional routes;
- **Allows optimum staffing**, through a continuous and dynamic opening up / shutting down of a controller's positions according to the traffic load.

3.2.2 Functions

An operational EUROCAT-E integrates a number of functions that support the Air Traffic Management, mainly in European countries.

This section presents the main subset of these functions ("baseline functions") that are involved in the WP6 technical validation.

The evolutions of these baseline functions, developed to support the technical validation of the new concept elements studied in EPISODE-3 are described in §5 and 6.

3.2.2.1 Radar data processing

It presents an air traffic situation to the controllers and provides a base upon which flight data functions and ATC tools may be performed.

It has been broken down into two separate and parallel sub-functions:

- The main radar data processing that consists of multi-radar tracking (ARTAS);
- The fallback radar data processing which is used in the event of a main radar processing failure or of an operational LAN failure. This is the EUROCAT Multi Radar Tracking System (MRTS), using the most advanced techniques in this field.

The Radar Data Function integrates new technologies – Mode-S information is used within the tracking algorithms, and the function is foreseen to develop to become a Multi-Sensor Tracking System (taking into account other sensor data).

3.2.2.2 Flight data processing

The EUROCAT-E Flight Data Processing function provides Air Traffic Controllers with accurate and up-to-date flight information, in a timely fashion, for use in flight planning, co-ordination, and control. The processing enables silent co-ordination and transfer between sectors or between a sector and an external ATC neighbour unit in order to reduce the controller's workload.

The system is designed to operate essentially as a strip-less system.

The EUROCAT-E manages an interface with IFPS / CFMU, to act as a primary source of flight plans within the European context, and for the support of EUROCONTROL managed flow management.

The system manages the runway in use at known airports, allocates SIDs and STARs accordingly, and provides interfaces with external tower systems.

The Flight Data Processing function manages and allocates SSR Codes within the system airspace, and is ready to be developed for support of European centralised code management.

The EUROCAT-E has the ability to feed sub-systems with flight plan information, which is used for a variety of tasks (Arrival Management, Billing, Airport Ground Systems, etc.).

Note: the WP6 technical validation is based on scenarios involving only domestic flights. The inter-sector or inter-ATC units related functions (notification, coordination, transfer) will therefore not be used.

3.2.2.3 Coupling

A Coupling function (by SNMAP) provides an association between system tracks and flight plans, based on SSR codes, received Mode S data, and on the flight plan route data.

When the system wide coupling function (by SNMAP) is unavailable at current site level, the system maintains coupling and is capable of performing local manual coupling at CWP level.

3.2.2.4 Advanced safety Nets and ATC Tools

EUROCAT-E provides a complete set of Safety Nets and ATC Tools to improve the capacity and safety of the ATC centres:

Safety Nets	MONitoring Aids	Flight Plan Conflict Probe
Based on surveillance tracks. **STCA:** Short Term Conflict Alert **MSAW:** Minimum Safe Altitude Warning **APW:** Area Proximity Warning **DPM:** Departure Path Monitoring **APM:** Approach Path Monitoring	For coupled tracks, based on flight plan 4-D trajectory prediction. **RAM:** Route Adherence Monitoring **CLAM:** Cleared Level Adherence Monitoring **HAM:** Holding Adherence Monitoring **HVI:** Holding Volume Infringement	Based on flight plan 4-D trajectory prediction. **MTCD:** Medium Term Conflict Detection **SAP:** Segregated Area Probe

Table 1 – EUROCAT-E safety Nets and ATC Tools

3.2.2.5 Airspace Structure Management

The principle of Air Traffic Management is built around the allocation of responsibility of a portion of airspace (also called sector) to an ATC control team. Each sector is defined as a *volumic* sector with geographic and altitude borders.

Since various flows of aircraft may cross a *volumic* sector, (e.g. civil or military aircraft, aircraft about to land or having just taken-off, etc.), each *volumic* sector is allocated to one or more *functional* sectors (e.g. TMA, En-route or Military). A TMA *volumic* sector is often allocated to two functional sectors: one for Departure flights, one for Arrival flights.

The traffic related to a functional sector is allocated to a control team, using an *ATC suite*, which may group one or more functional sectors. This allocation is called *"sectorisation"* and is enabled by EUROCAT easy and flexible functions.

Each ATC suite is manned by one or more controllers, using ATC working positions.

This structure depends on the controllers' operational working methods and may be adapted to the traffic load. Basically, a functional sector may be composed of one Executive Controller position and one Support (also called "Planning") Controller position or of only one Executive Controller position.

The system is structured such that if a flight is forecast to be of interest to the controller, then she/he will be presented with the relevant information.

3.2.2.6 Operator Display System (ODS)

EUROCAT-E Human-Machine Interface provides all the tools required to enable Controllers to work in a fully electronic environment, making most of the control functions available via the Air Situation Display.

The definition of the EUROCAT-E HMI is based upon a set of general rules, which ensure the overall consistency of layout and interactions. Interaction through the HMI is intuitive.

All data to be presented to the operator is made available through windows, which are used for all operator inputs. The direct manipulation principle is systematically applied throughout the HMI, which enables the presented data to be minimised: the same screen area can be used for presenting, editing or entering data. The same data may appear in several windows at one time, making it available and accessible in several places simultaneously. Relevant information is directed to the appropriate controller's screen only.

Alerts are presented with a hierarchy of severity to focus the controller on relevant information. Audible alerts are available to support this prioritisation.

3.2.2.7 Aeronautical Information System

EUROCAT provides an integrated Aeronautical Information System (AIS).

The AIS receives and automatically processes aeronautical and weather data from different sources (AFTN, external AIS computer etc.) including NOTAM, METAR/SPECI, TAF, SIGMET, SNOWTAM and AIREP to be displayed to the Operators in textual, video, graphical, spreadsheet, and map formats (within ODS windows).

Data may also be entered from specific EUROCAT-E editorial positions.

All these messages and operational data are stored in a specific AIS database mostly managed by an AIS Operator. Some of this data is used for internal EUROCAT-E processing.

3.2.2.8 Air-Ground Data Link function

The Air-Ground Data Link function supports the establishment and management of communication with all **FANS-1** or **FANS-A** equipped aircrafts via data link.

Its operational benefit is to reduce the controller's workload ensuring clear and unambiguous communication with the pilot.

It provides the following data link operational services:

- Services based on the ARINC 623 Air Traffic Service applications over ACARS (e.g. Departure clearance (DCL) service);
- Services based on the ARINC 622 Air Traffic Service applications (in FANS over ACARS):
    - Context Management (CM) application which provides the Data Link Initiation Capability (DLIC) service;
    - Controller Pilot Data Link Communication (CPDLC) application (e.g. ATC Clearances Messages (ACL) service).

The CPDLC is integrated into the EUROCAT HMI.

3.2.2.9 Support Functions

EUROCAT system is provided with complete support functions, such as:

- System Monitoring and Control;
- Recording and Playback;
- Environmental Data and System Parameter Management;
- Data Analysis Facility;
- Traces Logger function;
- Software Management and System Configuration.

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4 PLATFORM ARCHITECTURE

The following figure presents the global technology validation platform architecture.

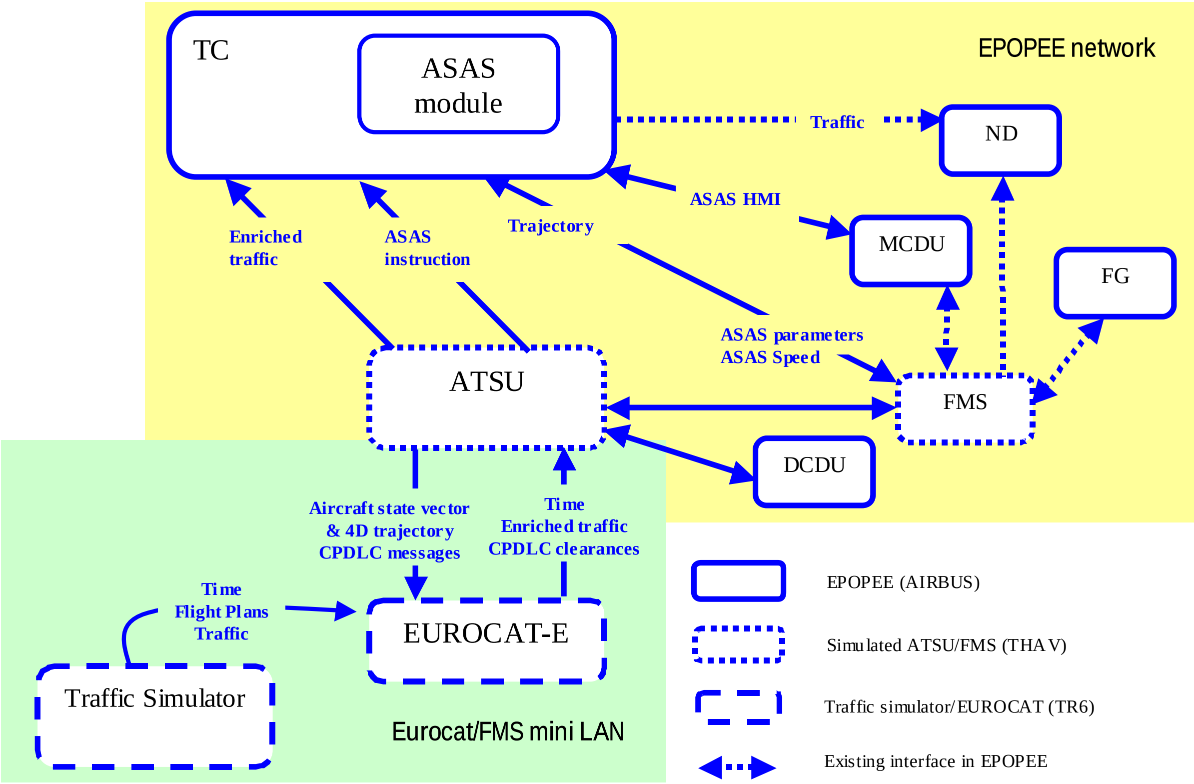

Figure 4-1. – Overall architecture of the Platform

The technology validation platform is made of:

- A ground ATC system, which represents an ATC centre (EUROCAT-E) with some adaptations for the integration with the airborne system;
- An airborne system, which includes:
    - o A simulated FMS, which allows the pilot to prepare the flight (through the MCDU FMS pages), informs the pilot on the flight situation (through the MCDU and the ND), optimises the flight trajectory, guides the aircraft along the flight trajectory thanks to a coupling with the FG, transmits the flight trajectory to other systems
    - o A simulated ATSU, which manages the interface with the ground system for data link;
    - o A TC, which manages the traffic
- A simulation environment comprising a cockpit simulator including visual called EPOPEE, which simulates an aircraft (AIRBUS A340-600), and an air traffic simulator capability connected to the ATC platform;

Ground system capabilities:

- C-EUR-000: The traffic received from the air traffic simulator is enriched and sent to the airborne system;

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- C-EUR-005: The simulated time is sent to the airborne system, using a specific format;
- C-EUR-010: The position, state vector and planned 4D trajectory of the simulated aircraft are received from the airborne system and can be displayed to the controller;
- C-EUR-015: CPDLC Connexion and messages can be exchanged with the airborne system, provided a logon procedure has been completed successfully previously.

Simulated ATSU capabilities:

- C-ATSU-001: The simulated ATSU allows down-linking to the ground system the position, state vector and planned 4D trajectory of the simulated aircraft received from the simulated FMS
- C-ATSU-002: A CPDLC connexion with ground system can be established;
- C-ATSU-003: CPDLC messages received from the ground system are displayed on the DCDU;
- C-ATSU-004: The pilot can answer a CPDLC message with a WILCO, UNABLE or STANDBY, and send the answer to the ground system;

Simulated FMS capabilities:

- C-FMS-001: The simulated FMS provides a realistic FMS behaviour representative of the state-of-the-art;
- C-FMS-002: The simulated FMS sends the position and state vector of the simulated aircraft to the simulated ATSU;
- C-FMS-003: The simulated FMS sends the flight trajectory to the simulated ATSU;

Simulated TC capabilities:

- C-TC-001: The TC receives the traffic information and forwards the useful information to the rest of the simulation. It includes several functions: Filtering (type, range, etc.), ADS-B, TCAS, Traffic selection and display;
- C-TC-002: The ASAS module implements the control law associated with the ASAS spacing. It includes the guidance algorithm for the acquisition and maintaining of the spacing between two aircraft.

Simulation environment capabilities:

- C-SIM-001: The air traffic simulator allows preparing exercises from an ATC view point corresponding to predefined scenarios;
- C-SIM-002: The air traffic simulator allows running an exercise at a time chosen by the ATC operator.
- C-SIM-003: The air traffic simulator provides simulated traffic to the ground system and manages a simulated time, which enables the synchronisation with the ground system.
- C-SIM-004: The cockpit simulator provides a realistic environment to the pilot;
- C-SIM-005: The cockpit simulator provides recording facilities;
- C-SIM-006: The enriched traffic received from the ground system is sent to the Traffic Computer with an update rate of 1s, using a specific format;
- C-SIM-007: The simulated time received from the ground system is sent to the simulated FMS and to other sub-systems on EPOPEE network for time synchronisation purpose;

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- C-SIM-008: The control message generated by EPOPEE to initialize, start and stop the simulated aircraft is transmitted to the ground system to control the simulated traffic scenario.
- C-SIM-009: The platform allows the pilot to request from the FMS an upload of winds and temperatures, simulating an AOC datalink for meteo data (uploaded winds and temperatures are defined in a text file).
- C-SIM-010: A performance evaluation tool allows running several batches of scenarios and collecting statistical results, making vary some environmental input parameters. It uses the same simulated FMS as the one integrated in the technical validation platform with a representative aircraft model.

In addition to the functional evolutions of the existing elements, one major activity in the scope of EPISODE3 is to integrate these elements into a single technical validation platform. This activity includes the definition of the interfaces between these elements.

The following figure presents the physical architecture of the technology validation platform.

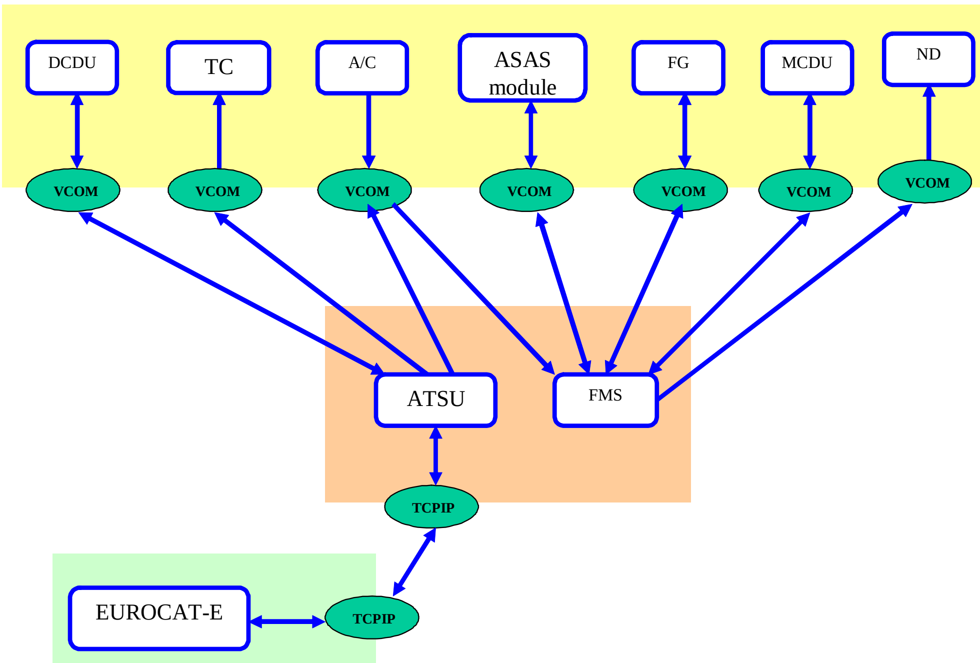

Figure 4-2. – Physical architecture of the Platform

The following table gives a synthesis of exchanged messages:

Producer	Customer	Description	Protocol	Format
A/C	FMS	Status of the simulation	VCOM	XML file
A/C	FMS	Data from EPOPEE A/C simulation to FMS	VCOM	XML file
MCDU	FMS	MCDU action	VCOM	XML file
FMS	MCDU	MCDU display	VCOM	XML file
FG	FMS	Flight guidance information	VCOM	XML file
FMS	FG	Data from FMS to Flight Guidance	VCOM	XML file
FMS	ND	ND display	VCOM	XML file

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Producer	Customer	Description	Protocol	Format
ASAS Module	FMS	ASAS parameters	VCOM	XML file
ASAS Module	FMS	ASAS speed	VCOM	XML file
FMS	ASAS Module	Flight information for ASAS	VCOM	XML file
ATSU	A/C	Time message	VCOM	XML file
ATSU	DCDU	DCDU display	VCOM	XML file
DCDU	ATSU	DCDU action	VCOM	XML file
ATSU	TC	EUROCAT simulated traffic	VCOM	XML file
ATSU	TC	CPDLC ASAS instruction	VCOM	XML file
ATSU	EUROCAT	Control message (start, stop…)	UDP	XML file
ATSU	EUROCAT	A/C state vector and 4D trajectory	UDP	Asterix cat 62
ATSU	EUROCAT	CPDLC downlink message	TCP/IP	CPDLC
EUROCAT	ATSU	CPDLC uplink message	TCP/IP	CPDLC
EUROCAT	ATSU	Time message	TCP/IP	Specific
EUROCAT	ATSU	Simulated traffic	UDP	Asterix cat 62

Table 2 – Synthesis of Exchanged Message

5 PLATFORM CAPABILITIES FOR INITIAL SCOPE

The technology validation platform gives the capability to run, as a first step, the "initial scope" validation scenarios defined in EP3 WP 6.4.2 and WP6.4.3 (manoeuvres 1 and 2 only), in particular:

- To downlink 4D trajectory from airborne to ground system periodically and on predefined events;
- To use this downlink 4D trajectory in the ground system to improve the ground-based trajectory prediction;
- To apply ATC constraint modifying the reference trajectory (PTC 2D, CTA);
- To define an ASAS S&M procedure, including the two manoeuvres "Remain behind", "Merge then Remain" that allow acquiring and maintaining spacing in en route, descent and approach.

5.1 Scenario Definition

A scenario is supported by a context (country, airport, procedures, etc.) and one or several exercises.

The context implies the definitions of data set in the traffic simulator, EUROCAT-E and EPOPEE. As far as possible, existing data set should be used.

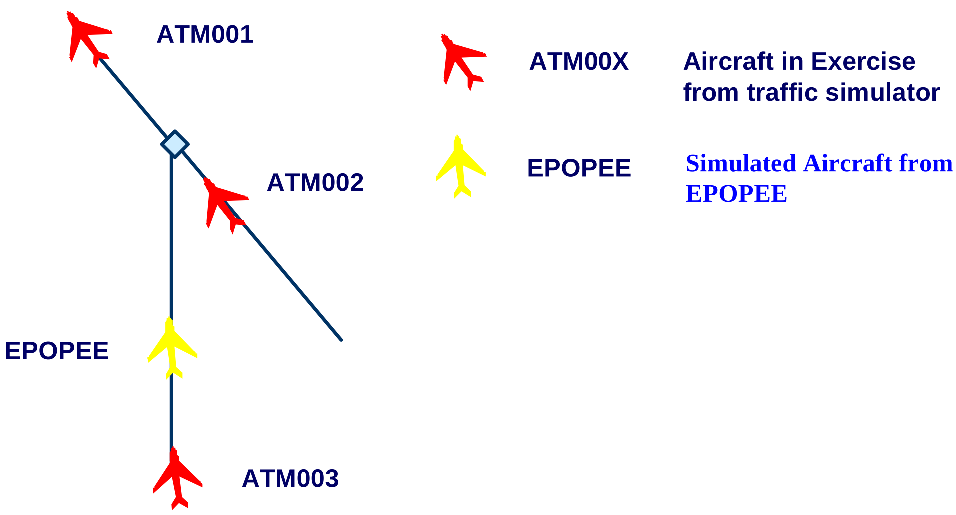

Figure 5-1. – Scenario initial situation

One key issue will be the synchronisation of the ground system and the airborne system so that the simulated aircraft could be inserted in the exercise at a given time of the exercise and at a predefined position and then ground air airborne system running under the same time reference. For the initial scope, this synchronisation is performed manually by starting at the same moment the EPOPEE aircraft and the traffic simulator.

N.B.: For ASAS simulation, the scenarios were run without EUROCAT and Thales simulated FMS thus, no integration of these two components was done for Initial scope.

5.2 SYSTEM CAPABILITIES FOR INITIAL 4D

This paragraph details the evolutions of platform capabilities linked to the initial 4D function.

5.2.1 EUROCAT

The capabilities correspond to the following elements of "**Initial 4D**":

- C-EUR-120: The ground system allows receiving and processing the down linked **4D Trajectory** (periodically and on specific events), in order to improve the Ground-based predicted trajectory;
- C-EUR-121: Following trajectory negotiation and agreement, the ground system shall perform a minimum conformance check consisting in verifying that the final points in the subsequent downlinked airborne 4D trajectories are identical to those in its flight plan;
- C-EUR-122: If the ground system detects that the airborne 4D Trajectory does not conform with its flight plan (using the minimum conformance check), it shall reject it;
- C-EUR-125: The ground system allows requesting a Time Information (ETA_{min} - ETA_{max} interval) for a given waypoint to the aircraft;
- C-EUR-130: The ground system allows receiving and processing an ETA_{min} - ETA_{max} interval (answer to CPDLC free-text message), transmitted by the aircraft;
- C-EUR-135: The ground system allows displaying, for a given point, the Estimated Time Over (Traffic Management Lists - TML);
- C-EUR-137: The ground system allows the Controller to:
    - o Graphically modify the future route of the aircraft (displayed by a dedicated colour);
    - o Probe it to assess potential conflicts with other aircraft; and
    - o Update it if the Controller decides to implement the modifications;
- C-EUR-140: The ground system allows up-linking a CTA to the aircraft via CPDLC, using messages UM#51+UM169[3];
- C-EUR-145: The ground system allows up-linking the **PTC-2D** CPDLC message to the aircraft, with or without CTA, using one or several messages among UM#79, UM#80, UM#83 [4] ;

Note: Since the resolution of the time information in UM#51 is limited to 1min resolution, they are complemented by a UM#169 free text message providing the seconds of the CTA.

- C-EUR-150: The ground system shall provide the controller with the display of the uplinked CPDLC messages and downlinked received responses in a window, allowing visualizing the messages in a per dialogue basis;

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[3] UM#51 = CROSS [position] AT [time] with time having 1s resolution (seconds sent via UM169)

[4] UM#79 = CLEARED TO [position] VIA [routeClearance]

UM#80 = CLEARED [routeClearance]

UM#83 = AT [position] CLEARED [routeClearance]

- C-EUR-155: When receiving the downlink “WILCO” CPDLC message in acceptation of an uplink clearance, the ground system shall modify automatically the flight plan route according to the clearance.
- C-EUR-160: When receiving the downlink “UNABLE” CPDLC message in response to an uplink clearance, the ground system:
    - Shall display an alert on the corresponding track label indicating the UNABLE response;
    - Shall not change the Flight Plan route;
- C-EUR-165: The ground system shall provide the controller with a capability to visualise all CPDLC dialogs, closed and in progress

5.2.2 Simulated ATSU

The capabilities correspond to the following elements of "**Initial 4D**":

- C-ATSU-101: The simulated ATSU allows down-linking to the ground system the planned 4D trajectory of the simulated aircraft received from the simulated FMS, according to a pre-defined ADS-C contract[5];
- C-ATSU-102: The simulated ATSU allows receiving and processing a Time Information (ETA_{min} - ETA_{max} interval) request for a given waypoint transmitted by the EUROCAT.
    - The request is received through a free text CPDLC message, which is not displayed to the pilot;
    - The simulated ATSU requests to the simulated FMS the ETA / ETA_{min} / ETA_{max} for the waypoint contained in the CPDLC message;
    - ETA / ETA_{min} / ETA_{max} as received from the simulated FMS are sent to the EUROCAT, using a free text CPDLC message which is not presented to the flight crew;
- C-ATSU-103 The simulated ATSU allows the pilot to interact with the DCDU so as to load the content of some up-linked CPDLC messages (UM#51+UM169, UM#79, UM#80, and UM#83) into the simulated FMS, which can then display the new constraints on the MCDU FMS pages.

5.2.3 Simulated FMS

The capabilities correspond to the following elements of "**Initial 4D**":

- C-FMS-101: The simulated FMS computes ETA_{min} - ETA_{max} interval for a given waypoint;
- C-FMS-102: The simulated FMS allows receiving CPDLC messages from the simulated ATSU when pilot’s actions ask for that information to be loaded in the FMS;
- C-FMS-103: The simulated FMS allows flying a RTA in compliance with Initial 4D performance requirement

[5] The ADS-C contract is not received from the ground system but is defined in a configuration file. It includes a periodic contract and event contracts (Extended projected profile change - waypoint change, level change and Time change only).

6 PLATFORM CAPABILITIES FOR EXTENDED SCOPE

The technology validation platform for extended scope will give the capability to run the "extended scope" validation scenarios defined in WP 6.4.2, WP 6.4.3 and WP 6.4.4. In addition to the capabilities described for the initial scope, the platform allows:

- EUROCAT to send a whole Route clearance including final approach (STAR + VIA + Final Approach + Runway). Depending on the STAR and the RUNWAY selected by the Controller, EUROCAT will determine the VIA and the Final Approach.
- To define an ASAS S&M procedure, including the manoeuvre 'vector then merge".

6.1 Scenario Definition

For the ASAS simulation, the extended scope covers the collaboration between the controller and the pilot to achieve the ASAS manoeuvre. Therefore, the exercises run for the validation scenarios require a consistent simulated surrounding traffic both on ground and in the aircraft.

The solution retained for the validation platform is to send the simulated traffic from the ground traffic simulator to the Traffic Computer (capability C-SIM-006).

The ASAS function relies on relative spacing between aircraft. Therefore it is essential that EPOPEE aircraft and simulated traffic are synchronized. It means that ground and airborne systems share the same time reference (capability C-SIM-007) and that both EPOPEE aircraft and simulated traffic are started at the same moment by a single control command (capability C-SIM-008).

6.2 System capabilities for initial 4D

This paragraph details additional evolutions of platform capabilities linked to the initial 4D function.

6.2.1 EUROCAT

The additional capability for the extended scope is:

Transmission of a whole Route clearance including final approach (STAR + VIA + Final Approach + Runway) (capability C-EUR-200). Depending on the STAR and the RUNWAY selected by the Controller, EUROCAT will automatically determine the VIA and the Final Approach (capability C-EUR-205).

This will be applicable to all messages encompassing a route clearance.

6.2.2 Simulated ATSU

No additional capability for extended scope.

6.2.3 Simulated FMS

No additional capability for extended scope.

6.3 System capabilities for ASAS Sequencing and Merging

This paragraph details the evolutions of platform capabilities linked to the ASAS Sequencing and Merging function.

6.3.1 EUROCAT

- C-EUR-250: Graphical HMI enabling the Controller to locally elaborate and validate an ASAS S&M instruction;
- C-EUR-255: Graphical HMI enabling the Controller to monitor an ASAS S&M procedure;
- C-EUR-260: HMI enabling the Controller to cancel an ASAS S&M procedure;
- C-EUR-265: Graphic HMI enabling to designate the instructed aircraft;
- C-EUR-270: Graphic set up of a link between the instructed and target aircraft;
- C-EUR-275: Setting up of a trail of several aircraft;
- C-EUR-280: Verification of the eligibility;
- C-EUR-285: Display sharing;
- C-EUR-290: Transmission of the "IDENTIFYING" instruction;
- C-EUR-295: Reception of the confirmation of the "IDENTIFYING" instruction;
- C-EUR-297: Transmission of the ASAS SM instruction.

6.3.2 Simulated ATSU

The capabilities correspond to the following elements of "**ASAS Sequencing and Merging**":

- C-ATSU-201: The simulated ATSU allows the pilot to interact with the DCDU so as to load the content of up-linked CPDLC ASAS instruction in the Traffic Computer, which can then display the instruction on the MCDU TRAFFIC page;

6.3.3 Simulated FMS

The capabilities correspond to the following elements of "**ASAS Sequencing and Merging**":

- C-FMS-201: When an ASAS manoeuvre selection is received from the TC, the simulated FMS sends flight information to the TC (including trajectory, distance to merge point, merge point sequencing);
- C-FMS-202: The simulated FMS receives the ASAS S&M instruction parameters from the ASAS module. If the instruction is “vector then merge”, these parameters are used by the FMS to update the flight trajectory according to the ASAS S&M instruction. The new trajectory is stored in a temporary flight plan;
- C-FMS-203: When an ASAS manoeuvre activation is received from the TC, If the instruction is “vector then merge”, the simulated FMS inserts the temporary flight plan in the active flight plan (the new trajectory is then down-linked to the ground system);
- C-FMS-204: When an ASAS manoeuvre activation is received from the TC, the simulated FMS sends the ASAS speed received from the TC to the FG.

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7 TRACEABILITY TO VALIDATION REQUIREMENTS

This paragraph provides a traceability matrix between validation platform capabilities and validation requirements specified in document [1].

Capability Id	Capability title	Requirement Id
C-ATSU-001	Downlink state vector and 4D trajectory	E3-AIR-4D-TRAJ-1
C-ATSU-002	Establish a CPDLC connexion	E3-AIR-4D-TRAJ-13
C-ATSU-003	Receive and display CPDLC message	E3-AIR-4D-TRAJ-3
C-ATSU-004	Answer to CPDLC message	E3-AIR-4D-TRAJ-4
C-ATSU-004	Answer to CPDLC message	E3-AIR-ASAS_SM-11
C-ATSU-101	Downlink 4D trajectory using an ADS-C contract	E3-AIR-4D-TRAJ-2
C-ATSU-102	Answer to ETAmin - ETAmax information request	E3-AIR-4D-TRAJ-15
C-ATSU-102	Answer to ETAmin - ETAmax information request	E3-AIR-4D-TRAJ-6
C-ATSU-102	Answer to ETAmin - ETAmax information request	E3-AIR-4D-TRAJ-7
C-ATSU-103	Load CPDLC message in FMS	E3-AIR-4D-TRAJ-5
C-ATSU-201	Load ASAS CPDLC message in TC	E3-AIR-ASAS_SM-9
C-EUR-000	Forward and enrich traffic received from air traffic simulator to airborne system	E3-GND-PSA-3
C-EUR-005	Transmission of the simulated time to the airborne system	E3-SYS-TEST–1
C-EUR-010	Reception and display of the position and trajectory of the simulated aircraft	E3-GND-4D-TRAJ-1
C-EUR-010	Reception and display of the position and trajectory of the simulated aircraft	E3-GND-4D-TRAJ-5
C-EUR-010	Reception and display of the position and trajectory of the simulated aircraft	E3-GND-4D-TRAJ-7
C-EUR-015	Exchange of CPDLC messages between air and ground	E3-GND-RBT-1
C-EUR-120	Receiving and processing the downlinked 4D Trajectory	E3-GND-4D-TRAJ-1
C-EUR-120	Receiving and processing the downlinked 4D Trajectory	E3-GND-4D-TRAJ-4
C-EUR-121	Conformance monitoring of the final points of Airborne 4D trajectory	E3-GND-4D-TRAJ-2
C-EUR-122	Acceptance of the Airborne 4D trajectory	E3-GND-4D-TRAJ-3
C-EUR-125	Requesting a Time Information (ETAmin - ETAmax interval) for a given waypoint	E3-GND-RBT-4
C-EUR-130	Receiving and processing an ETAmin / ETAmax interval	E3-GND-RBT-5
C-EUR-135	Displaying, for a given point, the Estimated Time Over (Traffic Management Lists - TML)	
C-EUR-137	Probing potential route changes	E3-GND-4D-TRAJ-6
C-EUR-140	Up-linking a CTA to the aircraft via CPDLC	E3-GND-RBT-6
C-EUR-140	Up-linking a CTA to the aircraft via CPDLC	E3-GND-RBT-7

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Capability Id	Capability title	Requirement Id
C-EUR-145	Up-linking the PTC-2D CPDLC message to the aircraft, with or without CTA, using one or several messages among UM#79, UM#80, UM#83	E3-GND-RBT-7
C-EUR-150	Display of uplinked and downlinked CPDLC message	E3-GND-RBT-8
C-EUR-155	Receipt of WILCO Downlinked CPDLC message	E3-GND-RBT-9
C-EUR-160	Receipt of UNABLE Downlink CPDLC message	E3-GND-RBT-10
C-EUR-165	CPDLC messages display	E3-GND-RBT-11
C-EUR-200	Transmission of a whole Route clearance including final approach	E3-GND-RBT-3
C-EUR-205	Automatic Selection of the VIA and the Final Approach to be sent in the Route clearance	E3-GND-RBT-2
C-EUR-250	Graphical HMI enabling the ATCo to locally elaborate and validate an ASAS S&M instruction	E3-GND-ASAS_SM-1
C-EUR-255	Graphical HMI enabling the ATCo to monitor an ASAS S&M procedure	E3-GND-ASAS_SM-2
C-EUR-260	HMI enabling the ATCo to cancel an ASAS S&M procedure	E3-GND-ASAS_SM-3
C-EUR-265	Graphic HMI enabling to designate the instructed aircraft	E3-GND-ASAS_SM-4
C-EUR-270	ASAS SM procedure: graphic set up of a link between the instructed and target aircraft	E3-GND-ASAS_SM-5
C-EUR-275	ASAS SM procedure: setting up of a trail of several aircraft	E3-GND-ASAS_SM-6
C-EUR-280	Verification of the eligibility of the aircraft to be involved in an ASAS S&M procedure	E3-GND-ASAS_SM-7
C-EUR-285	Display sharing	E3-GND-ASAS_SM-8
C-EUR-290	Transmission of the "IDENTIFYING" instruction	E3-GND-ASAS_SM-9
C-EUR-295	Reception of the confirmation of the "IDENTIFYING" instruction	E3-GND-ASAS_SM-10
C-EUR-297	Transmission of the ASAS SM instruction	E3-GND-ASAS_SM-11
C-FMS-001	Realistic FMS	E3-AIR-PRE–1
C-FMS-001	Realistic FMS	E3-AIR-PRE–2
C-FMS-001	Realistic FMS	E3-AIR-PRE–3
C-FMS-002	Send position and state vector	E3-AIR-PRE-4
C-FMS-003	Send flight trajectory to ATSU	E3-AIR-4D-TRAJ-1
C-FMS-101	Compute ETA_{min} - ETA_{max}	E3-AIR-4D-TRAJ-6
C-FMS-102	Process loaded CPDLC message	E3-AIR-4D-TRAJ-5
C-FMS-103	Achieve RTA function	E3-AIR-4D-TRAJ-10
C-FMS-103	Achieve RTA function	E3-AIR-4D-TRAJ-11
C-FMS-103	Achieve RTA function	E3-AIR-4D-TRAJ-12
C-FMS-103	Achieve RTA function	E3-AIR-4D-TRAJ-8
C-FMS-103	Achieve RTA function	E3-AIR-4D-TRAJ-9
C-FMS-201	Send flight information to TC	E3-AIR-ASAS_SM-2

Capability Id	Capability title	Requirement Id
C-FMS-202	Build a trajectory for “vector then merge” ASAS instruction	E3-AIR-ASAS_SM-3
C-FMS-203	Activate the trajectory for “vector then merge” ASAS instruction	E3-AIR-ASAS_SM-4
C-FMS-203	Activate the trajectory for “vector then merge” ASAS instruction	E3-AIR-ASAS_SM-5
C-FMS-204	Send ASAS speed to FG	E3-AIR-ASAS_SM-10
C-SIM-001	Preparation of exercises using ATG-X	E3-GND-PSA-3
C-SIM-002	Running exercises using ATG-X	E3-GND-PSA-3
C-SIM-003	Provision of simulated traffic and time by ATG-X	E3-GND-PSA-3
C-SIM-004	High fidelity aircraft simulation	E3-AIR-TEST–1
C-SIM-005	Airborne Data Recording	E3- AIR-TEST–4
C-SIM-006	Send simulated traffic to TC	E3-AIR-TEST–2
C-SIM-007	Synchronize time reference	E3-SYS-TEST–1
C-SIM-008	Centralize simulation control	E3-SYS-TEST–2
C-SIM-009	Simulated an AOC datalink for meteo data	E3-AIR-TEST–3
C-SIM-010	Batch mode	E3- AIR-TEST–5
C-SIM-010	Batch mode	E3- AIR-TEST–6
C-SIM-010	Batch mode	E3- AIR-TEST–7
C-SIM-010	Batch mode	E3- AIR-TEST–8
C-SIM-010	Batch mode	E3- AIR-TEST–9
C-TC-001	Traffic information management	E3-AIR-ASAS_SM-2
C-TC-002	ASAS module	E3-AIR-ASAS_SM-1
C-TC-002	ASAS module	E3-AIR-ASAS_SM-6
C-TC-002	ASAS module	E3-AIR-ASAS_SM-7
C-TC-002	ASAS module	E3-AIR-ASAS_SM-8
C-TC-002	ASAS module	E3-AIR-ASAS_SM-9

Table 3 – Traceability matrix

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8 REFERENCE AND APPLICABLE DOCUMENTS

[1] **Episode 3** **D6.3-01 -** Requirements for technical validation (Extended Scope)

[2] **Episode 3** **D6.4-01** - Technical validation scenarios

[3] **Episode 3** **D2.2-039** - Glossary of Terms and Definitions (Lexicon)

[4] **EUROCAE** **ED-100A** - Interoperability requirements for ATS applications using ARINC 622 data communications (FANS 1/A INTEROP Standard), April 2005

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END OF DOCUMENT