



Episode 3
D6.3-01 - Requirements for technical validation

Version: 1.00

EPISODE 3

Single European Sky Implementation support through Validation



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EXECUTIVE SUMMARY

From the very beginning of the Episode 3 life cycle, the need has been identified to reconcile the understanding of the technical experts on the technical problematic behind the SESAR concept and the need for technical validation to support the operational validation activities performed in Episode 3.

Workshops and collaborative remote working sessions have therefore been organized in order to identify the technical validation needs together with their operational consistency. This document aims at identifying, organizing and synthesising them, such that it could be used as the fundamental input for the requirements validation and traceability process.

The Episode 3 WP6 scope being primarily devoted to the technical validation of Airborne and Ground Enablers, this document focuses on both air and ground identified functional specifications for 4D Trajectory Exchange and ASAS Sequencing and Merging.

The described airborne functional architecture is normally scoped towards civilian carrier, most probably also valid for some military ones (e.g. the A400M), involved in the negotiation process of 4D business trajectory (i.e. requiring amongst others Flight Management System (FMS) equipment capable of Required Time of Arrival (RTA) negotiation processing).

Other Mission Trajectory negotiation exchanges will most probably require different level of functionalities, for sure not covered by the current WP6 activities.

As soon as Operational Air Traffic (OAT) could be considered as General Air Traffic (GAT) and associated Business Trajectory could be agreed by air and ground, current Initial 4D and ASAS S&M concepts could be applied. The handling of more sophisticated Mission Trajectory is also not covered by current WP6 activities.



1 INTRODUCTION

1.1 PURPOSE OF THE DOCUMENT

This document is produced as part of WP6.3 of Episode 3, which objective is to define the validation strategy applicable to technical validation.

Its purpose is:

- To set up the perimeter of the technical validation (e.g. ATM capability level 2 limited to Initial 4D and ASAS Sequencing and Merging);
- To derive validation requirements (what to validate? how? and where) including the criteria for success.

Technical validation activities have been scheduled in two steps:

- An initial step called "Initial scope" focuses on the Initial 4D concept and the two ASAS S&M manoeuvres that are neither requiring FMS modifications, nor the TR6 air traffic simulator use;
- 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 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.

This document addresses the validation strategy for the "Extended scope". However reference to "Initial scope" is kept for traceability purposes. This version will be formally made public and delivered to the EC.

1.2 INTENDED AUDIENCE

This document is to be used:

- As a project deliverable to the community, including the EP3 consortium and the European Commission;
- As a reference for technical validation teams to ensure major strategic elements are properly shared and agreed.

1.3 DOCUMENT STRUCTURE

Section 2 sets up the perimeter of the technical validation. It starts from the CTA and ASAS Sequencing and Merging ATM concepts addressed in the prototyping sessions of EP3 WP5 (refer to [3]). It analyses the Enablers, OI Steps and Procedures linked to these concepts, which define the scope of the technical validation. Therefore, the R&D needs identified by SESAR for these OI steps are analysed to build the technical validation objectives. Then, the validation strategy to reach these objectives is elaborated. A high-level impact analysis is carried out to determine the major impact on existing ground and airborne systems.

Section 3 details the functional architecture and the functional requirements needed to reach the technical validation objectives. The requirements are relative to both tested products (ground system, airborne systems, communications) and test means (simulated traffic, recording, models...). Each time a requirement is based on an assumption, it is identified. Then all the stated assumptions are summarized in section 3.3.

A unique number identifies the validation requirements. They are referenced in document [1] "**Episode 3** Overall description of the platform and its capabilities E3-WP6-D6.2-01-TEC 0.06, 25/09/2008 TRS T06/22316 TC Public Deliverable D6" to give traceability between



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platform evolutions and implemented validation requirements. They are also referenced in document [2] “**Episode 3** Technical validation scenarios E3-WP6-D6.4-01-TEC 0.09, 20/03/2009” to give traceability between validation scenarios and tested validation requirements.

1.4 BACKGROUND

This document forms part of the ongoing validation activities undertaken during the EP3 project. The EP3 project is an early-stage validation of the SESAR concept, and this particular task seeks to identify, on the basis of near-term industrial products evolution, requirements that could be validated within such technological validation scope as presented in the section 2 Perimeter of the technical validation.

1.5 GLOSSARY OF TERMS

Term	Definition
2D	Two Dimensional (LAT, LONG)
4D	Four Dimensional (LAT, LONG, ALT, TIME)
A/C	Aircraft
ADD	Aircraft Derived Data
ADS	Automatic Dependent Surveillance Programme
ADS-B	Automatic Dependent Surveillance-Broadcast
ADS-C	Automatic Dependent Surveillance-Contract
AMAN	Arrival MANagement
AOC	Airline Operational Communications
APR	Automatic Position Report
ASAS	Airborne Separation Assurance System
ASPA	Airborne SPacing Application
ASTERIX	All Purpose STRuctured EUROCONTROL SuRveillance Information EXchange
ATC	Air Traffic Control
ATM	Air Traffic Management
ATN	Aeronautical Telecommunication Network
ATSAW	Air Traffic Situational Awareness
ATSU	Air Traffic Service Unit
BTV	Brake To Vacate
CPDLC	Controller Pilot Data Link Communication
CDA	Continuous Descent Approach
CTA	Controlled Time of Arrival
CTO	Controlled Time Over
DCDU	Datalink Control and Display Unit
DODs	Detailed Operational Description Documents
E-OCVM	European Operational Concept Validation Methodology



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Term	Definition
EP3	Episode 3 project
ETA	Estimated Time of Arrival
ETAmx	Latest achievable ETA over a waypoint
ETAmIn	Earliest achievable ETA over a waypoint
ETR	Runway Entry Point
FANS	Future Air Navigation Systems
FCU	Flight Control Unit
FDP	Flight Data Processing
FMD	Flight Management Display
FMS	Flight Management System
F-PLN	FMS Flight Plan page
GAT	General Air Traffic
HMI	Human Machine Interface
LR	Long Range
MFD	FMS Multi-Function Display
MTCD	Medium Term Conflict Detection
ND	FMS Navigation Display
OAT	Operational Air Traffic (military flights)
ODS	Operator Display System
OI	Operational Improvement
OSED	Operational Service and Environment Description
PT	Predicted Trajectory
PTC	Precision Trajectory Clearance
RBT	Reference Business Trajectory
RFG	Requirement Focus Group
RNP	Required Navigation Performance
RTA	Required Time of Arrival
S&M	Sequencing and Merging
SA	Single Aisle
SAP	Segregated Airspace Probe
SESAR	Single European Sky ATM Research
SSR	Secondary Surveillance Radar
TBD	To Be Defined
TMA	Terminal Manoeuvring Area
TMR	Trajectory Management Requirement
TP	Trajectory Prediction
TR6	THALES Air Systems



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Term	Definition
TRL	Technology Readiness Level
UPR	User Preferred Route
VNAV	Vertical Navigation
WP	Work Package

Table 1 - Glossary of Terms



2 PERIMETER OF THE TECHNICAL VALIDATION

2.1 FOCUS OF TECHNICAL VALIDATION

Technical validation is defined as a set of activities leading to the:

- Demonstration of Industrial Feasibility:
 - Demonstration that industrial developments are ready to be launched and that any technical blocking point has been detected and solved;
 - Supports technical derisking;
 - Includes work on airborne and ground architectures supporting the envisaged operations;
 - Includes cockpit integration.
- Assessment of technology choices;
- Assessment / trade off between required and possible performances:
 - Including accuracy, availability and integrity of data;
 - Response time...
- Interoperability (as defined in EUROCAE documents):
 - Data exchanged, Protocols used...

Industrial maturity assessment is based on the TRL (Technology Readiness Level) concept based on NASA initial definitions, which can be applied to technologies, functions, architectures, or methods & tools.

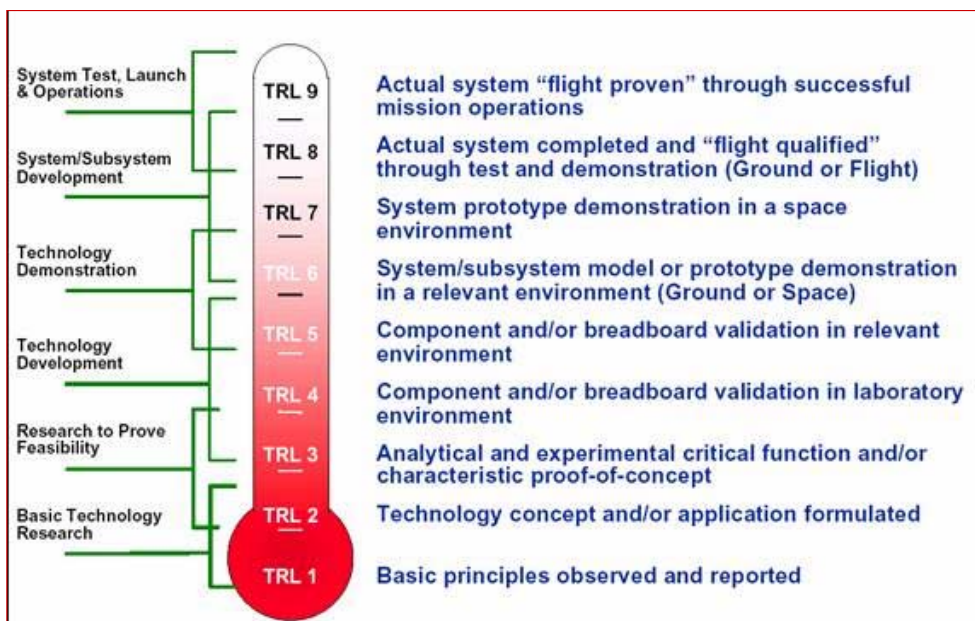


Figure 2-1 – NASA TRL scale

The TRL scale can be roughly linked to E-OCVM concept maturity levels as presented below.

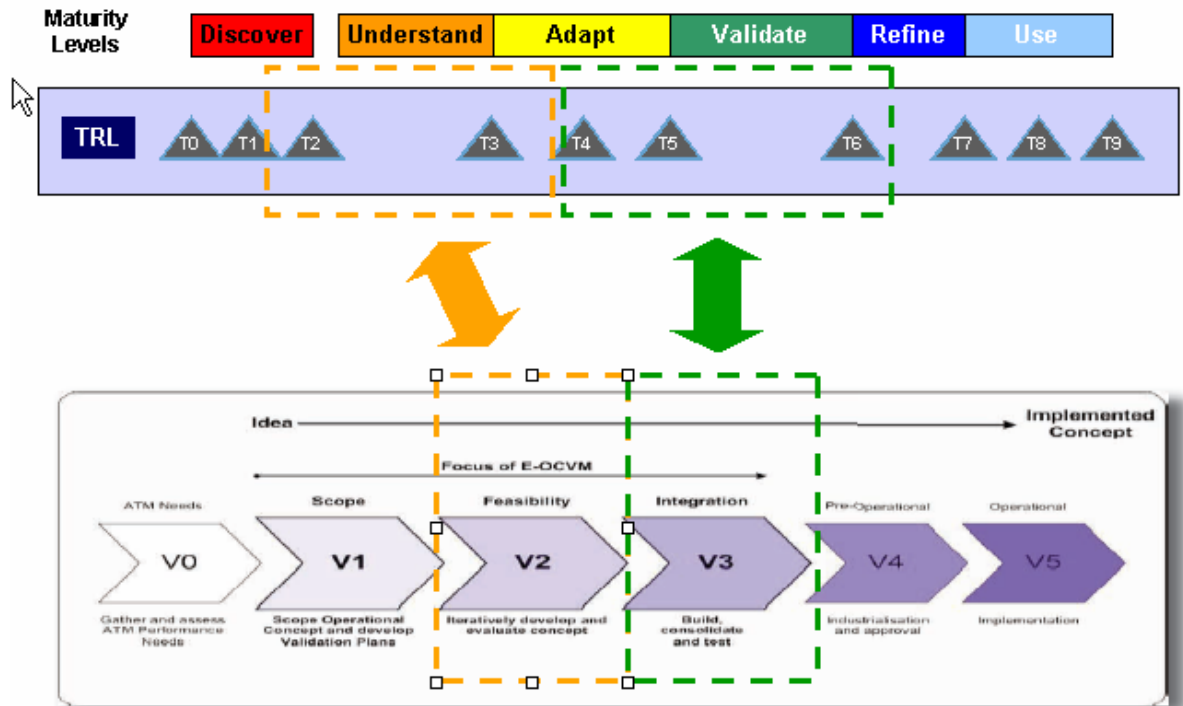


Figure 2-2 – Rough correspondence between TRL and E-OCVM scales

The focus of the EP3 WP6 activity is the technical validation of Airborne and Ground Enablers linked to ATM Capability Level 2. Its objective is to reach a TRL4 for the tested functions. It corresponds to an early validation process that enables to refine the system specification of the function, to demonstrate that the function is feasible and measure function performances.

The WP6 validation platform evolutions follow a typical industrial development, adapted to allow quick loop development and validation:

- High-level specifications for the evolutions derived from operational needs identified by Episode 3 operational work packages (WP5.3.6, TMA Expert Group WP5.3.1) and Standardization Working groups (Initial 4D, ASAS S&M RFG);
- Specifications and validations of the sub-system evolution (simulated FMS, simulated ATSU, ground system).

Then two kinds of evaluations are carried out:

- Technical evaluations focussing on the validation of performances of the technical solutions, which can use validation platform without human in the loop (use of AIRLAB, use of batch tool);
- Technical validation evaluating the operability of the HMI and operator situation awareness from pilot and controller point of view, which uses EPOPEE. These sessions are typically organized in 3 steps: Briefing, evaluation run, debriefing.

The mentioned OI Steps and Procedures are those related to ATM Service Level 2 supported by the validated enablers and were used to build the validation scenarios.

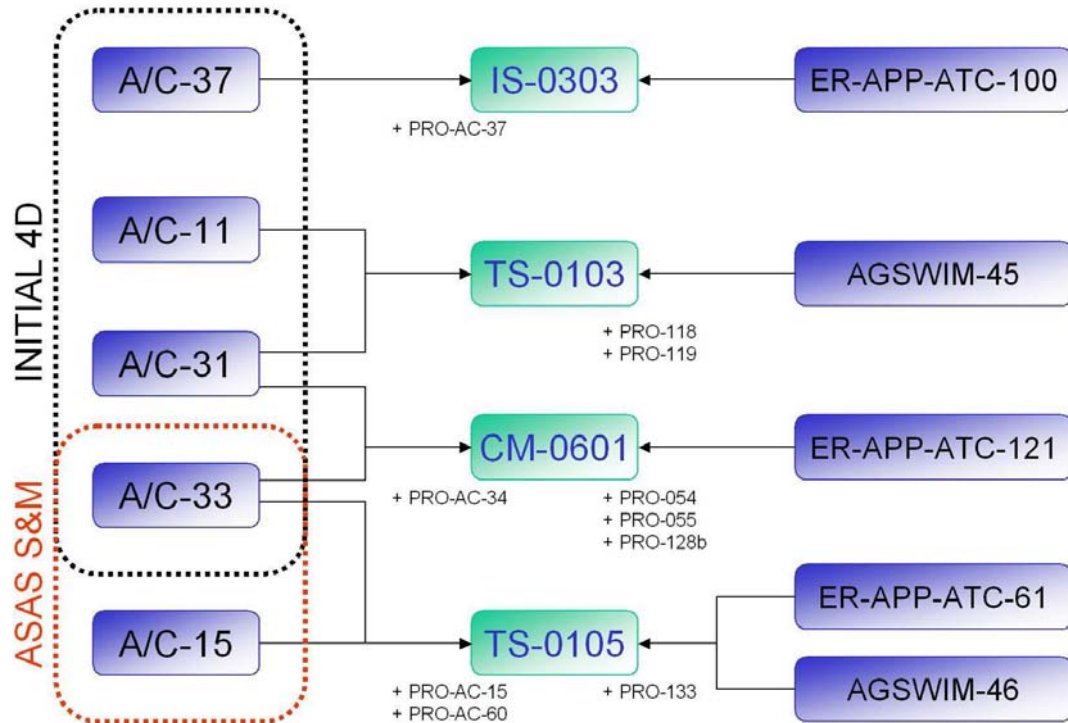


Figure 2-3 – Technical validation scope

The following tables provide the description, as found in the current ATM Master Plan, of the considered enablers, OI steps and Procedures.

Operational Improvement Steps	
CM-0601	Precision Trajectory Clearances (PTC)-2D Based On Pre-defined 2D Routes
IS-0303	Use of Predicted Trajectory (PT) to Enhance ATM Ground System Performance
TS-0103	Controlled Time of Arrival (CTA) through use of datalink
TS-0105	ASAS Sequencing and Merging as Contribution to Traffic Synchronization in TMA (ASPA-S&M)
A/C Enablers & Procedures	
A/C-11	Flight management and guidance to improve time constraints management (CTA)
A/C-15	Flight management and guidance to support ASAS spacing (ASPA)
A/C-31	Uplink and automatic loading in onboard navigation system of route, altitude and time constraints
A/C-33	Uplink and automatic loading in onboard navigation system of clearances
A/C-37	Downlink of predicted trajectory in case of activation onboard of agreed or revise trajectory or in case proposal of onboard preferred trajectory avoiding an up linked area
PRO-AC-15	Cockpit Procedure for Airborne Spacing
PRO-AC-34	Cockpit manoeuvre to automatically load and comply to up linked Precision Trajectory Clearances (2D/3D PTC)



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PRO-AC-37	Cockpit procedure to automatically downlink the Predicted Trajectory in case of activation onboard of an agreed or revised Reference Business Trajectory
PRO-AC-60	Cockpit Procedures for identifying target aircraft and manoeuvring a/c in compliance with responsibility to maintain spacing
Ground Enablers & Procedures	
AGSWIM-45	Transmission of CTA (initial and potential updates) to the aircraft through datalink
AGSWIM-46	Datalink supporting dialogues and exchanges for ASAS S&M
ER APP ATC 61	Adapt Controller and Local and Sub-regional Demand & Capacity Balancing tools to manage delegation of separation responsibilities to aircraft
ER APP ATC 100	Enhance En-Route ATC sub-systems to use RBT and PT provided from aircraft systems and provide constraints and clearances to aircraft systems
ER APP ATC 121	Enable En-Route and Approach ATC sub-system to manage 2D precision trajectory clearances
PRO-054	ATC Procedures for greater use of vertical performance/constraints in separation management
PRO-055	ATC Procedures for gaining greater benefits from new tools such as MTCD
PRO-118	ATC Procedures to identify responsibilities in issuing CTA (timing, sector responsible)
PRO-119	ATC Procedures to define the CTA (mandatory, guidance)
PRO-128b	ATC Procedures to prepare, issue and monitor Precision Trajectory Clearances (PTC) 2D
PRO-133	ATC Procedures for identifying and issuing and ensuring compliance with ASAS spacing applications

Table 2 - Validation scope



2.2 FUNCTIONS INVESTIGATED FOR TECHNICAL VALIDATION

2.2.1 Initial 4D

“Initial 4D” is based on the use of:

- A 4D trajectory exchanged and synchronized between air and ground;
- The use of CTO with a precision of 30s (at 95%) in En-Route and 10s (at 95%) in terminal area.

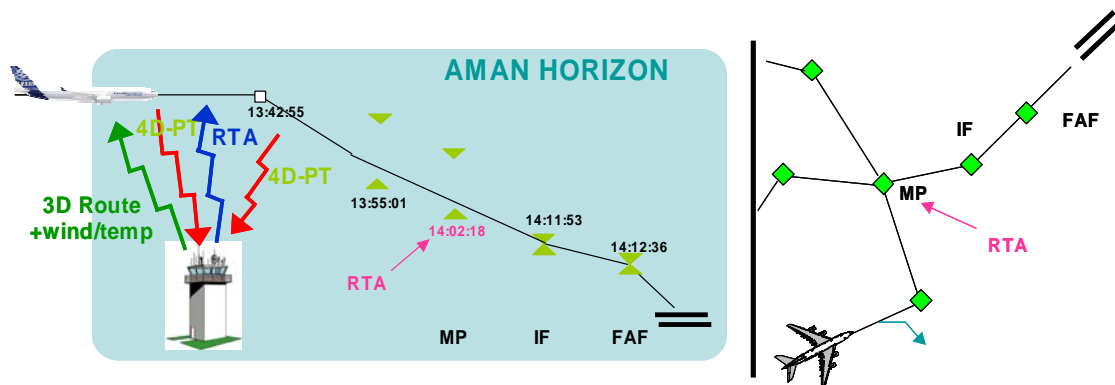


Figure 2-4 – Initial 4D Operations

“Initial 4D” functions are used for planning and sequencing ATM activities but not for separation.

Air-Ground trajectory synchronization is transparent.

Datalink exchanges are handled as per FANS function:

- Exchanges between flight crew and ATC via DCDU;
- Flight plan and RTA can be loaded from DCDU to FMS SEC FPLN.

When set by the flight crew, RTA is managed by the FMS.

Accurate ETA calculation requires meteo data to be uploaded into the FMS.

The associated key elements of such concept are:

- CTA – time constraint on a defined merging point associated to an arrival runway:
 - Airborne: being able to reach a given point at a requested time (provided about XX nm before);
 - Ground: have the capability to deal with the agreed constraint (for consistency with the rest of the traffic).
- Precision Trajectory Clearances (PTC-2D), and Trajectory Control by Ground Based Speed Adjustment:
 - PTC-2D: Envisaged to be of high importance during transition period, while a large amount of the traffic will still remain non FMS/4D and data-link equipped, although the RBT concept of operation should also be applicable to them;
 - Ground Based Speed Adjustment: to be discussed with SESAR concept experts (this procedure seems to correspond to "open-loop" instruction).
- Uplink of ATC constraints and downlink of 4D data:



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- ATC constraints;
- Downlink of 4D data: current position, predicted positions (Altitude, Latitude, Longitude, Time Over significant Point, Point Type), and FMS status (managed, selected, etc.).

The expected benefits of Initial 4D can be summarized as follow:

- 1st results of benefits analysis performed with support of EUROCONTROL tend to show interesting potential benefits from airside perspective, assuming several feasibility road blocked are cleared through validation:
 - Reduction of fuel consumption and emissions through CDA enabled by Initial 4D;
 - Reduction of crew workload in descent and approach;
 - Reduction of delays in TMA and En-Route.
- Initial 4D used to de-bunch traffic at TMA entry should also bring good benefits from ATC perspective:
 - Reduction of controller workload;
 - Predictability of traffic;
 - Enhanced coordination between ground actors;
 - Reduction of environmental impact.

(Hyp-1)

It is assumed for the purpose of this exercise that the Initial 4D Trajectory is a reasonable approximation of the RBT.

(Hyp-2)

Five levels of wind / temperature are available in meteo data.

2.2.2 ASAS spacing:

ASAS Spacing is considered to be the first step of ASAS, the 2013 target necessary step before ASAS Separation (2020).

- Three manoeuvres (Remain behind, Merge then Remain, Vector then Merge) are defined in [13] **RFG** Package I – Enhanced Sequencing and Merging Operations (ASPA S&M) - Application Description v2.3 20 - Jan-2009;
- The acquisition and maintaining of spacing in end of En-Route, descent and approach is performed with a precision of 5s;
- There is no delegation of separation responsibility to the A/C;
- Airborne: capability to fly the ASAS spacing procedures in managed mode;
- Ground: capability to initiate an ASAS S&M instruction, and to monitor its execution.

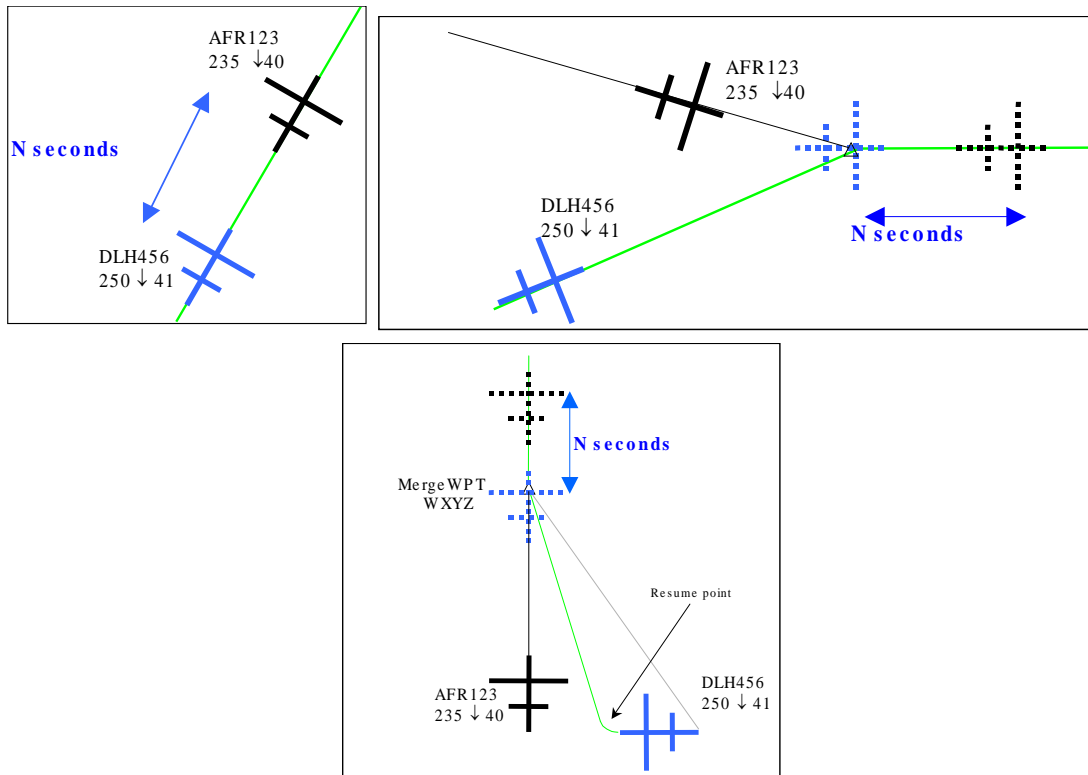


Figure 2-5 – ASAS S&M Manoeuvres: Remain behind, Merge then Remain, Vector then Merge

Its principle is based on:

- The controller delegates a manoeuvre to the flight crew:
 - The controller requests the flight crew to identify the target A/C.
Example of phraseology: "AIRBUS 001, select target CSN 781 and advise relative position".
 - Spacing instruction from the controller → the flight crew establishes and maintains a TIME SPACING between its A/C and another A/C.
Example of phraseology: "AIRBUS 001, remain 90 seconds behind target".
- The controller remains responsible of SEPARATION between A/C.

The associated hypotheses are:

(Hyp-3)

ASAS Spacing is available in En-Route and in Descent flight phases.

(Hyp-4)

"Target" and "Instructed" A/C have FMS / navigation capabilities / performances that are similar and suitable for ASAS manoeuvres.

(Hyp-5)

Both A/C follow the same flight plan (at least once the spacing is established).



(Hyp-6)

A/C has to be pre-sequenced before using ASAS S&M:

- **Manual controller sequencing;**
- **4D used as tool for pre-sequencing;**
- **Use of AMAN as support for pre-sequencing.**

(Hyp-7)

Initial 4D and ASAS modes are mutually exclusive

The ASAS expected benefits are summarized as follows:

- Capacity / Regularity due to less radar vectoring;
- Combined with CDA, it may reduce fuel consumption and emissions;
- Complementary to 4D at big airports;
- Probably more beneficial at secondary airports;
- Robustness of the procedures.

With a Target frame for operations:

- Spacing application for pioneers in the 2013 timeframe;
- Applications in Approach and Oceanic environments;
- Automated solution with limited impact: Software only, using ATSAW baseline.

2.2.3 Business / Mission trajectory:

Business trajectory: see "Initial 4D" paragraph above.

The DODs do not at present specify the military aspects. It is expected that they will be mature at a later date¹ such that the requirements for the mission trajectory can then be specified.

¹ Aligned with SJU WPs activities under preparation.



2.3 TECHNICAL VALIDATION OBJECTIVES

The targeted validation activities are aiming at:

- Relevance of the Initial 4D function:
 - Variations of engine speed according to the different accuracy values and outside parameters (wind, temp);
 - Robustness of the RTA algorithm according to the outside parameters (wind, temp);
 - Understanding of the Initial 4D procedure;
 - Capacities to negotiate the RTA, follow the RTA instructions of ATC, and monitor the Initial 4D mode.
- Relevance of WIND/TEMP uplink information and mechanization (procedure via AOC);
- Appropriateness of RTA access mechanization and presentation;
- Relevance and appropriate understanding of ETA window;
- Appropriate understanding of missed/made status (RTA page, F-PLN, ND);
- Communications relative to the Initial 4D function:
 - Understanding of the ATC instructions (CPDLC / voice);
 - Integration of the task within the CPDLC clearances procedure (CLEARED TO ...);
 - Appropriateness of CPDLC message phraseology of RTA instruction ("CROSS <> AT <>").
- Appropriateness to perform the ASAS S&M manoeuvre (before the engagement and during the manoeuvre);
- Acceptability of the prerequisites of the ASAS S&M function;
- Relevance of the use of datalink instead of voice (workflow, type of message, parameters to load...);
- Understanding and appropriateness of the ownship behaviour;
- Relevance, consistency (with the phraseology), understanding and completeness of the information provided;
- Test the ASAS S&M function in degraded cases:
 - Impossibility to engage (one or more pre-requisite missing or algorithm detecting the impossibility to do the requested S&M manoeuvre);
 - Impossibility to acquire the instructed spacing;
 - Impossibility to maintain the instructed spacing.
- Assessment of the predicted trajectory "quality" of the current and future FMS (implementing the Initial 4D). Address the impact of wind information;
- Validate the choice of set of data, downlinked from A/C to the ground, and the way they are transmitted (event-based, cyclically...). Make sure that they are relevant;
- Assessment of the improvement brought to the ground functions by the downlinked 4D-Trajectory.



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The table below summarizes the link between exercises and R&D needs expressed by SESAR while specifying the answers that will be provided as part of EP3 WP6.

Id	Question	Source	Objective	Exercise
1	What are the performance requirements of the airborne FMS RTA function? (Link to FMS accuracy enabler R&D work)	SESAR	Measurement of 2D trajectory performance in terms of integrity, accuracy and stability and of single CTA compliance.	6.4.1
2	What is FMS capability to stick to RTA constraint after tactical clearance?	WP6	Not addressed by WP6: In the scenarios, the aircraft is flying in full managed mode.	
3	What is the minimum time horizon for RTA negotiation?	WP6	Measurement of the ETA_{min} / ETA_{max} window size as a function of the time to go the RTA waypoint.	6.4.1
4	What is the most efficient way to adjust the speed schedule or cost index of the aircraft to meet the RTA?	SESAR	Assess CTA compliance and accuracy through FMS Speed control.	6.4.1
5	Besides the FMS, what kind of other automation tools (autopilot, VNAV descent modes, auto-thrust) is required in the aircraft to comply with RTA? How should this automation operate?	SESAR	Demonstrate, at the technology level, that the RTA with 10s accuracy in descent can be achieved in full managed mode (lateral, vertical and speed), thus with auto-pilot and auto-thrust.	6.4.1
6	What is the required time tolerance of the FMS RTA function at the RTA constraint and at each distance before the RTA constraint? What should be the strategy of the FMS to achieve the RTA?	SESAR	Assess ability to meet CTA compliance within a time window appropriate to support a Ground given arrival slot.	6.4.2
7	How to maintain controller situation awareness for an aircraft with a CTA	WP6	Assess CWP HMI capability of presenting necessary information to monitor Aircraft flying an RTA.	6.4.2
8	Which level of CTA monitoring conformance should be available? When an alarm is raised, who is acting?	WP6	Assess detection and signalling of CTA non-conformance both on the air and groundside.	6.4.2
9	What is the required granularity of forecasted winds to meet the RTA with the required tolerance?	SESAR	Impact of meteo on FMS predictions.	6.4.1
10	Is there a relation of this time tolerance with the operating context (En-Route, TMA) and/or the phase of flight (cruise, descent, approach)?	SESAR	Assess RTA performance for different RTA waypoints (before T/D, in descent, above or below FL 100).	6.4.1
11	Definition of the format and content of air-ground data link messages required to support the exchange of CTA constraints.	SESAR	Assess the ability to negotiate a CTA constraint via datalink between air and ground.	6.4.2



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Id	Question	Source	Objective	Exercise
12	How do trajectory prediction tools use improved aircraft RNP capability to improve Medium Term Conflict Detection (MTCD) accuracy and reduce uncertainty?	SESAR	<p>Check the validity of the method and strategy selected by the Ground ATC automation system to take into account the airborne trajectories.</p> <p>Check the capability of the Ground Trajectory Predictor to generate and provide 4D-predicted trajectories in a smooth and timely manner, to the other ground functions that need them (e.g. Controller Working Position, MTCD).</p> <p>Assess impacts on the interactions between the Ground Trajectory Predictor function and the other ground-based functions.</p>	6.4.2
13	<p>Which data needs to be downlinked?</p> <p>When and how often does the data need to be downlinked?</p> <p>In which format does the data need to be downlinked?</p>	SESAR	<p>Demonstrate, at the technology level, that the Ground ATC automation system will be capable to efficiently take into account the trajectory data downlinked by the airborne system. Define the technical characteristics of this process (downlink, fusion with ground trajectory).</p>	6.4.2
14	What level of tools and automation is required on the cockpit to set up, complete and execute the ASAS manoeuvre?	SESAR	<p>Assess the ability to provide efficient tools to the pilot to execute an ASAS Sequencing and Merging manoeuvre.</p> <p>Measurement of performance of ASAS spacing procedure in term of integrity, accuracy and stability.</p>	6.4.3
15	What will be the communications, navigations and surveillance requirements between ATC and the target and delegated aircraft to set up, execute and complete the ASAS manoeuvre?	SESAR	<p>Assess the ability to initiate an ASAS Sequencing and merging manoeuvre via datalink.</p>	6.4.3
16	What level of surveillance is required? Do existing applications of CPDLC, ADS-C and ADS-B support this?	SESAR	<p>Not addressed by WP6.</p>	
17	How to maintain controller situation awareness during an ASAS manoeuvre?	WP6	<p>Assess CWP HMI capability of presenting necessary information to monitor Aircraft during an ASAS manoeuvre.</p>	6.4.3
18	In an ASAS manoeuvre what are the instructions that have to be transmitted by voice or by datalink?	WP6	<p>ASAS experiments are using both voice and datalink. Capture pilots and controllers preference for media addressed by 6.4.3.</p>	6.4.3
19	What are the downlinked data necessary for the controller to monitor an ASAS manoeuvre?	WP6	<p>Define the data to be downlinked during an ASAS manoeuvre and check that it is sufficient for the controller to monitor the ASAS manoeuvre.</p>	6.4.3



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Id	Question	Source	Objective	Exercise
20	Evaluation of the merits of relative (ASAS) or absolute (RTA) Time Based Separation (TBS) techniques; in terms of runway throughput. Both techniques appear to have merits under different circumstances. Are there local issues that influence the answer? Associated is the issue on evaluation of feasibility and safety of less than 50 second spacing on final approach, especially if this involves late clearance to land.	SESAR	To study the transition aspects between Initial 4D and ASAS (RTA on a waypoint and then ASAS instruction after this waypoint).	6.4.4
21	Does the underlying communications method (i.e. VDL2, 1090MHz ES, satellite) provide sufficient capability (bandwidth, speed, etc), or are new communications links required?	SESAR	Not addressed by WP6.	
22	What navigation performance is required by the target and delegated aircraft?	SESAR	Not addressed by WP6.	

Table 3 - Links between exercises and R&D needs



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The table below summarizes the link between enablers, validation activities and platform evolution.

Enabler	Validation activity	Platform evolution
<p><u>AC-11</u> Flight management and guidance to improve time constraints management, i.e. Controlled Time of Arrival (CTA) with control loop in descent down to FAF and accuracy down to +/-10 seconds, improved 4D prediction algorithms using enriched meteorological modelling.</p>	<p>Single CTA, improved 4D prediction algorithm Impact of weather context</p>	<p>RTA management FMS predictions taking into account current and predicted winds and temperatures</p>
<p><u>AC-15</u> Flight management and guidance to support ASAS spacing (ASPA) application (addition of target tracking and separation monitoring function).</p>	<p>ASAS S&M Integration 4D/ASAS (new scenario, no development foreseen on platform)</p>	<p>ASAS S&M</p>
<p><u>AC-31</u> Uplink and automatic loading in onboard navigation system of routes (2D/3D), altitude and time (CTO/CTA) constraints.</p>	<p>Uplink and automatic loading in FMS of routes 2D and time constraints</p>	<p>Uplink management (list of messages to be defined), downlink of ETA min – ETA max, DCDU integration</p>
<p><u>AC-33</u> Uplink and automatic loading in onboard navigation system of clearances for a segment of RBT, for ASAS and for BTV manoeuvres.</p>	<p>Uplink and automatic loading of 2D clearances for a segment of RBT Uplink and automatic loading of ASAS S&M order (new message)</p>	<p>ASAS uplink management, new interface with ASAS module</p>
<p><u>AC-37</u> Automatic downlink of the predicted trajectory in case of activation onboard of the agreed or revised trajectory (predicted trajectory corresponding to the agreed or revised Reference Business Trajectory). Downlink of the onboard preferred trajectory avoiding an up linked area not existing in onboard database.</p>	<p>Automatic downlink of predicted trajectory</p>	<p>4D trajectory downlink</p>
<p><u>AGSWIM-45</u> Transmission of CTA (initial and potential updates) to the aircraft through datalink (The CTA must be provided to the Pilot as soon as available. The Air-Ground Data Link Ground Management System (AGDLGMS) is transmitting it after having received the relevant shared flight data update.</p>	<p>Transmission of CTA to the aircraft Downlink of ETAMin / ETAMax, allocation of the CTA by the ground</p>	<p>Implementation of CTA transmission by the ground system, following an uplink / downlink exchange to get the FMS ETAMin / ETAMax</p>



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Enabler	Validation activity	Platform evolution
<p><u>AGSWIM-46</u></p> <p>Datalink supporting dialogues and exchanges for ASAS S&M (Request for clearance are given by the aircraft, clearances are given by the ER APP ATC, dialogues will be supported as well).</p>	<p>Scenarios will be run using datalink</p> <p>Note: Low communication layers of the datalink are not implemented</p>	<p>CPDLC exchanges between ground and airborne systems</p>
<p><u>ER APP ATC 61</u></p> <p>Adapt Controller and Local and Sub-regional Demand & Capacity Balancing tools to manage delegation of separation responsibilities to aircraft (Modify systems to recognise where delegation is allowable and enable it to be a selectable service state for aircraft).</p>	<p>ASAS S&M procedure - Spacing Performance Validation</p> <p>4D – ASAS transition</p>	<p>ASAS S&M instruction 4D – ASAS transition</p>
<p><u>ER APP ATC 100</u></p> <p>Enhance En-Route ATC sub-systems to use RBT and PT provided from aircraft systems and provide constraints and clearances to aircraft systems (Controller workstation, FDP and flight path monitor and tools modified to allow management of all aspects of 4D trajectories -including clearances, RBT update proposal, constraints, Pilot request, TMR, CTA...-).</p>	<p>Use of Predicted Trajectory provided from aircraft systems</p> <p>Provision of constraints and clearances to aircraft systems</p>	<p>Improvement of ground-based TP using Airborne Predicted Trajectory</p> <p>Transmission of constraints and clearances to aircraft systems</p> <p>Allocation and transmission of CTA</p>
<p><u>ER APP ATC 121</u></p> <p>Enable En-Route and Approach ATC sub-system to manage 2D precision trajectory clearances.</p>	<p>PTC-2D</p>	<p>PTC-2D</p> <p>Note: No processing of aircraft request, or UPR</p>

Table 4 - Links between enablers, validation activities and platform evolution



2.4 TECHNICAL VALIDATION STRATEGY

The main guideline for technical validation is to focus on the assessment of the acceptability and usability of the proposed initial 4D and ASAS S&M concepts and functions as described in the preceding paragraphs.

- The WP6 approach is to set-up an environment that is realistic enough to allow consistent situation awareness for both pilots and air traffic controllers, while nevertheless taking into account industrial constraints, including business case aspects. By nature, this will limit the scope of possible validation area within WP6, but allows a high quality progressive build-up process.
- The WP6 is investigating the use of integrated air-ground platforms to perform industrial feasibility assessment. The WP6 technical validation is focusing on air and ground ATM capabilities to be deployed by 2013-2015. It will therefore enhance maturity of those capabilities and pave the way to SESAR projects by using the platform and techniques (Airbus Cockpit Simulator - EPOPEE, Thales simulated FMS and EUROCAT ATC system).
- By using state-of-the-art industrial components, the WP6 approach allows to demonstrate that advanced concepts as investigated in more experimental contexts (e.g. Gate2Gate, Mediterranean Free Flight, TMA2010+, etc.) for which identified requirements (e.g. in [13] “**RFG** Package I – Enhanced Sequencing and Merging Operations (ASPA S&M) - Application Description v2.3 20 - Jan-2009”, can be assessed without having to suffer from some simplified modelling techniques. Its validation results are therefore ‘making the bridge’ that could introduce further industrialisation phases as described by the TRL process.
- As presented in document [4] “**Episode 3** WP5 Validation Strategy E3-WP5-D5.2.1-01-PLN-V1.01 07/04/2009”, the validation strategy of the other Episode 3 work packages will be more focusing on the operational concepts validation:

“...In many cases only parts of the OI-steps will be validated, e.g. regarding AO-0301 Crosswind Reduced Separations for Departures and Arrivals all procedural aspects how reduced separations could be achieved and managed are not part of the approach. Instead, the exercise assumes that reduced separations can be achieved, and it validates the impact with regard to the possible capacity increase. The same is valid for most of the other OI-steps as the validation exercises focus on concept clarification and expanding the repertoire of cost-effective validation techniques”.

WP6 has therefore a complementary approach, providing a sound basis for the hypothesis used in the elaboration of the operational concepts validation scenarios.



3 FUNCTIONAL REQUIREMENTS

3.1 FUNCTIONAL ARCHITECTURE

Initial 4D is a key element of SESAR Implementation Package 2, with an Initial Operating Capability around 2013-2015 (ATM Capability Level 2).

ASAS Spacing application for pioneers are foreseen in the 2013 timeframe.

Therefore, the proposed implementation takes benefits of existing technology, which ensures that the upgrade cost will remain at an acceptable level.

The functional architecture defined for the technical validation platform is based on existing systems:

- For the airborne side, it is based on FMS2 for SA/LR;
- For the ground side, it is based on the EUROCAT-E Air Traffic Control system, which is in operation in many countries worldwide, and already implements advanced functions such as for instance a High-Performance Trajectory Prediction based on parameters calculated from the total energy model using EUROCONTROL's Base of Aircraft DATA (BADA), or automatic coordination and transfer with inter-sector, inter-centre. This is the baseline on which EP3-specific evolutions are developed.

The communication between ground and airborne systems are expected to rely on ATN. In the scope of Episode 3, the technical validation platform does not investigate the protocol aspect of air/ground communications. It uses existing interfaces to exchange data with some extensions to transfer data necessary for Initial 4D and ASAS spacing functions.²

(Hyp-8)

The WP6 platform simulates the relevant elements of an operational system made of air and ground segments. The operational system would include ground-based surveillance means such as radar and ADS-B ground stations, complemented by ADS-C.

The corresponding simulated data are derived from the data provided by the simulated FMS (EPOPEE aircraft) and those transmitted by the Air Traffic Generator (surrounding traffic).

² For instance, the platform uses FANS1A for CPDLC, but the new messages related to Initial 4D or ASAS are exchanged through text messages.



3.1.1 Airborne System Functional Architecture

The following figure depicts the functional diagram of the airborne system³, and its interfaces with the ground system.

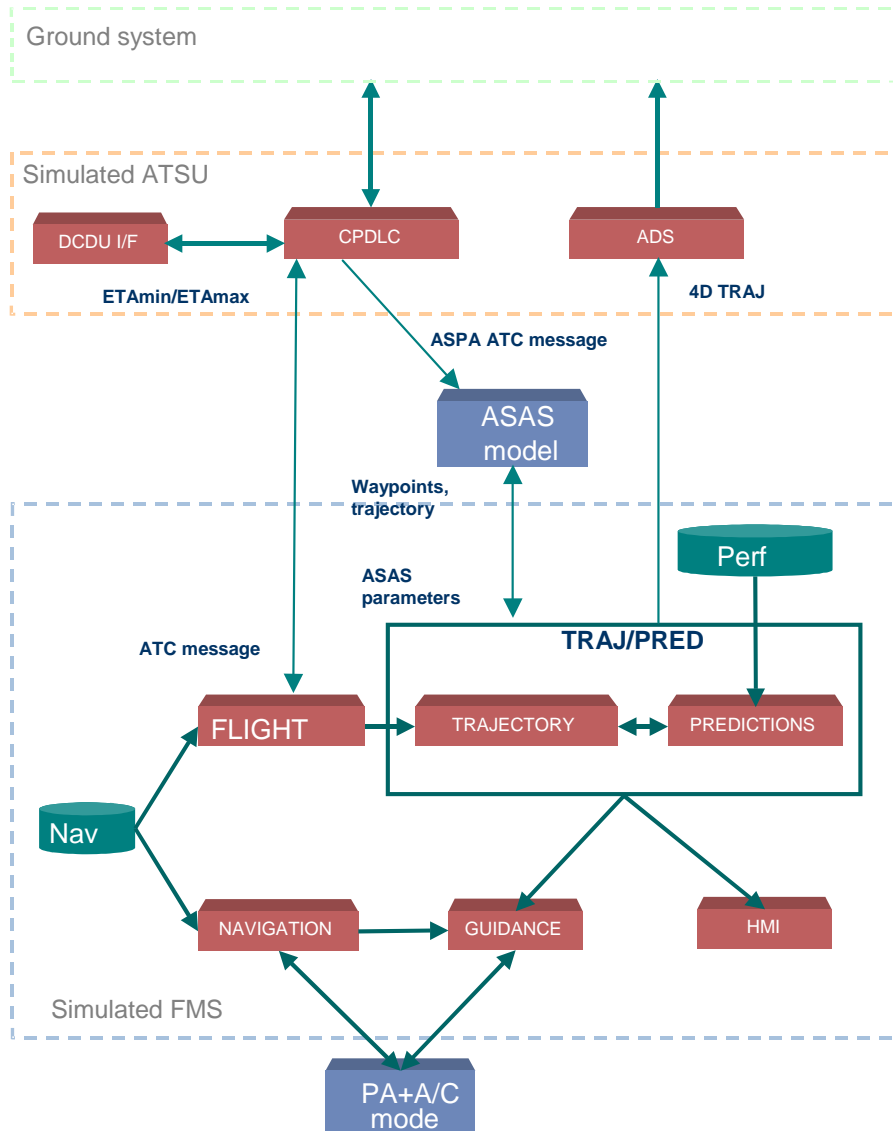


Figure 3-1 – Functional diagram of the airborne system

The main functions of the Simulated FMS are:

- To prepare the flight;
- To inform the pilot on the flight situation (via the FMD and the MFD);
- To optimize the flight trajectory;

³ This functional architecture is normally scoped towards civilian carrier, most probably also valid for some military ones (e.g. the A400M), involved in the negotiation process of 4D business trajectory (i.e. requiring among others a FMS equipment capable of RTA negotiation processing). Other Mission Trajectory negotiation exchanges will most probably require different level of functionalities, for sure not covered by the current WP6 activities.



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- To guide the plane along the flight plan by coupling with the Autopilot;
- To communicate the flight plan to other systems (e.g. ATSU);
- To receive and upload in the flight plan ATC messages from the ATSU;
- To compute the trajectory corresponding to the ASAS S&M “vector then merge” instruction.

The elements of the Flight Plan (waypoints, NAVAIDS, terminals, procedures...) are stored in the ARINC 424 database.

The main functions of the Simulated ATSU are:

- To downlink Aircraft derived data and 4D trajectory to the Ground system;
- To Exchange CPDLC⁴ messages with the Ground system;
- To interact with the pilot for CPDLC message management (through the DCDU);
- To send ATC messages to the FMS;
- To send the ASAS Sequencing and Merging instruction received from the Ground system to the ASAS component.

3.1.2 Ground System Functional Architecture

Figure 3-2 depicts the functional diagram of the ground system, made of a **EUROCAT** Approach/En-Route ATC Segment (derived from the operational EUROCAT) and the **Air Traffic Generator (ATG-X)**, and its interfaces with the airborne system.

Some functions of the operational EUROCAT will not be used, since they are not relevant for the technical validation.

⁴ ADS-C is not mentioned here, as current level of concept maturity does not allow any detailed data format exchanges specifications.

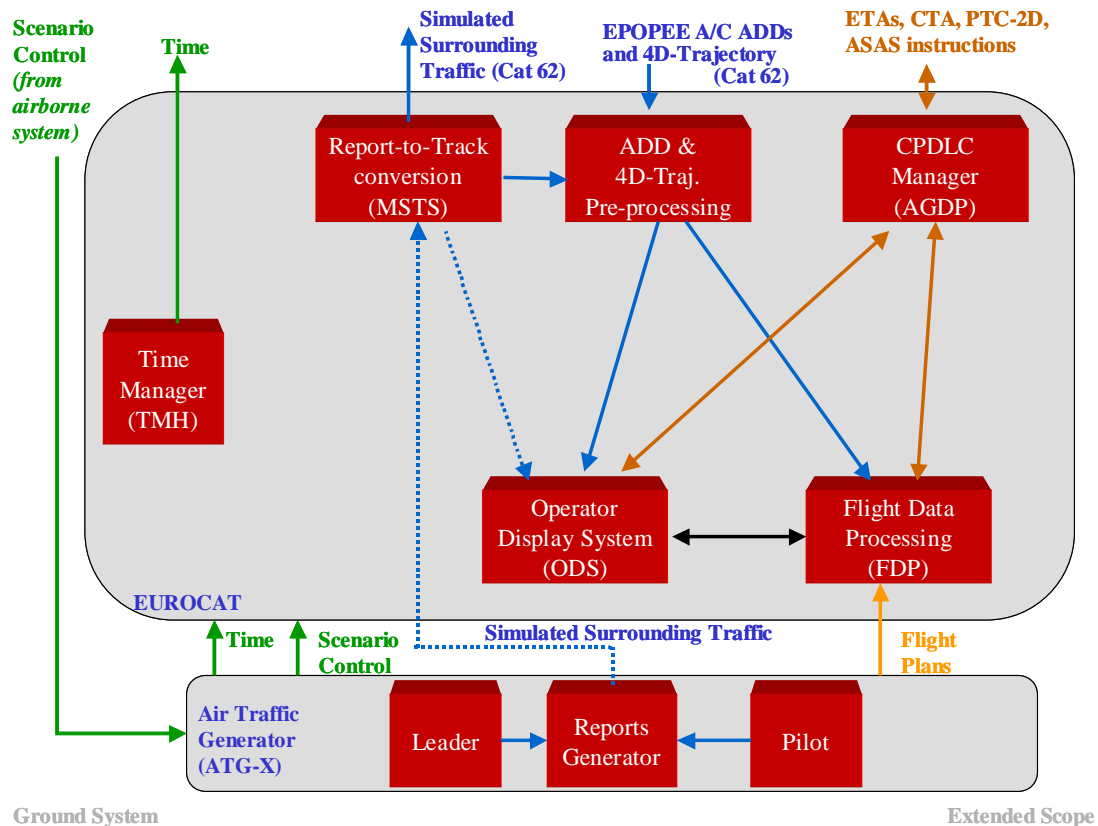


Figure 3-2 – Functional diagram of the ground system

The main functions of **EUROCAT** that will be directly used and/or impacted in Episode 3 technical validation scenarios are listed below:

Safety Net & Monitoring Aids (SNMAP):

ADD & 4D-Trajectory Pre-Processing, receiving the Aircraft Derived Data (ADD) and 4D-Trajectories down-linked from the airborne system and performing the following pre-processing:

- Convert the message from ASTERIX Category 62 to internal data format;
- Check the validity of the received data;
- Analyse the received 4D-Trajectory in order to discard it if the changes are under pre-defined thresholds;
- Forward the ADD and the 4D-Trajectory to the Flight Data Processing.

Coupling, associating the system tracks and flight plans, based on SSR codes, received Mode S data, and on the flight plan route data.

Automatic Position Reporting, generating automatically, periodically and on waypoint crossing, automatic position reports (APR) that provide the Flight Data Processing with actual time & level position of the aircraft on the flight path.

Cleared Level Adherence Monitoring (CLAM) and Route Adherence Monitoring (RAM):

These monitoring functions provide the following controller support:



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- Route Adherence Monitoring (RAM) for 2D route adherence warns the controller when a flight deviates laterally or in time from the current flight plan route. It is available for aircraft within radar coverage. This function checks if an aircraft is adhering to its planned route by comparing the actual position of the track with known points of the planned route;
- Cleared Level Adherence Monitoring (CLAM): warns the controller when a flight's altitude or flight level deviates from the cleared level (CFL). It is available for aircraft within radar coverage. This function checks the conformance of the actual flight level of a track with respect to the Cleared Flight Level.

Flight Data Processing function (FDP):

This core system function is providing the following services:

- The Flight Data Processing (FDP) function provides the Air Traffic Controllers with accurate and up-to-date flight information, for use in flight planning, co-ordination, and control;
- FDP interfaces with the ATG-X, which simulates an IFPS/CFMU, to act as a primary source of flight plans;
- FDP manages the runway in use at known airports, allocates SIDs and STARs accordingly;
- FDP encompasses the Ground Trajectory Prediction (TP) function, which identifies the portion of the flight route within a defined area of interest and computes the 4-dimensional (4D) trajectory over that route portion;
- The description of the trajectory calculation makes use of a concept of target conditions that the flight attempts to meet. The target conditions are, in the simplest case, those requested in the flight plan (requested speeds, levels, etc.). However, these are regularly overridden by strategic ATC constraints such as maximum level, sector/FIR boundary crossing conditions, etc. During the course of the flight, tactical constraints (mainly controller orders) may further override the target conditions. The trajectory of the flight in reaching its target conditions is determined according to the performance of the aircraft and prevailing meteorological conditions;
- FDP receives and checks the time and position constraints, and 2D route clearances and record them for further use;
- FDP processes the received ADD and 4D Trajectories by the Ground Trajectory Predictor in order to enhance the predicted trajectories. This processing is performed for the climb, En-Route and approach phases of flights;
- FDP processes the Automatic Periodic Reports (APR) in order to update the predicted trajectories (ETO's, levels on next waypoints).

Medium Term Conflict Detection (MTCD):

The MTCD provides:

- Automatic flight plan conflict detection, based on existing flight plan information, with various levels of conflict severity;
- Probing for flight plan Predicted and Risks Of Conflicts as a result of proposed changes to existing flight plan details.

Operator Display System (ODS):

The Operator Display System (ODS):



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- Receives the Aircraft Derived Data (ADD) and the 4D-Trajectory from the ADD & 4D-Trajectory pre-processing function, and displays the current position of the aircraft, its downlinked Aircraft Parameters and its 4D planned trajectory;
- Receives and displays the 4D planned trajectory received from the Flight Data Processing system;
- Maintains "Traffic Management Lists" (TMLs) to display, for a given point, the ETO (Estimated Time Over) computed by FDP, the ETR received from the FMS and the CTA;
- Provides operator commands assisting the controller for preparing the time, position constraints and 2D route clearances (request for ETAMin - ETAMax, display of the pilot answer, determination of a CTA, PTC-2D clearances, etc... for the flight.);
- Once the constraints have been accepted by the pilot, they are transmitted to the FDP in order to be taken into account by the ground TP;
- New HMI for the selection of ASAS pairs (NO wording like "delegated", but rather "spaced")...

CPDLC Manager (AGDP):

This function focuses on air-ground exchanges. It supports:

- The management of the Air / Ground dialogue between controller (ODS) and pilot to (uplink the time/position constraints, and 2D route clearances (up to runway threshold), transmit to the controller the downlinked response from the pilot). This include support for ASAS instructions;
- The dialog with the FDP (ground TP) to keep it updated with the time / position constraints and route clearances.

Time Manager (TMH):

This function receives the time reference message from ATG-X, distributes it to the main functions of EUROCAT and exports it to the airborne system.

A recording function will be activated in EUROCAT to support the assessment of the ground TP performance.

In addition, the ground systems also includes:

Air Traffic Generator (ATG-X):

This module provides:

- Time Management Interface;
- Scenario control;
- Elaboration of Flight Plan messages;
- Trajectory simulation (based on offline prepared scenario and real time pilot commands).



3.2 FUNCTIONAL REQUIREMENTS

3.2.1 4D Trajectory Exchange Function

3.2.1.1 Introduction

“4D Trajectory Exchange” is part of the process ensuring that air and ground are agreeing on a single Reference Business Trajectory (RBT), i.e. the ground and airborne systems share along the flight a consistent view of the constraints to be taken into account for computing the predicted trajectory.

Once agreed, this Reference Business Trajectories (RBT) can be flown by the aircraft in managed mode.

The FMS can then compute 4D Trajectory Predictions.

This trajectory prediction is downlinked, and the ground system processes the received downlinked data to improve the ground prediction (taking benefit of the more accurate flight model), and to ensure that aircrew and controller share a common view of the trajectory to be flown.

Notes:

- Due to the platform, time schedule limitations, the ATC constraints will not be automatically produced by specific controller tool. Especially, the CTA values do not need to be produced by an AMAN, due to the limited number of aircraft involved in the simulation. Therefore, the CTA values used in the scenarios will be determined manually;
- ATC time constraints are assumed to be on waypoints known by ground ATC and the FMS.

3.2.1.2 Downlink and ground processing of the 4D trajectory

3.2.1.2.1 Requirements applicable to the airborne system

[E3-AIR-4D-TRAJ-8]

Requirement title RTA insertion

The airborne system shall allow the pilot to insert an RTA over a waypoint.

End of requirement

[E3-AIR-4D-TRAJ-9]

Requirement title RTA cancellation

The airborne system shall allow the pilot to cancel a previously defined RTA

End of requirement

(Hyp-9)

A RTA can be cancelled only on ground request when the RTA is not achievable or for traffic avoidance.



[E3-AIR-4D-TRAJ-10]

Requirement title RTA accuracy in descent

FMS RTA function required accuracy / reliability shall be ± 10 sec, 95% of the time for any descent waypoint (located down to FAF).

End of requirement

Additional information: 95% of the time shall be understood as follows: The RTA shall be satisfied with an accuracy of ± 10 sec considering the 95% probability wind, temperature and guidance errors. The 95% reliability only applies to cases where assigned RTA is within reliable ETA_{min} / ETA_{max} window.

[E3-AIR-4D-TRAJ-11]

Requirement title RTA accuracy En-Route

FMS RTA function required accuracy / reliability shall be ± 30 sec, 95% of the time for any cruise waypoint (located down to T/D).

End of requirement

(Hyp-10)

ATM requirements regarding RTA accuracy may be different within TMA or En-Route phase of flight. Since it is expected that flying high accuracy RTA will lead to fly less optimized trajectories (more margins to be taken into account in vertical profile computation...) with potential impact also on passenger comfort, it is preferable to fly with high accuracy RTAs only when required.

[E3-AIR-4D-TRAJ-12]

Requirement title Meteo data definition

It shall be possible to define 5 wind and 5 temperature values for 5 different altitudes related to DESCENT flight phase in the FMS.

End of requirement

[E3-AIR-4D-TRAJ-1]

Requirement title Airborne 4D trajectory download capability

The airborne system shall be able to downlink 4D trajectory data to the ground system.

End of requirement

[E3-AIR-4D-TRAJ-2]

Requirement title Airborne 4D trajectory download triggering

The airborne system shall be able to downlink 4D trajectory data to the ground system:

- Periodically; and
- On predefined events.

End of requirement

Additional information: period and events shall be easily tuned



3.2.1.2.2 Requirements applicable to the ground system

[E3-GND-4D-TRAJ-1]

Requirement title Airborne downlinked 4D trajectory processing capability

The ground system shall correctly receive and process all relevant downlinked data from the appropriate aircraft.

End of requirement

[E3-GND-4D-TRAJ-2]

Requirement title Airborne 4D trajectory conformance monitoring

Following trajectory negotiation and agreement the ground system shall check the conformance of the subsequent downlinked airborne 4D trajectories with the RBT.

End of requirement

E3-GND-4D-TRAJ-3]

Requirement title Airborne 4D trajectory acceptance

In the case the downlinked airborne 4D trajectory does not conform with the RBT, it shall be rejected by the ground system.

End of requirement

[E3-GND-4D-TRAJ-4]

Requirement title Improvement of the ground-based predicted trajectory with the downlinked 4D trajectory data

When the downlinked 4D trajectory complies with the reference trajectory, the ground system shall use the airborne 4D trajectory for the flight in order to enhance the trajectory prediction in climbing, in cruise and in descending phases.

End of requirement

Notes:

- This assumes that the ground system is able to generate a predicted trajectory based on a default aircraft performance model;
- The ground system will use the downlinked 4D predicted trajectory to adjust the offline parameters of its TP and of its Aircraft Performance Model trajectory prediction. It will then use in real time this more accurate data for computing the 4D trajectory. The data impacted in the ground-based 4D trajectory will be the ETO's and vertical profile.

[E3-GND-4D-TRAJ-5]

Requirement title Display of the aircraft trajectory predicted by the ground system

The ground system will enable the ATCo to display on her/his Controller Working Position the trajectory of the aircraft generated by the ground TP, enhanced by the aircraft downlinked trajectory.

The trajectory can be displayed using two views:

- Lateral air situation display in a "Main Radar window" (or "secondary radar window");
- Vertical profile in a so-called "vertical aid window".



The radar window enables to display the predicted trajectory from the current position of the track corresponding to the aircraft to its destination.

The radar window enables to display all waypoints of the predicted trajectory.

The radar window enables to display all ground-estimated times over the waypoints of the predicted trajectory.

The radar window displays the predicted trajectory using a dedicated colour.

The radar window enables to display potential conflicts with the predicted trajectories of other aircraft.

The "vertical aid window" enables to display the predicted vertical profile from the last reported position (APR) to its destination.

The vertical aid window displays the predicted vertical profile using a dedicated colour.

The vertical aid window enables to display the actual flight levels of the waypoints belonging to the predicted vertical profile.

The vertical aid window enables to display potential conflicts with the predicted trajectories of other aircraft, MTCD conflicts

End of requirement

[E3-GND-4D-TRAJ-6]

Requirement title Probing potential route changes

The ground system enables the Controller to:

- Graphically modify the future route of the aircraft (displayed by a dedicated colour);
- Probe it to assess potential conflicts with other aircraft; and
- Update it if the Controller decides to implement the modifications.

End of requirement

[E3-GND-4D-TRAJ-7]

Requirement title Display of the aircraft downlinked 4D-trajectory

The ground system will enable the Controller to display on her/his Controller Working Position the downlinked aircraft 4D-trajectory, independently of the aircraft trajectory predicted by the ground system.

The downlinked trajectory can be displayed using two views:

- Lateral air situation display in a "Main Radar window" (or "secondary radar window");
- Vertical profile in a so-called "vertical aid window".

The radar window enables to display the downlinked 4D-trajectory from the last waypoint that was over-flown by the aircraft to its destination.

The radar window enables to display all waypoints of the downlinked 4D-trajectory, and their type (e.g.: boundary, geographical, airport, reporting point).

The radar window enables to display all aircraft-estimated times over the waypoints of the downlinked 4D-trajectory.

The radar window displays the downlinked 4D-trajectory using a dedicated colour.

The "vertical aid window" enables to display the downlinked vertical profile from the current



position of the track corresponding to the aircraft to its destination.

The vertical aid window displays the downlinked vertical profile using a dedicated colour.

The vertical aid window enables to display the actual flight levels of the waypoints belonging to the downlinked vertical profile.

End of requirement

3.2.1.3 RBT negotiation exchanges

Hyp-11

The quality / robustness of the transmission protocol has no adverse impact on the exchanges

Hyp-12

« FANS » logics and sequence is complied with (WILCO means an action...)

3.2.1.3.1 Requirements applicable to the airborne system

[E3-AIR-4D-TRAJ-13]

Requirement title CPDLC connexion

The airborne system shall be able to establish a CPDLC connexion with the ground system.

End of requirement

[E3-AIR-4D-TRAJ-3]

Requirement title Uplink CPDLC message display

The airborne system shall be able to display on a DCDU an uplink CPDLC message received from the ground system.

End of requirement

[E3-AIR-4D-TRAJ-4]

Requirement title Answer to Uplink CPDLC message

The airborne system shall allow the pilot to answer an uplink CPDLC message received from the ground system

End of requirement

Additional information: answer can be WILCO, UNABLE, STANDBY.

[E3-AIR-4D-TRAJ-5]

Requirement title CPDLC message loading

The airborne system shall allow the pilot to load in the FMS the following CPDLC messages:

- Uplink message#79: Cleared to [position] via [route clearance];
- Uplink message#83: At [position] cleared [route clearance];
- Uplink message#80: Cleared [route clearance];



- CROSS [position] at [time] message.

End of requirement

Additional information:

- Time has a resolution of 1 second;
- The test scenarios are using the existing level of automation between the separated DCDU for the pilot / controller negotiation, and the Simulated FMS only controlled by the pilot. Some "FMS upload" from available DCDU data are foreseen, but manual inputs from the pilot on the FMS are still required.

[E3-AIR-4D-TRAJ-6]

Requirement title Answer to confirm ETA request

The airborne system shall answer a CONFIRM ETA AT [position]" uplink message by a downlink message "ETA AT [position] [time]" "ACHIEVABLE RTA WINDOW [[time] – [time]]", containing the ETA and the achievable earliest and latest ETA over the requested waypoint.

End of requirement

Additional information: Note that ETA_{min} / ETA_{max} values retrieved from FMS for answer message preparation will be related to the ACTIVE flight plan.

[E3-AIR-4D-TRAJ-14]

Requirement title Clearance limit display

The airborne system shall be able to display to the pilot a clearance limit of any CPDLC route clearance.

End of requirement

Additional information: Clearance limit is defined as a waypoint of the route.

[E3-AIR-4D-TRAJ-7]

Requirement title Check ETA_{min} / ETA_{max}

The airborne system shall allow the pilot to visualize on the DCDU the message "ETA AT [position] [time]" "ACHIEVABLE RTA WINDOW [[time] – [time]]" before sending to the ground system.

End of requirement

[E3-AIR-4D-TRAJ-15]

Requirement title automatic downlink of ETA_{min} / ETA_{max}

The airborne system shall be able to downlink of ETA_{min} / ETA_{max} over a requested waypoint without pilot awareness.

End of requirement

Additional information: The aim of this requirement is to simulate an ADS-C ETA_{min} / ETA_{max} report. The system shall be configurable to select either a manual or an automatic downlink of ETA_{min} / ETA_{max} .



3.2.1.3.2 Requirements applicable to the ground system

[E3-GND-RBT-1]

Requirement title Uplink of PTC2D CPDLC message upon route change

Upon manual route modification, the ground system shall enable the controller either to select the uplink of a CPDLC message containing the corresponding clearance, or not.

End of requirement

[E3-GND-RBT-2]

Requirement title Automatic selection of the uplinked PTC2D CPDLC message type (route change without CTA)

When, on graphical flight plan modification, the controller selects the sending of the uplink clearance, the ground system shall automatically select the uplink message to be generated according to the following rules:

- When the route modification consists in modifying the route (inserting some point(s) and possibly removing other point(s) between current position and a point A further on the current route), the uplink message shall be:

UM79: Cleared to A via [route clearance]

The [route clearance] shall provide the new list of points (A excluded) between current position and the destination point A;

- When the route modification consists in modifying the route (inserting some point(s) and/or removing other point(s)) between two further points A and B on the current route, the uplink message shall be:

UM83: At A cleared [route clearance]

The [route clearance] shall provide the new list of points between A (excluded) and B (included).

End of requirement

[E3-GND-RBT-3]

Requirement title CPDLC Complete RouteClearance Uplink

The ground system shall provide the controller with the capability to send to the aircraft a CPDLC RouteClearance providing the air system with a complete RouteClearance from the current aircraft position to the destination airport. This clearance shall reflect the current flight plan in the ground system. The uplink message shall be:

UM80: Cleared [route clearance]

End of requirement



[E3-GND-RBT-4]

Requirement title Request to confirm ETA on a further position

The ground system shall provide the controller with the capability to uplink to the pilot a CONFIRM ETA AT [position]" uplink message".

End of requirement

Additional information: This message does not exist in the current FANS 1/A or ATN standards, therefore a CPDLC free text message element will be used for its transmission.

[E3-GND-RBT-5]

Requirement title Receipt of downlinked ETA_{min} / ETA_{max} information

The ground system shall display to the controller the message "ETA AT [position] [time]" "ACHIEVABLE RTA WINDOW [[time] – [time]]" received in response to a request to confirm the ETA on the position.

End of requirement

[E3-GND-RBT-6]

Requirement title CTA with speed adjustment only

The ground system shall provide the controller with the capability to input a Controlled Time of Arrival (CTA) on any point of the flight path, without modifying the flight route, and to send to the aircraft the corresponding clearance. In such case the clearance shall be the following multi-element message:

UM51: CROSS [position] at [time] message

UM169: nn

Where nn is the number of seconds in the CTA expressed with two digits (the current standards define the [time] only in hour-minutes).

End of requirement

Additional information: time has a resolution of 1 second.

[E3-GND-RBT-7]

Requirement title PTC2D CPDLC message uplinked with CTA

The controller shall have the possibility to input in a two-step command a CTA on a point further on the route and a route amendment between current position and this point and to select or not the corresponding CPDLC message. The automatic selection of the message shall be the same as defined in requirement [E3- GND-RBT -2] above with, in addition, in the subfield Routeinformationadditional of the RouteClearance an RTA on the point on which the CTA is to be applied.

To be able to provide the pilot with a CTA in hour-minutes-seconds, the free text element UM169 shall be added in the message with the seconds expressed in two digits (nn).

End of requirement



[E3-GND-RBT-8]

Requirement title Display of uplinked and downlinked CPDLC message

The ground system shall provide the controller with the display of the uplinked CPDLC messages and downlink received responses in a window, allowing visualizing the messages in a per dialogue basis.

End of requirement

[E3-GND-RBT-9]

Requirement title Receipt of WILCO Downlinked CPDLC message

When receiving the downlink "WILCO" CPDLC message in acceptance of an uplink clearance, the ground system shall modify automatically the flight plan route according to the clearance.

End of requirement

[E3-GND-RBT-10]

Requirement title Receipt of UNABLE Downlink CPDLC message

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.

End of requirement

Additional information: On receipt of STANDBY, the ground system will not change the status of the clearance.

[E3-GND-RBT-11]

Requirement title CPDLC messages display

The ground system shall provide the controller with a capability to visualise all CPDLC dialogs, closed and in progress.

End of requirement

[E3-GND-RBT-12]

Requirement title Cancel RTA

The ground system shall provide the controller with a capability to cancel RTA. This process could result from a pilot information that the RTA became non achievable, on the basis of a traffic avoidance event, or more generally for the release of unnecessary constraint.

End of requirement



3.2.2 ASAS Sequencing and Merging Function

3.2.2.1 Introduction

The ASAS S&M functions will take into account a target aircraft designated in the ASAS S&M manoeuvre instruction. The position and possibly the intent of the target aircraft (transmitted via ADS-B technique) will be used by the Instructed Aircraft, to fly the S&M procedure.

This new function implementation in the FMS and in the ground system allows optimising the completion of the ASAS S&M procedure by the aircraft.

3.2.2.2 Functional Requirements

3.2.2.2.1 Requirements applicable to the airborne system

[E3-AIR-ASAS_SM-1]

Requirement title **ASAS SM instruction manual definition**

The airborne system shall allow the crew to manually define an ASAS SM instruction.

End of requirement

[E3-AIR-ASAS_SM-2]

Requirement title **Target aircraft identification**

The airborne system shall allow the crew to identify the target aircraft of the ASAS SM instruction.

End of requirement

[E3-AIR-ASAS_SM-3]

Requirement title **ASAS SM instruction insertion**

The airborne system shall allow the crew to insert the ASAS SM instruction in the active flight plan.

End of requirement

[E3-AIR-ASAS_SM-4]

Requirement title **ASAS SM trajectory computation**

The airborne system shall compute an ASAS trajectory from the inserted ASAS SM instruction.

End of requirement

[E3-AIR-ASAS_SM-5]

Requirement title **ASAS SM trajectory guidance**

The airborne system shall guide the aircraft along the ASAS trajectory.

End of requirement



[E3-AIR-ASAS_SM-10]

Requirement title ASAS SM speed

The airborne system shall manage the aircraft speed so as to respect the spacing requested by the ASAS SM instruction.

End of requirement

[E3-AIR-ASAS_SM-6]

Requirement title ASAS SM information display

The airborne system shall be able to display to the crew the parameters necessary for the crew to monitor the ASAS instruction.

End of requirement

[E3-AIR-ASAS_SM-7]

Requirement title ASAS SM instruction cancellation

The airborne system shall allow the crew to cancel an ASAS SM instruction.

End of requirement

Additional information: behaviour of the airborne system in case of ASAS SM instruction cancellation is TBD.

[E3-AIR-ASAS_SM-8]

Requirement title ASAS SM warning

The airborne system shall warn the crew when the ASAS SM instruction cannot be met.

End of requirement

[E3-AIR-ASAS_SM-9]

Requirement title ASAS SM CPDLC message loading

The airborne system shall allow the pilot to load the ASAS SM CPDLC message.

End of requirement

[E3-AIR-ASAS_SM-11]

Requirement title Answer to ASAS SM CPDLC message

The airborne system shall allow the pilot to answer an ASAS SM CPDLC message received from the ground system.

End of requirement

Additional information: answer can be WILCO, UNABLE, STANDBY.

3.2.2.2.2 Requirements applicable to the ground system



[E3-GND-ASAS_SM-1]

Requirement title ASAS SM instruction manual elaboration

The ground system shall allow the controller to manually elaborate and validate an ASAS SM instruction, using graphical tools.

End of requirement

[E3-GND-ASAS_SM-2]

Requirement title ASAS SM procedure monitoring

The ground system shall provide graphical means allowing the controller to monitor the progress of the ASAS SM procedure applied to a pair of aircraft.

End of requirement

[E3-GND-ASAS_SM-3]

Requirement title ASAS SM procedure cancellation

The ground system shall allow the controller to cancel an ASAS SM procedure.

End of requirement

[E3-GND-ASAS_SM-4]

Requirement title ASAS SM procedure: graphic designation of the instructed aircraft

The ground system shall enable the ATCo to designate the instructed aircraft of the ASAS S&M manoeuvre using graphical tools on her/his Controller Working Position.

End of requirement

[E3-GND-ASAS_SM-5]

Requirement title ASAS SM procedure: graphic set up of a link between the instructed and target aircraft

The ground system shall enable the Controller to establish a link from the instructed aircraft to the target aircraft using graphical tools on her/his Controller Working Position.

End of requirement

[E3-GND-ASAS_SM-6]

Requirement title ASAS SM procedure: setting up of a trail of several aircraft

The ground system shall enable the Controller to combine several designations and setting up of links between target aircraft and instructed aircraft, in order to constitute a trail of aircraft

End of requirement

[E3-GND-ASAS_SM-7]

Requirement title ASAS SM procedure: verification of the eligibility

The ground system shall check that the designation and link operations requested by the Controller are applied on eligible aircraft (e.g. the corresponding flight is "assumed", the track



is coupled to a flight plan, etc.).

End of requirement

[E3-GND-ASAS_SM-8]

Requirement title ASAS SM procedure: display sharing

Once the Controller has designated and set up a link between the instructed aircraft and the target aircraft, the corresponding symbols representing this situation shall appear on all Controller Working Positions that display the two aircraft involved in the ASAS SM procedure.

End of requirement

[E3-GND-ASAS_SM-9]

Requirement title ASAS SM procedure: transmission of the "IDENTIFYING" instruction

Once the link has been set up between the instructed aircraft and the target aircraft, the ground system will enable the Controller to transmit the IDENTIFYING instruction to the aircraft by CPDLC. The graphic display of the link between the two aircraft shall change to reflect this new situation.

End of requirement

[E3-GND-ASAS_SM-10]

Requirement title ASAS SM procedure: reception of the confirmation to the "IDENTIFYING" instruction

Once the ground system has received a confirmation from the aircraft, the status of the link between the instructed and the target aircraft will become "IDENTIFIED". The graphic display of the link between the two aircraft shall change to reflect this new situation.

End of requirement

[E3-GND-ASAS_SM-11]

Requirement title ASAS SM procedure: transmission of the ASAS SM instruction

Once the link between the target aircraft and the instructed aircraft has changed to "IDENTIFIED", the ground system shall enable the Controller to transmit the ASAS SM instruction ('Remain Behind', 'Merge Behind' and 'Vector then Merge Behind') to the aircraft and manage its potential answers (WILCO, STANDBY, UNABLE). The graphic display of the link between the two aircraft shall change upon reception of a "WILCO".

End of requirement

3.2.3 Test means Requirements

3.2.3.1 Introduction

This paragraph contains requirements on test means necessary to carry out the scenarios defined in document [2] and to achieve validation objectives described in paragraph 2.3. It addresses simulation environment, recording and analysis capabilities, other functions (i.e. different from the tested functions described in the above paragraph) of ground or airborne systems which are requested to run the scenarios.



3.2.3.2 Requirements applicable to the platform

[E3-SYS-TEST-1]

Requirement title Time reference synchronisation

The time reference of the airborne system shall be synchronized with the time reference of the ground system

End of requirement

[E3-SYS-TEST-2]

Requirement title Centralized simulation control

The technical validation platform shall allow an operator to start the aircraft simulation and the surrounding traffic simulation using a centralized simulation control located in EPOPEE.

End of requirement

3.2.3.3 Requirements applicable to the airborne system

[E3-AIR-TEST-1]

Requirement title Aircraft simulation

The airborne system shall provide a high fidelity aircraft simulation

End of requirement

[E3-AIR-TEST-2]

Requirement title Surrounding traffic

The airborne system shall use the surrounding traffic generated by the ground system.

End of requirement

Additional information: the surrounding traffic is used for display on the ND and by the ASAS S&M function.

[E3-AIR-TEST-3]

Requirement title AOC wind and temperature

The pilot shall be able to request wind and temperature data from AOC and to insert them in the FMS.

End of requirement

Additional information: the AOC datalink has not to be realistic

[E3-AIR-TEST-4]

Requirement title Airborne Data Recording

The airborne system shall provide recording and visualisation of simulation data

End of requirement



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[E3-AIR-TEST-5]

Requirement title **Batch mode**

The airborne system shall be able to run in batch mode, without pilot action

End of requirement

Additional information: the aim of the batch mode is to get statistical results to test the RTA performance requirements.

[E3-AIR-TEST-6]

Requirement title **Batch scenarios**

The batch mode shall allow to run several scenarios without operator action

End of requirement

[E3-AIR-TEST-7]

Requirement title **Batch scenario input**

It shall be possible to make vary the following elements for each batch scenario:

- Flight plan Route
- Cruise FL
- Predicted winds and temperatures
- Moment when the RTA is entered in the FMS
- RTA point
- Value of the RTA relative to the ETA_{min} / ETA_{max} window

End of requirement

[E3-AIR-TEST-8]

Requirement title **Batch recording**

For each scenario, the difference between the RTA and the actual time over the RTA waypoint shall be recorded.

End of requirement

Additional information: this implies that in the batch mode, the aircraft shall be able to fly the predicted trajectory; therefore, it shall use a realistic modelling of the aircraft.

[E3-AIR-TEST-9]

Requirement title **Batch output**

The results of all the scenarios of one batch shall be presented in a graphical way.

End of requirement



3.2.3.4 Requirements applicable to the ground system

[E3-GND-PSA-2]

Requirement title Data Recording

The ground system shall provide the capability of real-time recording of data relative to:

- 4D-Trajectories and ADDs received from the EPOPEE aircraft;
- EPOPEE aircraft successive positions (provided by the ground surveillance means);
- 4D-Trajectories computed by the EUROCAT;
- CPDLC messages exchanged between Pilot and Controller;
- Key events of the scenario (e.g. CPDLC message exchange, fly over an intermediate point of the ASPA 'radar vector then merge' manoeuvre).

This data shall be easily readable to perform post simulation analysis, and to present them graphically.

End of requirement

Additional information: Off-line analysis will consist of:

- *Comparison of downlinked trajectory predictions and ground trajectory predictions;*
- *Comparison of ground trajectory predictions with or without use of downlinked 4D-trajectories.*
- *Comparison of ground trajectory predictions with the trajectories actually flown*

[E3-GND-PSA-3]

Requirement title Generation of Surrounding Air Traffic

The ground system shall include an Air Traffic Generator having the following capabilities:

- Simulation of the surrounding air traffic: generation of simulated aircraft trajectories (based on offline prepared scenarios and real time pilot commands);
- Elaboration of corresponding Flight Plan messages (sent to EUROCAT-E to initialise the flight plans of EPOPEE and the surrounding air traffic);
- Scenario control;
- Time Management.

End of requirement

3.2.4 Prerequisites

3.2.4.1 Introduction

This paragraph contains prerequisites for the tested systems, which are requested to run the scenarios. It addresses more specifically the simulated FMS since it does not implement all the functions of a real FMS. It ensures that the simulated FMS provided a set of existing functions necessary for the technical validation.



3.2.4.2 Requirements applicable to the airborne system

[E3-AIR-PRE-1]

Requirement title Flight planning

The FMS shall allow the pilot to define an entire flight plan with arrival procedures and corresponding altitude/speed constraints

End of requirement

[E3-AIR-PRE-2]

Requirement title Optimisation/Performance

The FMS shall compute position, altitude, speed and time predictions using wind and temperature information.

End of requirement

[E3-AIR-PRE-3]

Requirement title Guidance

FMS DES mode shall be implemented

End of requirement

Additional information: Descent segment can be flown using full managed.

[E3-AIR-PRE-4]

Requirement title Aircraft position

The airborne system shall send the position and state vector of the aircraft to the ground system

End of requirement

Additional information: This information is used by the ground system to display the simulated aircraft on the controller working position.



3.3 SUMMARY OF STATED ASSUMPTIONS

The following table summarizes the assumptions that have been identified within this document:

Title	Type	Description (including context)	Impact of this assumption on the global assessment and extrapolation of the results
Hyp-1		It is assumed for the purpose of this exercise that the Initial 4D Trajectory is a reasonable approximation of the RBT.	
Hyp-2		Five levels of wind/temperature are available in meteo data.	
Hyp-3		ASAS Spacing is available in En-Route and in Descent flight phase.	
Hyp-4		“Target” and “Instructed” a/c have FMS/navigation capabilities/performances that are similar and suitable for ASAS manoeuvres.	
Hyp-5		Both A/C follow the same flight plan (at least once the spacing is established).	
Hyp-6		A/C have to be pre-sequenced before using ASAS S&M. <ul style="list-style-type: none">• Manual ATCo sequencing.• 4D used as tool for pre-sequencing.• Use of AMAN as support for pre-sequencing.	
Hyp-7		Initial 4D and ASAS modes are mutually exclusive.	



Title	Type	Description (including context)	Impact of this assumption on the global assessment and extrapolation of the results
Hyp-8		<p>The WP6 platform simulates the relevant elements of an operational system made of air and ground segments. The operational system would include ground-based surveillance means such as radar and ADS-B ground stations, complemented by ADS-C.</p> <p>The corresponding simulated data are derived from the data provided by the simulated FMS (EPOPEE aircraft) and those transmitted by the Air Traffic Generator (surrounding traffic).</p>	
Hyp-9		<p>A RTA can be cancelled only on ground request when the RTA is not achievable or for traffic avoidance.</p>	
Hyp-10		<p>ATM requirements regarding RTA accuracy may be different within TMA or En-Route phase of flight. Since it is expected that flying high accuracy RTA will lead to fly less optimized trajectories (more margins to be taken into account in vertical profile computation...) with potential impact also on passenger comfort, it is preferable to fly with high accuracy RTAs only when required.</p>	
Hyp-11		<p>The quality / robustness of the transmission protocol has no adverse impact on the exchanges</p>	
Hyp-12		<p>« FANS » logics and sequence is complied with (WILCO means an action...)</p>	

Table 5 - List of stated assumptions



4 REFERENCES AND APPLICABLE DOCUMENTS

4.1 REFERENCES

- [1] Episode 3** Overall description of the platform and its capabilities E3-WP6-D6.2-01-TEC 0.06, 25/09/2008 TRS T06/22316 TC Public Deliverable D6
- [2] Episode 3** Technical validation scenarios E3-WP6-D6.4-01-TEC 0.09, 20/03/2009
- [3] Episode 3** Prototyping of a dense TMA Consolidated Plan E3-WP5-D5.3.6-01-PLN0.04, 26/03/2009
- [4] Episode 3** WP5 Validation Strategy E3-WP5-D5.2.1-01-PLN-V1.01 07/04/2009
- [5] EUROCONTROL** 4DTRAD OSED draft 0.38
- [6] EUROCONTROL** 4DTRAD CONOPS issue 1, December, 1st 2008
- [7] ICAO** PANS-ATM Doc 4444
- [8] ICAO** PANS-ATM Doc 9694 Part III - Draft11 (ADS-C)
- [9] ICAO** OPLINKP/1-WP/33 Appendix L (CPDLC Guidance Material) to the Report CPDLC Guidance Material
- [10] ICAO** Doc 9694 - The Manual of Air Traffic Services Data Link Applications
- [11] EUROCONTROL** EATM - DAP/SPR - LINK 2000+ PROGRAMME - BASELINE
- [12] EUROCONTROL** EATM - DAP/CSP - LINK 2000+ PROGRAMME - ATC Data Link Manual for Link 2000+ Services - version 4.0
- [13] RFG** Package I – Enhanced Sequencing and Merging Operations (ASPA S&M) - Application Description v2.3 20 - Jan-2009

4.2 APPLICABLE DOCUMENTS

- [14] Episode 3** Annex 1 – Description of Work E3-WP0-I0162-WKP-V3.00.tiff 10/07/2008



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END OF DOCUMENT