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Single European Sky Implementation support through Validation

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ANNEX E - VALIDATION PLATFORM

E.1 SUMMARY OF EXPERIMENT AND STRATEGY PLANNING

The objective of this paragraph is to provide integration and verification results for the technical validation platform described in EPISODE 3 WP 6 deliverable "Overall description of the platform and its capabilities" (Ref. [1]).

E.2 CONDUCT OF VALIDATION EXERCISE RUNS

E.2.1 Approach

The technical validation platform integrates already developed components from ground and airborne systems, adapted to cover the technical validation requirements defined in EPISODE 3 WP 6 deliverable "Requirements for technical validation" (Ref. [2]).

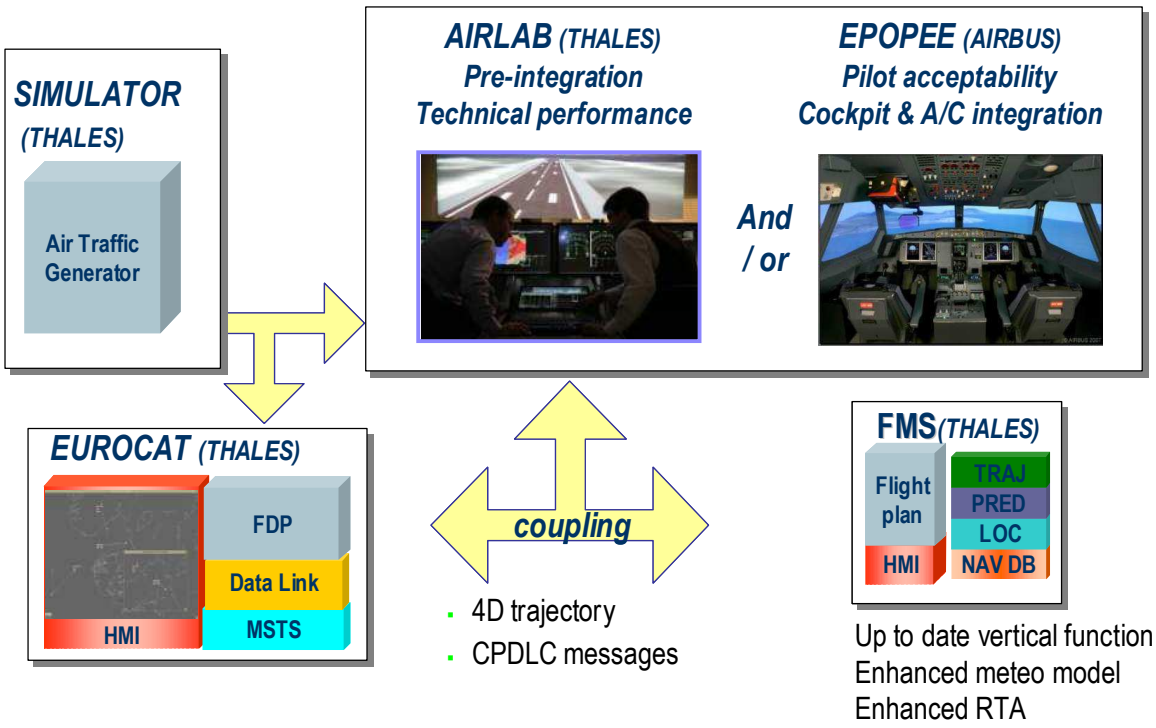

Figure E-1 – Integrated air-ground platform

The development of the technical validation platform followed a typical development process. This process is simplified compared to real equipment development since the technical validation platform is used for research only.

Starting from the technical validation requirements, System Requirement Document and System Interface Document have been written. Then for each system, detailed specifications have been edited[1].

One difficulty of the technical validation platform was the integration of heterogeneous systems:

[1] These documents are not deliverables for EPISODE 3

- The cockpit simulator provided by AIRBUS
- The simulated ATSU and FMS provided by THALES AVIONICS
- The ground system and the traffic simulator provided by THALES AIR SYSTEMS

The integration strategy was to reduce as far as possible the complexity of integration by performing pre-integration in existing context. This allowed a progressive integration with limited number of new interfaces.

Two pre-integration platforms have been used:

- In THALES AIR SYSTEMS premises: the pre-integration platform consists of a EUROCAT-E configuration identical to the one used in the EPOPEE platform, and a light version of the simulated ATSU and FMS (with a simplified aircraft model).
- In THALES AVIONICS premises: the pre-integration platform is the THALES AVIONICS research simulator called AIRLAB. This simulator integrates the simulated ATSU and FMS with representative environment models including a realistic A340 aircraft model. This platform also includes a light version of the EUROCAT-E product (with only one controller position) and the THALES AIR SYSTEMS traffic simulator.

The integration approach was the following:

- Parallel pre-integration on the THALES AIR SYSTEMS and THALES AVIONICS pre-integration platform
- Integration on the EPOPEE platform
- Functional validation of the new capabilities
- Formal verification (conformance to system requirements)

At the end of this process, the platform is ready for dry run of the scenarios and then evaluation of the tested capacities.

E.2.2 Initial Scope

The initial scope focussed on the Initial 4D function and on ASAS S&M manoeuvres “remain behind” and “merge behind”. To reduce the integration complexity the ASAS S&M was evaluated using an existing platform. Therefore the technical validation platform was used to validate the Initial 4D function.

The main purpose of the pre-integration activity was to test the interface between the EUROCAT-E and the simulated ATSU, that is:

- Downlink of the FMS predicted 4D trajectory
- CPDLC exchanges to support Initial 4D

The achievement of the pre-integration allowed pre-validation of the EUROCAT-E capabilities on the THALES AIR SYSTEMS platform, and of the simulated FMS on the THALES AVIONICS platform ([ETA_{min}, ETA_{max}] window computation, upload of CPDLC messages…).

This alleviated the integration effort between the EUROCAT-E and the simulated ATSU on the EPOPEE platform and allowed to devote the integration team's energies to the interface between the simulated ATSU and the DCDU model of EPOPEE.

The verification allowed checking the compliance of the technical validation platform with the Initial 4D requirements. Some technical verification, like the improvement the Ground-based

predicted trajectories, which do not require visual verification, were carried out on the THALES AVIONICS platform.

The results of the verification are synthesized per capability in the following table:

Capability Id	Capability title	Test results
C-ATSU-001	Downlink state vector and 4D trajectory	OK
C-ATSU-002	Establish a CPDLC connexion	OK
C-ATSU-003	Receive and display CPDLC message	Partial (problem with route clearance containing approach): A turn around is to build the CPDLC message with a local interface on the simulated ATSU
C-ATSU-004	Answer to CPDLC message	Partial (for Initial 4D)
C-ATSU-101	Downlink 4D trajectory using an ADS-C contract	OK
C-ATSU-102	Answer to ETA_{min} - ETA_{max} information request	OK
C-ATSU-103	Load CPDLC message in FMS	OK
C-ATSU-201	Load ASAS CPDLC message in TC	Not tested in initial scope
C-EUR-000	Forward and enrich traffic received from air traffic simulator to airborne system	Not tested in initial scope
C-EUR-005	Transmission of the simulated time to the airborne system	Not tested in initial scope
C-EUR-010	Reception and display of the position and trajectory of the simulated aircraft	OK
C-EUR-015	Exchange of CPDLC messages between air and ground	OK
C-EUR-120	Receiving and processing the downlinked 4D Trajectory	OK
C-EUR-121	Conformance monitoring of the final points of Airborne 4D trajectory	OK
C-EUR-122	Acceptance of the Airborne 4D trajectory	OK
C-EUR-125	Requesting a Time Information ([ETA_{min}, ETA_{max}] window) for a given waypoint	OK
C-EUR-130	Receiving and processing an [ETA_{min}, ETA_{max}] window	OK
C-EUR-135	Displaying, for a given point, the Estimated Time Over (Traffic Management Lists - TML)	OK
C-EUR-137	Probing potential route changes	OK
C-EUR-140	Up-linking a CTA to the aircraft via CPDLC	OK

Capability Id	Capability title	Test results
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	Partial (the final approach is not transmitted)
C-EUR-150	Display of uplinked and downlinked CPDLC message	OK
C-EUR-155	Receipt of WILCO downlinked CPDLC message	OK
C-EUR-160	Receipt of UNABLE downlinked CPDLC message	OK
C-EUR-165	CPDLC messages display	OK
C-EUR-200	Transmission of a whole Route clearance including final approach	Not tested in initial scope
C-EUR-205	Automatic Selection of the VIA and the Final Approach to be sent in the Route clearance	Not tested in initial scope
C-EUR-250	Graphical HMI enabling the ATCo to locally elaborate and validate an ASAS sequencing & merging instruction	Not tested in initial scope
C-EUR-255	Graphical HMI enabling the ATCo to monitor an ASAS sequencing & merging procedure	Not tested in initial scope
C-EUR-260	HMI enabling the ATCo to cancel an ASAS sequencing & merging procedure	Not tested in initial scope
C-EUR-265	Graphic HMI enabling to designate the instructed aircraft	Not tested in initial scope
C-EUR-270	ASAS sequencing & merging procedure: graphic set up of a link between the instructed and target aircraft	Not tested in initial scope
C-EUR-275	ASAS sequencing & merging procedure: setting up of a trail of several aircraft	Not tested in initial scope
C-EUR-280	Verification of the eligibility of the aircraft to be involved in an ASAS sequencing & merging procedure	Not tested in initial scope
C-EUR-285	Display sharing	Not tested in initial scope
C-EUR-290	Transmission of the "IDENTIFYING" instruction	Not tested in initial scope
C-EUR-295	Reception of the confirmation of the "IDENTIFYING" instruction	Not tested in initial scope
C-EUR-297	Transmission of the ASAS sequencing & merging instruction	Not tested in initial scope
C-FMS-001	Realistic FMS	OK
C-FMS-002	Send position and state vector	OK

Capability Id	Capability title	Test results
C-FMS-003	Send flight trajectory to ATSU	OK
C-FMS-101	Compute ETA_{min} and ETA_{max}	OK
C-FMS-102	Process loaded CPDLC message	OK
C-FMS-103	Achieve RTA function	OK (but not a statistical assessment)
C-FMS-201	Send flight information to TC	Not tested in initial scope
C-FMS-202	Build a trajectory for “vector then merge” ASAS instruction	Not tested in initial scope
C-FMS-203	Activate the trajectory for “Heading then merge” instruction	Not tested in initial scope
C-FMS-204	Send ASAS speed to FG	Not tested in initial scope
C-SIM-001	Preparation of exercises using ATG-X	Not tested in initial scope
C-SIM-002	Running exercises using ATG-X	Not tested in initial scope
C-SIM-003	Provision of simulated traffic and time by ATG-X	Not tested in initial scope
C-SIM-004	High fidelity aircraft simulation	OK
C-SIM-005	Airborne Data Recording	OK
C-SIM-006	Send simulated traffic to TC	Not tested in initial scope
C-SIM-007	Synchronize time reference	Not tested in initial scope
C-SIM-008	Centralize simulation control	Not tested in initial scope
C-SIM-009	Simulated an AOC datalink for meteo data	OK
C-SIM-010	Batch mode	Not tested in initial scope
C-TC-001	Traffic information management	Not tested in initial scope
C-TC-002	ASAS module	Not tested in initial scope

Table E-1 – Verification results – Initial scope

E.2.3 Extended Scope

The extended scope focussed on “Heading then merge” instruction and on the transition between 4D and ASAS (i.e. a CTA constraint followed by an ASAS sequencing & merging instruction).

In this phase, the pre-integration activities were limited because the TCAS and the embedded ASAS model (including the ASAS algorithm) were not available on the pre-integration platforms.

As the integration on the EPOPEE platform was more complex than in the initial scope, it was carried out in two steps:

- Airborne system integration using the same EPOPEE traffic generator as in the Initial scope
- Ground system – Airborne system integration using the ATG-X traffic simulator.

In the first step, the three ASAS sequencing & merging manoeuvres were tested first with a manual definition of the manoeuvre by the pilot, and then through the upload of CPDLC messages from the simulated ATSU to the TCAS (the CPDLC messages were generated by a local interface on the simulated ATSU).

The second steps started with a test of the new interfaces between the EUROCAT-E, the simulated ATSU and the EPOPEE platform:

- Simulated time (check that the simulated time sent by the ATG-X is available on the EPOPEE platform)
- System synchronization (check that the simulation can be started from the centralized supervision of EPOPEE)
- Simulated traffic (check that the simulated traffic generated by the ATG-X is correctly displayed on the Navigation Display and can be processed by the TCAS).

Then the ASAS sequencing & merging CPDLC could be tested: Actions on the EUROCAT-E controller position generated CPDLC messages that can be displayed on the DCDU and loaded by the pilot in the TCAS.

The verification allowed checking the compliance of the technical validation platform with the ASAS sequencing & merging requirements.

The results of the verification are synthesized per capability in the following table:

Capability Id	Capability title	Test results
C-ATSU-001	Downlink state vector and 4D trajectory	OK
C-ATSU-002	Establish a CPDLC connexion	OK
C-ATSU-003	Receive and display CPDLC message	Partial (problem with route clearance containing approach): A turn around is to build the CPDLC message with a local interface on the simulated ATSU
C-ATSU-004	Answer to CPDLC message	OK
C-ATSU-101	Downlink 4D trajectory using an ADS-C contract	OK
C-ATSU-102	Answer to ETA_{min} - ETA_{max} information request	OK
C-ATSU-103	Load CPDLC message in FMS	OK
C-ATSU-201	Load ASAS sequencing & merging CPDLC message in TC	OK
C-EUR-000	Forward and enrich traffic received from air traffic simulator to airborne system	OK
C-EUR-005	Transmission of the simulated time to the airborne system	OK
C-EUR-010	Reception and display of the position and trajectory of the simulated aircraft	OK
C-EUR-015	Exchange of CPDLC messages between air and ground	OK

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Capability Id	Capability title	Test results
C-EUR-120	Receiving and processing the downlinked 4D Trajectory	OK
C-EUR-121	Conformance monitoring of the final points of Airborne 4D trajectory	OK
C-EUR-122	Acceptance of the Airborne 4D trajectory	OK
C-EUR-125	Requesting a Time Information ([ETA_{min}, ETA_{max}] window) for a given waypoint	OK
C-EUR-130	Receiving and processing an [ETA_{min}, ETA_{max}] window	OK
C-EUR-135	Displaying, for a given point, the Estimated Time Over (Traffic Management Lists - TML)	OK
C-EUR-137	Probing potential route changes	OK
C-EUR-140	Up-linking a CTA to the aircraft via CPDLC	OK
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	OK but not always interpreted by the simulated ATSU
C-EUR-150	Display of uplinked and downlinked CPDLC message	OK
C-EUR-155	Receipt of WILCO downlinked CPDLC message	OK
C-EUR-160	Receipt of UNABLE downlinked CPDLC message	OK
C-EUR-165	CPDLC messages display	OK
C-EUR-200	Transmission of a whole Route clearance including final approach	OK but not interpreted by the simulated ATSU
C-EUR-205	Automatic Selection of the VIA and the Final Approach to be sent in the Route clearance	OK
C-EUR-250	Graphical HMI enabling the ATCo to locally elaborate and validate an ASAS sequencing & merging instruction	OK
C-EUR-255	Graphical HMI enabling the ATCo to monitor an ASAS sequencing & merging procedure	OK
C-EUR-260	HMI enabling the ATCo to cancel an ASAS sequencing & merging procedure	OK
C-EUR-265	Graphic HMI enabling to designate the instructed aircraft	OK
C-EUR-270	ASAS sequencing & merging procedure: graphic set up of a link between the instructed and target aircraft	OK

Capability Id	Capability title	Test results
C-EUR-275	ASAS sequencing & merging procedure: setting up of a trail of several aircraft	?
C-EUR-280	Verification of the eligibility of the aircraft to be involved in an ASAS sequencing & merging procedure	?
C-EUR-285	Display sharing	?
C-EUR-290	Transmission of the "IDENTIFYING" instruction	OK but the simulated ATSU can process only multi-element message
C-EUR-295	Reception of the confirmation of the "IDENTIFYING" instruction	Not tested (ATSU can process only multi-element message)
C-EUR-297	Transmission of the ASAS SM instruction	OK
C-FMS-001	Realistic FMS	OK
C-FMS-002	Send position and state vector	OK
C-FMS-003	Send flight trajectory to ATSU	OK
C-FMS-101	Compute ETA_{min} and ETA_{max}	OK
C-FMS-102	Process loaded CPDLC message	OK
C-FMS-103	Achieve RTA function	OK (see also WP6.4.1 results)
C-FMS-201	Send flight information to TC	OK
C-FMS-202	Build a trajectory for “Heading then merge” instruction	OK
C-FMS-203	Activate the trajectory for “Heading then merge” instruction	OK
C-FMS-204	Send ASAS speed to FG	OK
C-SIM-001	Preparation of exercises using ATG-X	OK
C-SIM-002	Running exercises using ATG-X	OK
C-SIM-003	Provision of simulated traffic and time by ATG-X	OK
C-SIM-004	High fidelity aircraft simulation	OK
C-SIM-005	Airborne Data Recording	OK
C-SIM-006	Send simulated traffic to TC	OK
C-SIM-007	Synchronize time reference	OK
C-SIM-008	Centralize simulation control	OK
C-SIM-009	Simulated an AOC datalink for meteo data	OK
C-SIM-010	Batch mode	See WP6.4.1 results
C-TC-001	Traffic information management	OK
C-TC-002	ASAS module	OK

Table E-2 – Verification results – Extended scope

E.3 EXPERIMENT RESULTS AND ANALYSIS

The technical validation platform is globally compliant to the validation requirements defined in EPISODE 3 WP6 deliverable “Requirements for technical validation” (Ref. [2]). The problems have been identified and turn-around has been defined to conduct the evaluation sessions.

The technical validation platform integrates ground and airborne systems that are very representative of the real systems. It allowed

- To perform pilot and controller evaluations of “Initial 4D” and “ASAS sequencing & merging” functions,
- To carry out technical verifications based on recorded data to get preliminary results on the enhancement of ground predicted trajectory using downlinked 4D trajectory.

And thus contributed to mature Aircraft and ATC System Enablers up to TRL 4.

It proved to be a suited validation means for this maturity level combining both the realism of the systems under test and the flexibility of Rapid Prototyping.

E.4 REFERENCES AND APPLICABLE DOCUMENTS

E.4.1 References

[1] Episode 3 Overall description of the platform and its capabilities
E3-WP6-D6.2-01, v2.00, 12-Aug-2009

[2] Episode 3 Requirements for technical validation
E3-WP6-D6.3-01, v1.00, 21-Sept-2009

E.4.2 Applicable documents

None

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