



Final Project Report

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Task contributors

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Abstract

P4.10 was aimed at fully introduce General Aviation (GA) and Rotorcraft (RC) operations in the SESAR CONOPS with the main ambition, to act as a bridge between GA and RC communities' operational needs and SESAR work programme.

The project specifically addressed the acquisition of new knowledge and technology validation concerning GA and RC operations, and investigated the issue of integrating GA/RC operations in the future ATM environment taking into account both ANSPs and GA/RC users' perspective

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This deliverable consists of SJU foreground.

Acronyms

Acronym	Definition
ADS-C	Automatic Dependent Surveillance Contract
ATCO	Air Traffic Controller
ATM	Air Traffic Management
CTA	Controlled Time of Arrival
CPDL-C	Controller Pilot Data Link Communications
EHA	European Helicopter Association
ETA	Estimated Time of Arrival
EPP	Extended Projected Profile
FATO	Final Approach & Take Off area
FMS	Flight Management System
GA	General Aviation
GRACE	Generic Research Aircraft Cockpit Environment
IAOPA	International Council of Aircraft Owner Pilot Association
IFR	Instrument Flight Rules
LLR	Low Level IFR Routes
LPV	Localizer Performance with Vertical Guidance
MAPt	Missed Approach Point
MTCD	Medium Term Conflict Detection
NLR	Netherlands Aerospace Centre
OI	Operational Improvement
PED	Personal Electronic Device
PinS	Point In Space
RBT	Reference Business Trajectory
RC	Rotorcraft
RNP	Required Navigation Performance

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RWY	Runway
SNI	Simultaneous Non Interfering
TMA	Terminal Manoeuvring Area
VFR	Visual Flight Rules
WIMS	Weather Information Management System

1 Project Overview

In the context of SESAR key features (e.g. Advanced air traffic services, Enabling aviation infrastructure, etc.), the Project 04.10 focused on the definition and validation of potential solutions (RNP-1) routes for GA in the TMA environment, Low Level IFR routes RNP1.0 / 0.3, PinS (Point in Space) procedures, SNI Simultaneous-Non-Interfering operations (in a busy airports) and the application of the i4D services to the rotorcraft operations in order to improve accessibility to airspace and airports for GA\RC users, being however aimed at preserve or increase the flight operations safety level, taking into account both ANSPs and GA\RC users perspectives

1.1 Project progress and contribution to the Master Plan

The project has contributed to the definition (with the contribution of EHA Community for Rotorcraft and IAOPA Community for General Aviation) and target improvement of the some operational concepts (OIs) which are mainly ascribable to the context of the 'Optimized 2D/3D routes' environment.

The results of the Project 04.10 activities are based on Roadmap Datasets from 12 to 16 (ref. [4], [19]).

Based on results achieved in the frame of P04.10 First and Second Iterations validation activities, the achieved maturity level for both concepts "Standard PinS" and "Low Level IFR routes" is V3.

Specifically, with regards to OI AOM-0104, the Project 04.10 activities have been focused to mature the "Standard PinS" concept (V3 maturity level achieved at the end of SESAR 1), with straight segments based on RNP APCH specifications (DOC 8168 requirements). The development of "Advanced PinS" concept (e.g. curved procedures in the initial, intermediate, final and missed approach segments), using possible new enablers as SVS, EVS, GBAS (etc.) will be addressed in future R&D activities in the framework of SESAR 2020.

As far as the OI AOM-0810 the Project 04.10 activities have been focused to mature the "Low Level IFR Routes" concept bringing it at the full V3 maturity level. The related SESAR Solution will be focused on "Optimised Low Level IFR routes for rotorcrafts" and will encompass all characteristics related to the development of specific RNP1.0/0.3 routes at low level into the TMA airspace in order to optimize the management of rotorcraft airspace users in the TMA and in respect of the peculiar flight performances and type of operations (not pressurized, no de-icing capability, risk of encountering icing condition increases with altitude, etc.)

The current status of this SESAR 1 Solution will allow the community to deploy LLR in Europe as any other SESAR Solutions. On the other hand, this means that further R&D activities won't be needed in SESAR 2020

Code	Name	Project contribution	Maturity at project start	Maturity at project end
AOM-0104	Enhanced Rotorcraft Operations at VFR FATOs with specific Point-in-Space RNP approaches using satellite augmentation	Evidence gathered during V2 and V3 validation activities covered the "Standard PinS" concept with straight segments based on RNP APCH specifications (DOC 8168 requirements)	V2	V3*
AOM-0810	Integration into the TMA route structure of optimised Low Level IFR route network for rotorcraft using RNP-1/RNP-0.3	Evidence gathered during V2 and V3 validation activities covered the whole concept. (V3 maturity level). A major benefits of the implementation of Low Level Routes based on RNP 1, RNP 0.3 criteria is the ability to support	V1	V3

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		reduced en-route obstacle clearance area semi-widths for rotorcraft operations.		
AO-0316	Increased Airport Performance through independent IFR rotorcraft operations	Evidence gathered during V2 (and indirectly at V3 at designing- level only) validation activities covered partially the concept (V2 only) SNI operations concept includes several options in addition to the one as Standard PinS (e.g. straight in convergent segment) addressed within the Project.	V2**	V2
IS-0303-A	Downlink of on-board 4D trajectory data to enhance ATM ground system performance: initial and time based implementation	Evidence gathered during the V2 validations confirmed some benefits achievable by the possible implementation of this concept. Nevertheless, those results pave the way to further validation activities in the future research contexts.	V1	V2***
CM-0606	Separation Management in the TMA using Pre-defined Routes with 2D RNP Specifications	Evidence gathered during the V2 validation confirmed some benefits for the General Aviation achievable by the possible implementation of this concept. Nevertheless, it is not yet possible to conclude any explicit impact or changes to regulations or standardizations and those results currently can only pave the way to further validation activities in the future research contexts.	V0	V1

1.2 Project achievements

The Project was characterised by several phases in which different activities have been performed in order to cover the identified goals.

Project Phase 1: can be divided into two main phases:

- analysis of the current situation "Data Collection" (CONOPS for STEP1, 4.2, 5.2 DoDs);
- discussion with Airspace Users (EHA, IAOPA) to identify and refine their operational needs;

Both phases were aimed at the achievement of the following important actions:

- to integrate the project 04.10 within the SESAR programme;
- to establish the links from the General Aviation / Rotorcraft "R&D needs" to the technical solutions identified within the Data Collection;

* The development of "Advanced PinS" with curved procedures in the initial, intermediate, final and missed approach segments, using possible new enablers (e.g. SVS, EVS, GBAS...) will be addressed in future R&D activities in the SESAR 2020 framework.

** The initial maturity level is referred to a not full V2. The achieved maturity level, at the end of the Project, is confirmed as full V2.

*** As per conclusions detailed in §1.5, V2 is achieved for the Airborne side, needs to be consolidated for ATCO side.

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- to ensure that the validation strategy and any proposed exercises are designed to address concepts that have emerged from the operational concepts analyses.

Project Phase 2: in the framework of the First Iteration validation activities, three different experiments were performed:

- first two validation activities were focused on the validation of routes/procedures to improve accessibility to airspace and aerodromes for rotorcraft users, while maintaining or enhancing safety levels, specifically remaining focused on procedures, such as low-level instrument flight rules (IFR) routes, Standard Point-in-Space IFR approaches and departures to and from non-IFR installations, and simultaneous non interfering (SNI) operations at airports.
 - In order to performed these exercises several PBN routes/procedures have been designed in collaboration with ANSP Airspace Designing Department:
- The third validation activity was focused on the development of specific system functionalities (FMS System with i4D functions, Datalink for CM, CPDLC, ADS-C EPP & ETA min/max, and WIMS – Weather Information Management System for receive/upgrade on-board weather parameters) in flight scenarios where rotorcraft arriving needs to be segregated up to a point in approach, from commercial airline traffic, in adverse weather conditions.

Project Phase 3: in the framework of the Second Iteration validation activities, different experiments were performed:

- a complementary validation in order to furtherly mature the results achieved within the First Iteration activities was performed in support of two main SESAR Solutions: the "Standard PinS" procedures (...straight segment) and "Low Level IFR Routes" with V3 validation successfully achieved through Live Trials within Milan TMA (Malpensa, Linate and Lugano involved airports) using AW189 and AW139 AgustaWestland helicopters provided by LEONARDO Helicopters. The validated rotorcraft flight routes/procedures are linked to the low-level IFR route that is already published and in service in northern Italy between Turin and Venice; the procedures employ the navigation infrastructure under development by ENAV in the Piemonte Region. This network, designed for rotorcraft in accordance with the PBN concept, is the most advanced IFR network of its kind in the world. The results of this innovative and forward-looking project aim to contribute to expanding the safe and efficient use of rotorcraft platforms in Europe, and providing a model that can be applied elsewhere in the world. This work is expected to form the basis of further implementation work within the assessed environment.
- a complementary validation in order to furtherly mature the results achieved within the First Iteration activities was performed with V2 validation target, addressing the i4D trajectory management (for rotorcraft) and the dialogue between Pilot and ATCO, using a full Rotorcraft cockpit simulator (Airbus Helicopter Sphere simulator) including ATC Ground platform and all system functionalities (FMS system i4D capable, Datalink and WIMS) earlier developed within the iteration 1;
- P04.10 contributed to a validation activity with V2* validation target and focused on the operational concept applied within the conflict management service through the use of enhanced ATC tools. Main contribution to this validation activity was in designing new 2D RNP 1 arrival routes network to Ciampino airport (LIRA) and providing at the same time, a General Aviation cockpit simulation (GRACE), which was able to be configured to represent the avionics systems of different aircraft types. P04.10 has contributed also in the assessment, considering the exercise from a pilot point of view whilst making use of a concept of a Personal Electronic Device (PED), such as an iPad or a Windows tablet, loaded with navigation software as single navigation tool. The objective was also to investigate whether a VFR-only equipped GA aircraft flown by a GA pilot who does not necessarily have IFR experience and even would have no IFR rating, under given conditions and with low performance navigation equipment, can safely perform in an IFR environment

* CM-0606 is stated as reaching V1 (starting from V0). It is, however, acknowledged that work on the OI has been performed for the V2-V3 phase, but only partial V2 maturity was achieved at the end of SESAR 1.

1.3 Project Deliverables

The following table presents the relevant deliverables that have been produced by the project.

Reference	Title	Description
D06	First Iteration validation activities - Validation Report	This deliverable describes the First iteration validation activities' results. It also contains issues and recommendations for the Iteration 2 Validation activities
D09	Second Iteration validation activities - Validation Report	This deliverable describes the Second iteration validation activities' results. It also contains issues and recommendations for the deployment phase
D07	FINAL - SESAR Solution Guidance VV (i4D for Rotorcraft) - GEN	This deliverable aims at providing guidance about the SESAR Solution VV (i4D services for rotorcraft); It records information to be added on top of what already exists. This information is about environment, operational scenarios, safety & performance requirements, regulation and any other information that will allow the community to understand the state of the art at the end of SESAR. This Deliverable could be seen as a complementary contribution for maturing the i4D concept (applied to the rotorcraft operations) and it might be integrated as an additional part in other Final Deliverables of other SESAR Projects
D10	FINAL - SESAR Solution Guidance XX (PinS) - GEN	This deliverable aims at providing guidance about the SESAR Solution XX (PinS - "AOM-0104 Enhanced Rotorcraft Operations at VFR FATOs with specific Point-in-Space RNP approaches using satellite augmentation") and its implementation; It records information to be added on top of what already exists. This information is about environment, operational scenarios, safety & performance requirements, regulation and any other information that will allow the community to understand the state of the art at the end of SESAR. In addition to the information coming from the project P04.10, this document considers the outcomes of relevant Demo projects.
D11	FINAL - SESAR Solution Guidance YY (LLR) - GEN	This deliverable aims at providing guidance about the SESAR Solution YY (LLR - "AOM-0810 Integration into the TMA route structure of optimised Low Level IFR route network for rotorcraft using RNP-1/RNP-0.3") and its implementation; It records information to be added on top of what already exists. This information is about environment, operational scenarios, safety & performance requirements, regulation and any other information that will allow the community to understand the state of the art at the end of SESAR. In addition to the information coming from the project P04.10, this document considers the

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		outcomes of relevant Demo projects
D23	FINAL - SESAR Solution Guidance ZZ (SNI) - GEN	This deliverable aims at providing guidance about the SESAR Solution ZZ (SNI - Simultaneous Non Interfering) operations for Rotorcraft; It records information to be taken into account during future research and Development activities, in order to allow the community to understand the current state of the art and pave the way to possible future research activities.
D24	FINAL - High Level Functional Airborne Architectures for Rotorcraft - TS	This deliverable (FINAL version) includes the final results of the impact analysis of rotorcraft relevant SESAR operations on the current and future rotorcraft system architectures. Furthermore it's complemented with recommendations for equipment's adds-on or upgrades for GA Aircrafts, taking into consideration the outcomes of the whole project.
P05.07.02 - D75	MD MC Multi Airport TMA-V2b Validation Report VP738-VP741	This deliverable shows the results of the undertaken V2a + V2b MD/MC (VP-738 and VP-741) (Italy and Spain) validation exercises as well as P5.7.3 VP-267 one. The assessment performed in this exercise was conducted from the ATCO (by ENAV) and from the pilot (by ENAVNLR) point of view.

1.4 Contribution to Standardisation

- Point in Space(AOM-0104), Low Level IFR Routes(AOM-0810) and SNI(AO-0316: no notable contribution from the project to standardisation activities;
- i4D (IS-0303-A) services for rotorcraft operations: regulation and standardisation initiatives may be impacted for:
 - the transition area where ATCO PILOT exchanges turn from datalink to voice;
 - the design of R/C GNSS procedure (to reduce the A/C-R/C separation issues);
 - the design of low altitude low speed route in TMA;
 - the integration of these route into the sequencing tool algorithms;
 - the logic of the prediction for the FMS, mainly for the use of an holding pattern;
 - the previous item should be addressed in terms of FMS prediction, information displayed to the ATCO and the logic to compute the time prediction after the holding pattern for both ATCO and crew
- Separation Management in the TMA using RNP routes (CM-0606): based on the current results obtained in the P04.10 validation activities, it is not yet possible to conclude any explicit impact or changes to regulations or standardizations. More research and validations are necessary to propose adaptations of current regulations to operate as "VFR flight" in an "IFR" environment. The recommendations (section §1.5) show suggested improvements to the evaluated GA PED applications for follow-up validations.

1.5 Project Conclusion and Recommendations

The main findings from the validation exercises can be summarised as follows:

- Instrumental access to the existing VFR FATOs
 - Reduced \unaltered workload for ATCO;
 - Reduced Pilot Workload
 - Reduced track mileage
 - Reduced fuel consumption
 - Better access to aerodromes
 - Increased safety and flight comfort thanks to geometric vertical guidance
 - Improvement of rotorcraft insertion in high density traffic
 - Implementation cost reduction as no specific infrastructure on ground at a particular airport is required
- Integration of Rotorcraft operations in dense / constrained airspace
 - Reduced\unaltered workload for ATCO ;
 - Reduced Pilot Workload;
 - Reduced track mileage;
 - Reduced fuel consumption;
 - Better transition to PinS rotorcraft approaches\ departures to/from heliports (FATOs) and from en-route to terminal route (and vice versa);
 - More direct routing in dense terminal airspace;
 - Airspace de-confliction of low altitude airways (more slots available on SIDs and STARS).
- Rotorcraft access to busy airports
 - Reduced\unaltered workload for ATCO ; (the concept removes slow traffic from runway operations and allows easier AC\RC separation);
 - Reduced Pilot Workload
 - Reduced fuel consumption
 - Better rotorcraft access to busy airports
 - Increased passenger throughput hence airport capacity at medium\large airport, removing IFR rotorcraft from active runways sequence
- Based on the outcomes from the Project activities, the i4D concept applied to the rotorcraft operations can be considered as partially achieved (V2 maturity level). This is justified by the fact that it was proved to be clear enough with regards to the airborne side, whilst the same cannot be currently confirmed for the ATCO side. For this last case, the concept needs still to be examined in depth with further studies, aimed at make clearer some operative details (e.g. metering point location before or after IAF, sequencing tool capable to take into account both aircraft and rotorcraft, etc.)
- As far as the activities which have involved the General Aviation, it has proved a real benefit deriving by the usage of some ATC tools (conflict detection tools) and 2D RNP routes for separation management. The general feedback was that MTCD, What-if and 2D RNP Routes can improve Teamwork, Workload, Usability and Situational Awareness. Their use can increase the traffic monitoring and decreases the number of task to perform. The what-if functionality was appreciated and controllers suggested also added way to use it (e.g. using it

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neighbouring sectors). As far as the airborne evaluation, it is concluded that the general impression about using a PED-concept is neutral. Most pilots were more or less satisfied with the presentation of waypoints, terrain, situation awareness and workload. The meaning of symbols and use of colours were clear in operating the PED. The results showed that pilots without or with little experience in instrument flying tended to have a more overall positive impression of the PED-concept compared to the pilots with "IFR experience" that consider the concept could be used only in special situations where all involved parties are aware of the restrictions and when the required measures are taken. It was found that situation awareness and safety were acceptable but that some training with the PED-concept for VFR-pilots would be necessary.

Concluding Remarks:

- The General Aviation (IAOPA) and Rotorcraft communities (EHA) are now recognised as players in the development of the future European ATM system;
- In conclusion the PED-concept needs still to be evaluated by establishing clear and suitable regulations, thanks to the follow-up research which will provide surely the needed inputs for the development. Flying and navigating with the PED-concept at the current maturity level of the concept and under the same conditions valid during the experiment, seems not to be satisfying enough to meet the RNP1 requirement. Only a clear and understandable regulations can allow that an acceptable level of Safety will be guaranteed. More research activities are required to determine exactly the scope of using the PED-concept in IFR environment. Naturally the success key will be a close collaboration between the industrial manufacturers, research Partners and regulation authorities;
- Rotorcraft unique capabilities and specific operations are fully considered in SESAR ConOps and in the European ATM Master Plan;
- SESAR R&D Projects and Large Scale Demonstrations related to rotorcraft operations are currently running and already delivered tangible / promising results (P04.10, PROuD), thus paving the way for operational implementation;
- In Italy and particular in Piemonte region, ENAV has started LLR (Low Level IFR Routes) RNP- 0.3 and PinS network for emergency rotorcraft operations in coordination with national emergency centre;
- The Project 04.10 activities have been focused to mature the "Standard PinS" concept (V3 maturity level achieved at the end of SESAR 1), with straight segments based on RNP APCH specifications (DOC 8168 requirements). The development of Advanced PinS concept (e.g. curved procedures in the initial, intermediate, final and missed approach segments, new enablers as SVS, EVS, GBAS, etc.) will be addressed in SESAR 2020 activities. Specifically the Project outcomes have confirmed the benefits (qualitative and some quantitative) and provided some foreseen assumptions for future implementation and research technology activities to be conducted in SESAR2020 such as:
 - Curved flight path for the entire approach phases, (including final approach segment and missed approach one) and the introduction of RF paths terminator. This will lead to a further and better optimisation of flight approach paths and will imply the major KPA/KPI to be further evaluated and improved;
 - Integration and validation of RNP 0.3 all phase of flight (as already verified and monitored during Flight Trials EXE-818) and assumption to down lower the RNP. This will increase airport capacity in some specific environmental operational scenario (i.e: mountainous areas, congested and rich obstacles environment, urban areas..etc), in which more tighter corridors and precise paths are required and applicable;
 - Future enablers like SVS and EVS could support and enhance new approach procedures to (VFR) FATO providing rotorcraft with specific instrument approaches according to a better design approaching minima, removing rotorcraft operations from main runway and improving rotorcraft flexibility operations in bad weather conditions, increasing pilots situational awareness.

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