***Contextual note – PJ.02-05***

***"Independent Rotorcraft operations at the Airport"***

***Purpose:***

*This contextual note introduces a SESAR solution (for which maturity has been assessed as sufficient to support a decision for industrialization) with a summary of the results stemming from R&D activities contributing to deliver it. It provides to any interested reader (external and internal to the SESAR programme) an introduction to the SESAR solution in terms of scope, main operational and performance benefits, relevant system impacts as well as additional activities to be conducted during the industrialization phase or as part of deployment. This contextual note complements the technical data pack comprising the SESAR deliverables required for further industrialization/deployment.*

## Improvements in Air Traffic Management (ATM)

SESAR solution "***Independent Rotorcraft operations at the Airport***" refers to simultaneous and non-interfering operations through SBAS (and GBAS as an optional enabler) approach/departure procedures independent from the main runway and dedicated only to rotorcraft operations.

The solution aims at moving rotorcraft operations from the active runway to facilitate fixed wing aircraft operations and improve rotorcraft operations by deploying specific IFR procedures to/from an existing VFR FATO. The independent procedures rely on performance-based navigation – specifically required navigation performance (RNP0.3) – to reach a point-in-space (PinS) to access the final approach and take-off area (FATO). The rotorcraft capabilities of tight turns, steep climb and descent, combined with dedicated IFR procedures based on GNSS and the RNP navigation specification not only avoid the interaction of rotorcraft with fixed-wing aircraft, but also optimise operations in obstacle-rich urban environments and noise sensitive areas. The solution targets, in particular, relatively large and very large airports and high complexity airspaces.

## Operational Improvement Steps (OIs) & Enablers

*Reference: Integrated Roadmap Dataset 19p complemented by change request CR-03260 reflecting the latest changes in the solution description.*

### AO-0316 Increased Airport Performance through Independent (parallel or convergent) IFR Rotorcraft Operations

Using Rotorcraft specific independent IFR procedures to/from Final Approach & Take-Off areas (FATO) located at airports will remove IFR rotorcraft operations from active runways and allow aircraft and rotorcraft simultaneous non-interfering operations (SNI). This rotorcraft specific independent IFR procedure will include (parallel or convergent) Point-in-Space (PinS) procedure to enable access to/depart from a FATO located at the airport. When reaching the



 

PinS, the pilot shall decide either to proceed to a landing or to abort the approach. The PinS is also the MAPt (Missed Approach point).

In case of IFR FATO implemented for SNI IFR operations, the specific independent IFR procedure could be designed as a direct procedure.

**Required Enablers:**

- Developed by the SESAR solution and covered in the solution data pack:
    - **PRO-251 ATC Procedure to handle SNI IFR rotorcraft operations using PinS**.

- Assumed and used by the SESAR solution:
    - A/C-01 Enhanced positioning for LPV/RNP based on Single Frequency SBAS;
    - A/C-04 Flight management and guidance for improved lateral navigation in approach via RNP;
    - A/C-04b Flight management and guidance for RNP 0.3 (Category H(rotorcraft)) in all phases of flight, except final approach and initial missed approach;
    - A/C-06 Flight management and guidance for LPV approach based on SBAS;
    - A/C-07 Flight management and guidance for RNP transition to ILS/GLS/LPV.

In its development, solution PJ.02-05 took into consideration as assumptions all the system technical enablers listed above, as these ones were already fully mature. Besides, the solution contributed mainly to mature the PRO enabler, specifically focused on independent rotorcraft operations (SBAS based).

**Optional Enablers:**

- A/C-02a Enhanced positioning using GBAS single frequency;
- A/C-23a Synthetic vision in low visibility conditions;
- BTNAV-0502 Update of Minimum Performance Standard for Enhanced Vision (EV);
- BTNAV-0503 New ARP standard for Transport Category Airplane HUD/SVS systems;
- BTNAV-0504 Update of Minimum Performance Standard for Airborne Synthetic Vision (SV);
- CTE-N07a GBAS Cat I based on Single-Constellation / Single-Frequency GNSS (GPS L1);
- REG-0009 AMC for Curved Approaches;
- STD-025 Harmonisation Specifications on Ground Based Augmentation System Ground Equipment to Support Category I Operations;
- STD-043 EN 303 084, Ground Based Augmentation System (GBAS) VHF ground-air Data Broadcast (VDB);
- STD-067 DO-253D GBAS MOPS' & DO-246E 'GBAS ICD.

Solution PJ.02-05 also confirmed that the new rotorcraft procedures can also be flown based on optional technical enablers related to synthetic vision systems (A/C-23a) and GBAS technology (A/C-02a). GBAS would be required for safely conducting the flight in those operating environments where SBAS is not available (e.g. Latitude > 60° N and < 60°S).

The independent rotorcraft operations considered in the context of solution PJ.02-05 are enabled by the Point-In-Space operational concept, defined by pre-SESAR **AOM-0104-A** *Enhanced Rotorcraft Operations at VFR FATOs with specific Point-in-Space RNP procedures using satellite augmentation* and SESAR solution PJ.01-06 (**AOM.0104-B** *Advanced Point-in-Space RNP approaches and departures)*, respectively focused on **Standard PinS** (straight final segment) and **Advanced PinS** (curved final segment) procedures.

## Background and validation process

Solution **PJ.02-05** activities focused on assessing the operational and technical feasibility of the independent IFR rotorcraft approach/departure procedures to/from a FATO located at the airports. The solution examined technical capabilities (both ground and airborne sides) and procedural means needed to enable independent rotorcraft operations to comply with ATC instructions and/or to integrate with other manned traffic into the same airspace and airport environment.

The solution work was based on the development and assessment of 4 independent SNI PinS Procedures. In particular, one departure SNI PinS procedure (**RNP MCE2**, RNP0.3) and three approach SNI PinS procedures (**RNP 310/320/350**, RNP0.3), characterised by different approach angles/GPA, were developed.

With the aim to complete the R&D phase and transition towards industrialisation and deployment, the solution work went through four V3 validation activities in realistic target environments with main following scopes:

- A real time simulation exercise assessed the benefits of introducing IFR independent procedures for rotorcraft to/from a FATO located at the airport. The procedures were designed in accordance with ICAO8168 and ICAO9643 requirements, and SBAS based for enabling the rotorcraft SNI operations and optimize the traffic flow to/from Milan Malpensa airport and Milan TMA airspace (LIMM ACC). The validation investigated human performance and safety;
- A real time simulation evaluated the rotorcraft on-board systems behaviour and the workload and situation awareness of the crew, using an avionics real time simulator "Avionic RIG" (provided by LEONARDO). The exercise assessed how the on-board systems react when the pilot is carrying out some specific operations (flying the SNI PinS procedures), considering also the additional value of curved segment and RNP 0.3 in all phases of flight. The exercise scope was limited only to the airborne assessment and it represented also a preparatory step for the live flight trial (see below) as the software and advanced simulation platforms equal in performances to the real ones;
- A live flight trial assessed the benefits of enhanced rotorcraft operations at VFR FATOs (located at the airport) with specific "Point in Space" RNP 0.3 approach/departure procedures using SBAS guidance as one of the main applications of the SNI operational concept. The scenario identified for flight trials was Milan Malpensa Airport (and



 

partially Milan TMA airspace \ LIMM ACC, classified as high complexity/high density environment);

- In addition, and in order to assess the optional technical enablers, a second live flight trial assessed the benefits (from the pilot's situational awareness point of view) of using synthetic vision systems (during the final phases of the approach) and specific GBAS based PinS procedures, in order to identify possible design criteria for GBAS PinS and reduce further the approach minima value.
  With the main scope to assure a dedicated set of information and post flight data analysis covering the GBAS concept of application, a set of specific flight campaigns took place at Zurich airport, Switzerland, supporting GBAS Cat I approaches. GBAS/GNSS approaches in relation to the on-board sensors are not new, however, the global standards of GBAS applied require certain approaches to be performed as well as GBAS parameters to be recorded and validated specifically for rotorcraft performances and FMS management.

**Additional Activities**

- The flight trials were performed also using helicopters' ADS-B OUT capabilities, which provided air traffic controllers with high accuracy positional data and flight information. The ADS-B output accuracy is greater when using satellite and transponder technology than with conventional radar surveillance. This enables ANSPs/CAAs (Air Navigation Service Providers / Civil Aviation Authorities) to potentially reduce the required separation minima between aircraft that are ADS-B equipped. ADS-B is a key element for maintaining future efficient airspace management in busy airspace, class A;
- Dedicated real time simulation runs were performed to assess how the flight crew could handle contingency events (e.g. loss of signal, loss of integrity). Those particular events of contingency have not been assessed during flight trials for safety reasons.

The first two validation exercises (RTS) took into consideration all the designed SNI PinS procedures, whilst during the Flight Trial only the SNI PinS RNP MCE02 (departure) and RNP350 (arrival) were considered.
This was due to the fact that the SNI PinS procedures, which have trajectories *not immediately interpretable/detectable by commercial aviation pilots*, should be avoided.

The post-run debriefings performed during the real time simulations confirmed that an SNI PinS trajectory convergent (e.g. RNP310/320) to ILS procedure could lead to an increase of workload of commercial pilots, given the possible pilot's requests for information to ATCOs. The possible pilot's increasing workload together with ATCO's preference for managing parallel traffic instead of convergent, justify the interest by solution PJ.02-05 to invest the R&D activities mainly on the independent procedures with final segment parallel to the ILS approach (e.g. RNP350).
The SNI PinS procedures convergent to the ILS procedures can, however, be very useful where the operating environments are less congested. Moreover, these procedures can better fit with the existing ATC elements (e.g. network routes, SIDs and STARs).

Finally, for completeness of the study, solution PJ.02-05 work referred to some results in terms of flight efficiency, achieved in SESAR 1 Projects (e.g. Project 04.10).

## Results and performance achievements

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

- **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;
  - Limited implementation costs as no specific ground infrastructure 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;
  - Improvement of rotorcraft insertion in high density/complexity airspace;
  - Airspace de-confliction of low altitude airways (more slots available on SIDs and STARS).

With specific reference to the performance areas, the main findings can be summarized as follows:

<u>Access & Equity</u>

- **Improved airspace accessibility**: currently the rotorcraft operations (strictly dependent on the ability to meet the VFR visibility standards) are usually segregated into uncontrolled airspace and as such these are operations not allowed within a large number of European TMA airspace (class A) and to/from most of the European airports.
  This SESAR solution offers the rotorcraft airspace users to fly from airport A to airport B inside a class A high complex/dense airspace (e.g. Milan ACC/TMA approach/departure sectors) and, simultaneously, without impacting the efficiency of the arrival/departure runway sequencing traffics. The introduction of SNI IFR Point-in-Space procedures (RNP0.3) to/from a FATO located at a large/very large airport demonstrated a significant improvement in terms of safety, efficiency and access & equity for the rotorcraft operations so far as IFR operations be allowed within TMA (class A) and to/from airports within CTRs in class D (or class C).

<u>Flight efficiency & environment</u>



 

- **Reduced fuel consumption and associated $CO_2$ emissions and flight duration:**
    - ≈ - 8.03 % fuel saved for RNP310/RNP320 and
    - ≈ - 18.79 % fuel saved for RNP350;
    - ≈ -41.25 kg of $CO_2$ emissions x R/C for RNP310/320 and
    - ≈ -96.45 kg of $CO_2$ emissions x R/C for RNP350;
    - ≈ -06:40 time reduction in approaching RNP310/RNP320 and
    - ≈ -08:23 time reduction in approaching RNP350.
- Time to fly each arrival leg and final approach procedure (e.g. IFR SNI PinS):
    - ≈ -21.25 % time reduction for RNP310/320 procedures and
    - ≈ -26.73 % time reduction for RNP350.
- Enhanced transition from the en-route phase (e.g. ACC/TMA sectors) to the approach phase (e.g. Point-in-Space SNI IFR rotorcraft procedures) to the final approach and take off area-FATO (and vice versa) located at large/very large airport;
- More direct routing in high-density terminal airspace.

Two main conclusions can be derived from the validation activities:

1. The new procedure forecasts an independent route segment with a final approach path dedicated to rotorcraft and allows rotorcraft to land without impacting conventional IFR traffics:
    - This brings qualitative benefits for all IFR traffic because they will not be impacted, especially in the approach phase, due to the rotorcraft lower speeds. In addition, rotorcraft can be cleared to an IFR procedure without having to suffer delays or limitations when mixed with a fixed-wing traffic;
    - Furthermore, the factor that both procedures do not interact with each other should always be taken into consideration. It means that one Rotorcraft can fly simultaneously to IFR traffic without interfering with each other;
    - The same benefits apply also to the ad-hoc departure procedure (RNP MCE2) that, disconnected from the other IFR SIDs and initial climb procedures, may either avoid delaying or limiting fixed-wing traffics departing on the same direction or interacting procedure, as well as allowing the rotorcraft to take off and follow a dedicated procedure better suited to both the characteristics of the aircraft and the FATO departure location.
2. The procedures contribute to reducing the flown distance and therefore improve fuel efficiency. The procedures also improve predictability:
    - The terminal and approach procedures (*RNP 310 & 320*) allow a reduction of 4.10 NM compared to the reference scenario;
    - In both the solution procedures a descent gradient of 5.4° in the glide path is designed from the FAF, which for a helicopter is an added value when compared to the standard 3° of the reference procedure. The improvement provides the possibility to have a better performance when compared to a fixed-wing aircraft;
    - The distance reduction improves even further up to 12.30 NM when the RNP 350 procedure is analyzed and compared with the reference;

- The low-noise IFR approach procedures were flown using accurate lateral and vertical guidance provided by EGNOS (European Geostationary Navigation Overlay Service), the European SBAS, and in the presence of fixed wing traffic, which proved the suitability of these rotorcraft-specific procedures to achieve SNI aircraft and rotorcraft IFR operations.

  The procedures assessed in the context of the Clean Sky Programme (GARDEN Project) were based on the noise optimised flight paths and have demonstrated noise footprint reductions of up to 50%. For more information, please refer to the project deliverables within the Clean Sky Programme.

In addition, the following main conclusions can be derived from the assessment of two non-nominal cases (i.e. on-board loss of GNSS integrity and loss of GNSS signal):

- In case of GNSS failure/incapability reported by the helicopter flying (convergent or parallel) SNI PinS procedures, after knowing about the conventional navigation capability or the request of surveillance radar assistance by the affected helicopter, this unusual situation could be managed as a failure of conventional radio aids (included the ground phraseology), already implemented;
- In case of low traffic in the TMA and failure on board of GNSS, it is better to apply radar vectoring than using conventional navigation to improve ATCOs situational awareness;
- In case of degraded RNP precision (failure on board), it is fundamental to define standardized information about significant deviations from procedures. This means that the training for both pilots and ATCOs will be fundamental for a successful implementation of the concept;
- No additional effort or decrease in pilot human performances has been highlighted or evaluated from the pilot's point of view. ATCOs' actions and management reverse to pilot vectoring clearances;
- Pilots' perceived level of safety and associated situational awareness is granted by the avionics monitoring and alerting, displayed on the cockpit instruments (e.g. PFD and MFD) during failures;
- A pilot identifying the impossibility to maintain the required RNP shall communicate to ATCO the failures with standard phraseology: 'Unable to maintain RNP due to…' with not additional workload or unexpected crew coordination on board;
- Once a failure typology identified, the flight was conducted with the same level of safety and in an efficient way, in line with the ATCO's guidance and vectoring.

## Recommendations and Additional activities

Based on the experience acquired in the context of solution PJ.02-05 work, it is agreed that there still are some aspects that deserve to be thoroughly evaluated in the industrialisation and deployment phase, in particular:



 

- Consider a number of parameters that can only addressed at local level, during the solution implementation. These include but are not limited to ATCOs and pilots' workload assessment during possible non-nominal events, ATCOs and pilots' training, local safety case;
- Assessing the opportunity to use a landing location fully adapted to the instrument operations (e.g. IFR FATO), firstly to achieve better integration of the rotorcraft in the applicable operating environments; secondly, to take into consideration the large interest of the rotorcraft users community in the opportunity to use an IFR landing location. The use of IFR FATO will allow using full-IFR arrival/departure procedures instead of hybrid solutions such as the PinS procedures. Furthermore, the implementation of the concept would be much simpler because the standardization and regulation between instrument operations (and related instrument procedures) might result simpler and safer.

## Actors impacted by the SESAR Solution

Airspace users (flight crew);
Air navigation service providers (ACC\TMA\TWR ATCOs);
Airports operators;
Industrial manufacturers (rotorcraft).

## Impact on Aircraft System

The concept related to the simultaneous non-interfering rotorcraft operations at airport (e.g. PinS procedures) is based on the state of the art and the advanced rotorcraft navigation capabilities (e.g. RNP 0.3 and Radius-to-Fix (RF) path terminators, advanced FMS capabilities, GBAS receiver, etc.) and flying techniques.
A twin-engine aircraft, dual/single IFR pilot, from 6.4 to 8.5 tonnes MTOW, state of the art avionic suite bay is considered as the typical rotorcraft flying the solution. The current avionics systems have the capability to perform these operations (e.g. RNP 0.3, Radius to fix path terminator, etc.) No specific upgrade of the current available rotorcraft suit-avionics bay is needed to deploy the concept, due to the fact that the new avionic adapted features will be part of the future standard IFR rotorcraft configuration.

## Impact on Ground Systems

None

## Regulatory Framework Considerations

There is no specific topic concerning the regulatory framework to be considered in the deployment process, beyond the applicable regulations currently existing and applicable.
The RNP0.3 navigation specification used for designing the SNI IFR Independent rotorcraft procedures are well described in ICAO Manual on Performance Based Navigation (PBN), DOC9613, 4th Edition.
The ICAO PBN (Performance Based Navigation) concept is fully integrated in EASA regulatory frameworks, thanks to the development of RNP1.0/RNP0.3 navigation applications:
**References for regulatory framework:**

- DOC 4444 PANS –ATM Horizontal separation standards;
- ICAO - DOC 9906 Guidance on procedure validation;
- ICAO DOC 8071 Flight inspection;
- ICAO Manual on Performance Based Navigation (PBN), DOC9613, fourth edition;
- ICAO Manual on Performance Based Navigation (PBN) operational approval, DOC9997;
- ICAO Procedures for Air Navigation Services - Aircraft Operations, Doc 8168 (PANS OPS, Parts I and III);
- EASA AMC 20-26 - Airworthiness Approval and Operational Criteria for RNP Authorisation Required (RNP AR) Operations;
- EASA AIR OPS DOC965;
- EASA Airborne Communications, Navigation and Surveillance CS-ACNS of 26 April 2019.

**Rotorcraft implementing rules/requirements referred to on board system:**

- Rotorcraft with E/TSO-C145a and E/TSO-C115b FMS use in accordance with FAA AC20.130A;
- Rotorcraft with E/TSO-C146a use in accordance with FAA AC 20-138 or AC 20-138A;
- Rotorcraft navigation data management is addressed in ICAO ANNEX 6 Part 1. The navigation database supplier shall be compliant with RTCA-DO200A/EUROCAE document ED76.

## Standardization Framework Considerations

Existing standards, either at European (EASA) or at international levels (ICAO) are already compatible with the implementation of the operational solution.
The SNI IFR rotorcraft approach/departure procedures network (realised and validated within the SESAR activities) were designed in accordance with the appropriate design standards, described in ICAO DOC 8168 VOL II.
In addition, as a starting point for the definition of independent parallel approaches between ILS to runway and PBN rotorcraft to FATO, ICAO DOC 9643 (SOIR – *Manual on Simultaneous Operations on parallel or near-parallel Instrument Runways*) was considered. Indeed, in the context of solution PJ.02-05, it was proposed to add a new mode of operations (e.g. Mode 5) to encompass simultaneous operations, which involves fixed-wing and rotorcraft.

The navigation database characteristics used during the research and development activities (required as minimal for the SESAR solution concept) meet the ICAO requirements and comply with database requirements detailed in EUROCAE ED 76A/RTCA Do 200A.
The documentation supporting the SNI IFR PinS procedures are:

- ICAO Doc 9613 on performance based navigation covers the RNP as well as RF legs in Appendix 1 to Part C;
- FAA AC-20-138d on airworthiness approval of positioning and navigation systems;
- EUROCAE ED-75C on minimum aviation system performance standards: required navigation performance for area navigation;
- ICAO DOC 4444 PANS –ATM horizontal separation standards.

## Considerations of Regulatory Oversight and Certification Activities

For implementing locally this SESAR solution, the contribution to safety of several ATM elements and related risks derivable from that specific operational environment must be taken into consideration.

The behaviour consequently derivable by the local implementation with the pre-existing ATS routes should be considered.

Special coordination between ATCO and pilot must be established before the deployment phase.

The training for both ATCOs & pilots must be considered in order to standardize the working methods and secure the required safety level for these operations.

## Solution Data Pack

The data pack for this solution includes the following elements:

- PJ.02-05 V3 CBA, D4.1.05, ed. 00.01.02, 2020.03.02
- PJ.02-05 V3 SPR-INTEROP/OSED (Part I-II-IV-V), D4.1.01
    - Part I, D4.1.01, ed. 00.01.03, 2020.03.06
    - Part II, D4.1.01-2, ed. 00.01.02, 2020.03.03
    - Part IV, D4.1.01-4, ed. 00.01.04, 2020.003.02
    - Part V, D4.1.01-5, ed. 00.01.02, 2020.03.02

## Intellectual Property Rights (foreground)

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