Release 5 SESAR Solution #113

Optimised low-level instrument flight rules (IFR) routes for rotorcraft

Contextual note – SESAR Solution description form for deployment planning

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)

Usually the rotorcraft operators have to face significant weather and terrain-related challenges when performing specific flight operations (e.g. civil transport, medical emergencies, etc.). For these reasons, the rotorcraft operations were suitably confined to flying only when they could meet strict visibility standards (VFR - Visual Flight Rules), limiting drastically their access in controlled airspace and accordingly the operations to and from airport included in class "A" airspace (e.g. TMA - Terminal Area).
In addition, low clouds, fog, rain and snow, and the possible presence of mountains and valleys could affect seriously safety and success of concerned operations.

Nowadays, the GNSS[1] technology enhanced by SBAS[2] systems (without ground infrastructures), allow designing specific instrument (IFR[3]) routes that provide the needed *integrity* for the GPS signal, together with an improved *accuracy*, *reliability* and *availability* enabling the rotorcraft operators to access into the controlled airspace. Furthermore, the ICAO PBN concept (Performance Based Navigation), thanks to the development of RNP1\RNP0.3 navigation applications makes available a wide range of benefits aimed at enhancing more and more the rotorcraft operations, fully integrating them into the future ATM system.

To this end, the SESAR Solution "Optimised Low Level IFR routes for rotorcraft" consists of a series of innovative IFR routes at very low flight level and based on GNSS (SBAS/EGNOS) technology, using an enhanced Required Navigation Performance (RNP 1.0 / 0.3) that allow an optimized use of the airspace within Medium dense/complex TMA - Terminal Manoeuvring Area (e.g. Milan TMA):

- **Class "A" Low Level IFR Route RNP 0.3** (3000 ft for the entire route):
    - designed with RNP 0.3 requirement due to the proximity the procedure itself to a specific Restricted Area overhead the urban centre;

[1] GNSS - Global Navigation Satellite Systems.

[2] SBAS - Satellite-Based Augmentation Systems is a civil aviation safety-critical system that supports wide-area through the use of geostationary (GEO) satellites which broadcast the augmentation information. In Europe the concerned satellite system is EGNOS (European geostationary navigation overlay system).

[3] IFR - Instrument Flight Rules.

  - RF (Radius to Fix) segment to reduce tactical intervention from the controller.
- **Class "A" Low Level IFR Route RNP 1.0** (between 3000 ft and 6000 ft):
  - this route with the previous one and some additional existing low level IFR routes (which links several areas/airports within a multi airports Terminal Area - TMA) represents the first European example of Low Level IFR routes network specific for rotorcraft airspace users (AUs);

Dedicated rotorcraft narrow corridors (Low Level IFR routes) not only increased the TMA's sectors *capacity*, but improve *safety*, *equity* and *accessibility* in the airspace inside the Terminal Area (TMA).

Today's rotorcraft advanced on-board avionics is compliant with the technical system requirements needed to fly these routes with very high accuracy (RNP1/RNP0.3) within 1.0/0.3 NM nautical miles on either side of the nominal flight path (flying straight or RF Radius to Fix segments). This translates into a greater ATCO's confidence in the track-keeping performance of traffic movements, allowing to place routes closer together.

In other words this SESAR Solution represents the best facilitation to allow rotorcraft operations in the controlled airspace and at the same time, it supports connectivity between the airports included into the TMA airspace, thanks to the implementation of "**Standard PinS - Point In Space**" procedures concept.

The PinS procedures consists to fly under instrument flight rules (IFR) to/from a Point-In-Space in the proximity of the landing/departure site using very high accuracy (RNP1/RNP0.3). The segment joining the "PinS" and the landing/departure site (FATO - Final Approach & Take-Off areas) is flown visually but does not require to meet the visibility standards (VFR).
The point-in-space procedures have the potential to enable an increasing of passenger throughput at medium and large airports, removing IFR rotorcraft from active runways (no low performance/low speed movements into the approach sequence to runway) and allowing an easier way to manage both traffic flows fixed-wing aircraft and rotorcraft, simultaneously and in a non-interfering way (SNI operations).

The implementation of rotorcraft specific approach procedures relying on GNSS/SBAS guidance and allowing SNI operations will improve the airport *capacity* and the *operational efficiency*, contributing to reduce both costs and the *environmental* impact.

Operational Improvement Steps (OIs) & Enablers

- **AOM-0810**[4]: Integration into the TMA route structure of optimised Low Level IFR route network for rotorcraft using RNP-1/RNP-0.3. The solution covers all aspects concerning this concept (RF curved segment as well);

[4] The *Rational* of the OI needs to be upgrades as follows: "*Provision of the IFR routes in controlled airspace procedurally separates rotorcraft and commercial traffic. The integration of an optimised Low Level IFR route network for rotorcraft can enhance flight safety and weather resilience of rotorcraft operations. Benefits for the environment may also be expected (less VFR flights at very low altitude AGL, avoidance of noise sensitive areas thanks to narrow or (and) curved Low Level IFR routes)*".
[**Note that**: The modification will be implemented into the Dataset DS17]

- **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.

Applicable Integrated Roadmap Dataset is DS16.

Background and validation process

The SESAR Solution has been validated through a series of activities including **a Fast Time Simulation,** a **1 Real Time Simulations** (Airborne assessment limited) and a **Flight Trial**, all focused on a range of objectives from a *Qualitative Analysis* (e.g. ATCOs and Pilots workload, Runway throughput, Time variability, Environmental and Flight efficiency) and from *Qualitative Analysis* focused on the evaluation of *flyability* and *acceptability* of the routes\procedures, Pilot's situational awareness and perception of the addressed concepts.

- **Fast Time Simulation**: Evaluate benefits provided by the introduction of the Point-in-Space procedures (PinS), **Low Level IFR routes (LLR)** and the Simultaneous-non-Interfering operations (SNI) for Medium/Medium complex/dense TMA environment (scenario) as Milano Terminal Area included Milano Malpensa and Linate Airports where FATOs (Final Approach and take-off area) are located, by observing some performance areas such as Environmental Sustainability & Fuel Efficiency, Safety, Predictability and Capacity.
- **Real Time Simulations**: evaluate the benefits provided by the introduction of the Point-in-Space procedures (PinS), **Low Level IFR routes (LLR)** and the Simultaneous-non-Interfering operations (SNI) concept of operation for Medium/Medium complex/dense TMA environment (scenario) as Milano Terminal Area included Milano Malpensa and Linate Airports where FATOs (Final Approach and take-off area) are located, considering the **Pilot (perspective)** workload and situation awareness when performing its flight, flying routes and procedures to/from a VFR FATOs close to an airport environment (or included within the airport layout)
- **Live Trials**: the main goal of the activity was to demonstrate how, in a real medium density/complexity TMA, rotorcraft operations can be improved by implementing several PBN procedures such as PinS (Point-in-Space) and **Low Level IFR Routes** (Required Navigation Performance RNP1.0/0.3) whilst maintaining or increasing the flight operations safety level.

Additional Activities

- *The flight trials were performed also using helicopters **ADS-B OUT** capabilities which provided air traffic controllers, "positional data" with an high level of accuracy and several flight information. The ADS-B output accuracy, using satellite and transponder technology, is greater than using conventional radar surveillance. This enable ANSP/CAA (Air Navigation Service Providers/Civil Aviation Authorities) to potentially reduce the required separation minima between aircrafts that are ADS-B equipped. ADS-B is a key element for maintaining future efficient airspace management in busy airspace, class "A".*
- *Specific RTS activities (Dress Rehearsal) was performed aiming at the evaluation of Pilot/Crew and ATCOs' feedbacks concerning some* Contingency *Events ("Use cases" as, for instance, Loss of Signal, Loss of the Integrity, etc.). Those particular events of contingency have not been assessed during Flight Trials due to several safety reasons. This activity was aimed at completion of the maturity level of SESAR Solution*

Results and performance achievements

Validation activities for this concept demonstrated that:

Capacity

- Reduced\unaltered workload for ATCO: *the post-analysis data confirmed that the ATCO workload was not negatively affected by the introduction of the operational concept which instead enables a more efficient distribution of the traffic volumes*;
- Reduced overall Pilot workload: *the results confirmed a decreased workload for the Pilot (≈-7,1%) between the Reference and Solution scenario*;

Access & Equity

- Improved Airspace Accessibility: *being aware that currently the rotorcraft operations (strictly dependent on the ability to meet the visibility standards VFR) are usually segregated into uncontrolled airspace and then not allowed within a large number of European TMA airspace (class "A").This SESAR Solution offers the only way that rotorcraft airspace users have to be able to fly within class "A" airspace (M/M or H/H complex/density, Multi Airports TMA) and linking departure and approach segments of two different airports, ensuring the highest achievable performances in terms of safety, efficiency and access & equity*;

Flight Efficiency (Environment)

- Reduced track mileage, resulting in less fuel consumption and associated CO2 emissions [(≈ -8,06% Fuel save), (≈ -10,61% Distance Flown), (≈ -8,06% CO2 Emission);
- Fuel burnt and CO_2 emission were reduced about 0.29% also for a 80 aircraft positively affected by the introduction of the operational solution
- Enhanced transition from the en-route phase (flying the Low Level IFR routes) to the approach phase (e.g Point In Space IFR rotorcraft procedures) to the Final Approach and Takeoff Area-FATO (and vice versa);
- More direct routing in dense terminal airspace

Safety

- Airspace de-confliction of low altitude airways (more slots available on SIDs and STARS). The post-analysis data confirmed an overall conflict reduction (between 25 – 30 %) for some TMA sectors. It can result more visible into those sectors (up-stream sectors) where the ATCO is arranging the arrivals sequence;

Recommendations and Additional activities

No further validation of the concept is necessary

Actors impacted by the SESAR Solution

Airspace Users (Crew), Air Navigation Service Provider ANSP (ACC\TMA\TWR ATCOs), Airports Operators and Industrial Manufacturers (Rotorcraft).

Impact on Aircraft System

The Low Level IFR Routes concept takes benefit by exploiting the state of the art and the advanced rotorcraft navigation capabilities [e.g. RNP 0.3 and Radius-to-Fix (RF) Path Terminators] and flying techniques. No specific upgrade of the current available aircraft suit avionics bay are needed to deploy the concept. No specific changes in the functional requirements or in the current avionics architecture have been identified.

Impact on Ground Systems

The SESAR Solution analysis has reported and evaluated if the Ground Equipment or System capabilities were safe in terms of following indicators:

- Surveillance issue
- Communication issue

The analysis hasn't pointed out issues regarding the Equipment (Surveillance and Communication).
ATCOs haven't reported any problems with Radio Communication and Surveillance (Radio failure, Radar Failure). This is also confirmed by the fact that ATCOs haven't used any contingency procedures for Radar failure and/or Radio failure.
The experience did not show any need to update existing ground systems and regulation or standardisation documents.

Regulatory Framework Considerations

There is no specific topics concerning the regulatory framework to be considered in the deployment process, beyond the applicable regulations currently existing and applicable.

The RNP1.0 and RNP0.3 navigation specification used for designing the Low Level IFR Routes 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 SESAR and EASA 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

Rotorcrafts 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;
- Rotorcrafts 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 comply with RTCA-DO200A/EUROCAE document ED76.

Standardization Framework Considerations

Current existing standardisation frameworks, either at European (EASA) either at International levels (ICAO) are already compatible with the implementation of the operational solution.
Starting saying that, the Low Level routes network (realized and validated within the SESAR activities) have been designed in accordance with the appropriate design standards, described in depth into the ICAO DOC 8168 VOL II.
Concerning the Navigation Database characteristics used during the research and development activities (required as minimal for the SESAR Solution concept) has proved being able to meet the ICAO requirements and complying with database requirements which are detailed in EUROCAE ED 76A/RTCA Do 200A.

Details on the specifications which support the Low Level IFR routes are provided below:

- 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
- 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.

Due to possibly airspace structure, it might be needed to design the Low Level IFR routes in a way that they pass through different classes of airspaces (e.g. a first segment in airspace class "A" and the following one in airspace class "G" and so on). Special coordination between ATCO and Pilot must be established before the deployment phase.

Solution Data pack

The Data pack for these solutions includes the following document:

- SESAR, DEL04.10-**D11** "*SESAR SOLUTION GUIDANCE (LLR)"*: the deliverable aims at providing guidance about the SESAR Solution #113 "*Optimised Low Level IFR routes for rotorcrafts*" 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;

Intellectual Property Rights (foreground)

The foreground is owned by the SJU.