Release 5 SESAR Solution #10

Optimised route network using advanced required navigation performance (RNP)

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)

The SESAR Solution "Optimised route network using advanced required navigation performance (RNP)" is based on Advanced-RNP navigation specification and the design of optimised routes e.g. Closely Spaced Parallel Routes (CRS), Fixed Radius Transition (FRT) and Tactical Parallel Offset (TPO), further enhanced by on-board performance monitoring and alerting and the execution of more predictable aircraft behaviour.

The SESAR Solution provides a Performance Based Navigation (PBN) solution to link Free Route airspace (FRA), above FL310, to the Final Approach via a set of defined and de-conflicted routes, from fixed entry points at the base of the FRA to the Final Approach Segment. The solution focuses on the work of three projects; 1) 'Use of Performance Based Navigation (PBN) for En Route Separation Purposes' 2) 'Full implementation of P-RNAV in TMA' 3) 'Approach Procedures with Vertical Guidance (APV)' and suggests one possible PBN scenario based on current published and planned European legislation.

The SESAR Solution considers a high density traffic environment which requires flows of traffic below FL310 to be strategically de-conflicted by the appropriate placement of ATS routes and the utilisation of Advanced Required Navigation performance (A-RNP) together with a consistent and highly repeatable turn performance provided by Fixed Radius Transitions (FRT) in the en-route and Radius to Fix (RF) path terminators on the instrument flight procedures (IFPs). The entry and exit from the FRA will be at defined waypoints which the ATS routes will connect to. This document is aimed to support SESAR Solution 10 which is an optimised route network using advanced RNP; this solution does not consider operations above FL310. The figure below shows the operations under consideration.

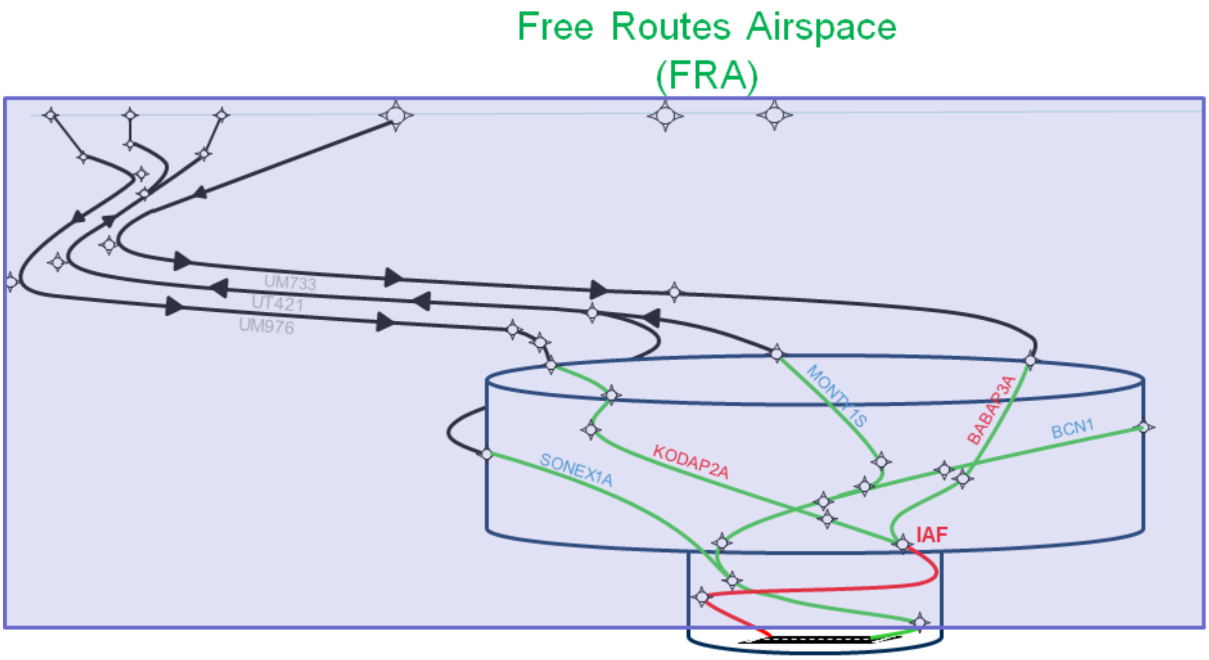

Figure 1 - Scope of Proposed Solution

The 'Use of Performance Based Navigation (PBN) for En Route Separation Purposes' project considered en-route strategically de-conflicted flows of traffic closely spaced and utilising the FRT functionality, which supports this solution. The project 'Full implementation of P-RNAV in TMA' investigated the full implementation of P-RNAV (lateral performance is the same as RNAV1) in TMA; however, although this project investigated the application of Point Merge, which is part of the proposed solution, the aircraft functionality did not include 'on-board performance monitoring and alerting' and radius-to-fix (RF) turn performance. For the approach phase, one possible method to support these operations was investigated by the project 'Approach Procedures with Vertical Guidance (APV)'. This project looked at Approach Procedures with Vertical Guidance (APV) supported by satellite based augmentation and flown to localiser performance with vertical guidance (LPV) minima. Both latterly mentioned projects focused on TMA operations, whilst the first only studied en route operations. Figure 2 below summaries the interaction between the three associated projects but does not highlight the connectivity issue of the different concepts.

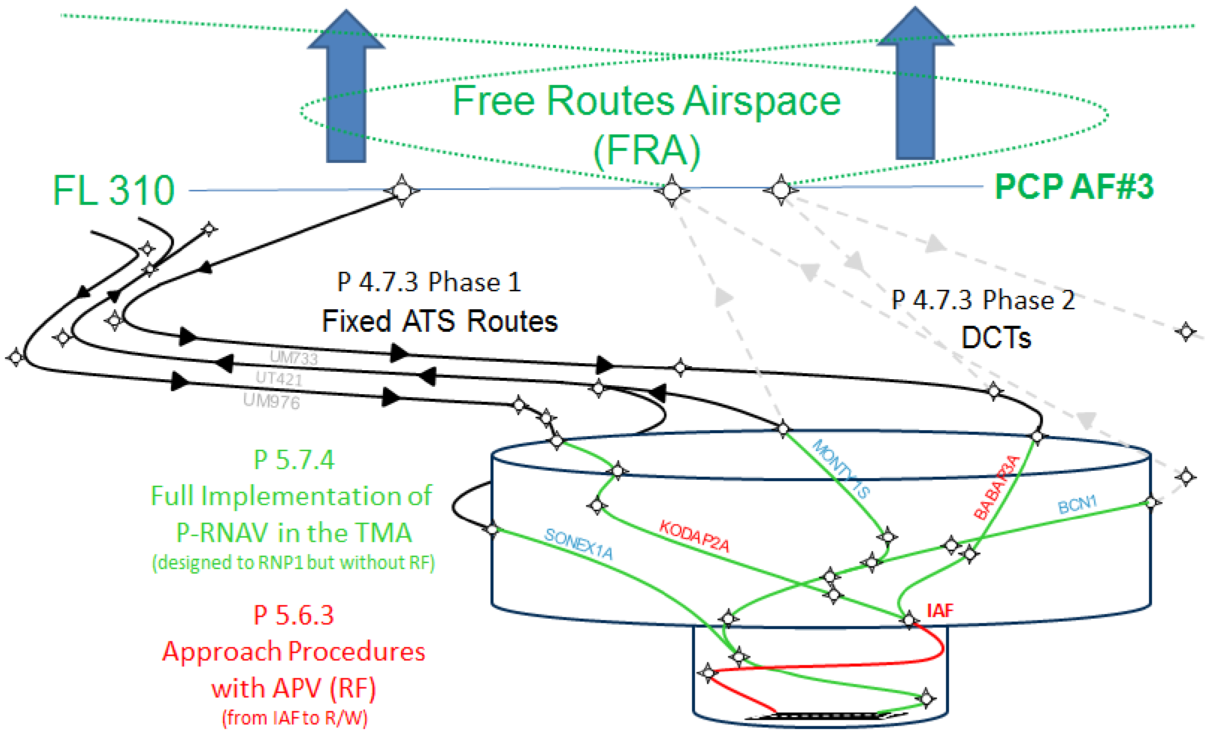

Figure 2 - Projects providing input to the proposed solution

Operational Improvement Steps (OIs) & Enablers

AOM-0404: Advanced RNP is implemented and supports enhancements of route structure. Spacing between routes is reduced where required, with commensurate requirements on airborne navigation and ground systems capabilities.

- A/C-04a - Flight management and guidance for Advanced RNP
- AIMS-14 Set up a digital data chain to ensure the Aeronautical Information data provision into on-board avionic systems
- APP ATC 94 ATC tools in support of RNP.1 for Approach/TMA
- ER ATC 94 ATC Tools in support of RNP.1 for En-route

Applicable Integrated Roadmap Dataset is DS15.

Background and validation process

The SESAR Solution has been validated through a series of five Real Time Simulations and a gap analysis paper exercise, three validating PRNAV and Point Merge in London and Milan TMAs, and three validating Conflict management and Separation Provision using Advanced RNP in high density Rome airspace. A high level summary of each validation is presented hereafter:

1. Real Time Simulation testing PRNAV in a Complex TMA at a maturity level of V3:
    - Development & assessment of P-RNAV application with a view to full implementation of P-RNAV in the TMA.
    - Define a set of P-RNAV manoeuvres, operational procedures, routes and sector structures. Test and evaluate them (with Madrid TMA as selected complex TMA environment).
    - Address issues on safety, complexity, capacity and work-load of the final operational scenario and operational and design requirements will be developed.
    - Consolidate and validate Eurocontrol P-RNAV requirements, procedures and guidelines for the deployment of P-RNAV in a complex European Terminal Area and develop the business justification for implementation.
2. Real Time Simulation testing Point merge in complex TMA in London TMA at a maturity level of V3:
    - Development & assessment of Point Merge technique in a complex TMA with a view to integration with AMAN and implementation generalized in multi-airport TMA:
    - Define & evaluate a set of operational procedures introducing Point Merge technique.
    - Test and evaluate an operational scenario of complex TMA (with London TMA as selected complex TMA environment) through FTS then RTS.
    - Address issues on safety, complexity, capacity and work-load of the final operational scenario and operational procedures.
    - Develop the business justification for implementation.
3. Real Time Simulation testing Point merge in complex TMA in Milan TMA at a maturity level of V3:
    - As previous RTS (2), but in Milan TMA environment.
4. Real Time Simulation testing Conflict Management Services Air-Separation Provision Services Air- Step1 at a maturity level of V2:
    - Evaluated the benefits accrued through the utilisation of aircraft navigational capabilities to maximise the efficiency of a given piece of high density airspace, it was carried out using ENAV's real time simulator in Rome airspace over a period of 5 working days.
5. Real Time Simulation was a follow on from the previous simulation (4), further testing Conflict Management Services Air-Separation Provision Services Air- Step1 at a maturity level of V2:
    - In comparison with the previous Real Time Simulation, this exercise was more challenging in respect of the use of more Close Route spacing and the complexity due to the interaction with TMA airspace. The main objective of this exercise was to see if the benefits demonstrated in the previous, using strategically placed routes with 7 NM spacing, fixed radius transitions and tactical use of the parallel offset functionality, would also bring benefit in a more complex environment.

- This exercise also focused attention on assessing the benefits coming from the use of a medium term conflict detection (MTCD) tool in combination with the main elements of Advanced-RNP operational concept in assuring strategic en-route separation. It also allowed a more representative test case, due to a remote link between the ground simulation platform and a cockpit simulator. The remote cockpit simulator enabled evaluation of a more mixed trajectory-type environment and evaluated the actual airborne performance in an A-RNP scenario.

6. Gap Analysis of PBN functionality in Optimised 2D/3D Routes Paper Exercise at a maturity level of V3:
    - To assess in an En-Route environment the route spacing achieved during previous real-time simulations and a Fixed Radius Transitions live data collection activity.
    - To demonstrate that the PBN functionality was assessed in a generic en-route environment.
    - To highlight the requirements at V3 Advanced RNP navigation specification has when utilised on en-route operations, they have a positive impact on controllers' acceptability as per the previous RTSs.

Results and performance achievements

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

1. In the TMA;
    - Overall, approach controllers using the P-RNAV system reported reduced workload, improved situation awareness and reduced R/T. They issued fewer instructions than in current day operations and the spare capacity this provided improved their capability to deal with a range non-nominal scenarios simulated throughout the exercise.
    - Aircraft spent less time holding overall and a significant reduction was observed in the level of outer holding in the TMA.
    - Speed control becomes the principal method of separation assurance and the use of the Mode-S downlinked IAS value was found to support the controller task.
    - The controllers felt their ability to manage non nominal situations was not affected by the introduction of Point Merge. In some cases, such as single aircraft R/T failure, the increased level of systemisation improved their response.

2. In En Route;
    - In general, PBN capabilities were easy to use and accepted by ATCOs, as well as being suitable for the introduction in current operations.
    - There was an increased situational awareness owing to the use of PBN. It was acknowledged that there was an enhanced stability of the mental picture of

traffic evolution, with reference to both controller's own sector and neighbouring sectors, facilitating a less tactical and a more monitoring activity and improved inter-sector coordination

- The use of PBN assists in solving conflicts using horizontal rather than vertical separation. This enables a more extended use of the horizontal plane, resulting in more efficient use of the airspace.
- In line with the performance expectations, the Environmental Impact Assessment shows a fuel consumption saving. The reduction in fuel burnt leads to a reduction in CO2 emission and in cost per flight.

The following potential benefits have been identified:

- ENVIRONMENT / FUEL EFFICIENCY (TMA) - A decrease in fuel burn per flight, partly related to CDAs enabled by P-RNAV operations.
- ENVIRONMENT / FUEL EFFICIENCY (ENR) - An average fuel burn reduction per flight was observed in the experimental scenario vs. the reference scenario. This represents a reduction in the total fuel burnt within the bounds of the assessed airspace volume.
- AIRSPACE CAPACITY (TMA) - An increase in the number of handled traffic per hour as inbound arrival capacity. Surrounding aerodromes not impaired.
- AIRSPACE CAPACITY (ENR) - In the evaluated sectors, controllers were able to handle an increased traffic load in the reference scenario without major problems.
- AIRPORT CAPACITY (TMA) – An increase in average landing runway throughput.
- PREDICTABILITY / FLIGHT DURATION VARIABILITY (ENR) - Improved adherence to flight plans was observed for the majority of flights.
- COST EFFECTIVENESS – DIRECT ANS COST/ ATCO Productivity (TMA) - A reduction in controller Workload. Estimated reduction in R/T communication. Estimated reduction in the need of vectoring aircraft.

Recommendations and Additional activities

The following activities are relevant once transitioned to industrialization (V4):

1. EASA is encouraged to develop appropriate certification and operational approval documentation for both Advanced Required Navigation Performance (A-RNP) and Fixed Radius Transition (FRT) functionality as soon as possible. This should ensure the aircraft and flight crews are appropriately trained and ready for the prescribed operations.

2. At the global level, through the Instrument Flight Procedures Panel (IFPP), the Air Traffic Management Operations Panel (ATMOPS), the Separation and Airspace Safety Panel (SASP) and the Flight Operations Panel (FlightOps) the following proposals for amendment are discussed and developed:

- ATS route designator for FRT (Annex 11 Appendix 1)
- Flight Plan codes for A-RNP and FRT (PANS ATM)
- Guidance material on the design and deployment of FRT (PANS OPS)

3. The SJU endorses the Project's position that operations on closely spaced parallel routes with transitions calling for fixed radius turns is restricted to only certified aircraft with FRT functionality and operated by appropriately trained and qualified flight crews. No mixed mode operations should be allowed to obtain full potential benefit with the solution. In mix mode operations capacity might be restrained and safety could be compromised if flight fails to comply with FRT.

4. In SESAR 2020 VLD flight trials are undertaken on a set of carefully designed parallel routes 7NM spaced with several FRT transitions and flown by A-RNP with FRT capable aircraft. Furthermore, the VLD should examine operations in terminal airspace outside of Final Approach as within SESAR1 no studies have been undertaken for RNP SID/STAR operations with/without radius to fix (RF); however, it should be noted that one SESAR partner has undertaken successful flight trials on RNP1 SIDs with RF.

5. To support operations in non-nominal events SESAR2020 should investigate downlinking the 'Unable RNP' alert to the controller, collect and examine failure case data to cover for when the pilot fails or is unable to communicate that the aircraft no longer meets the performance requirement of the ATS route.

6. Local Safety Net may be tuned to the context of the local operations during implementation.

Actors impacted by the SESAR Solution

Airspace Users (Pilots), TMA and En Route Controllers.

Impact on Aircraft System

The Advanced RNP concept takes benefit by exploiting advanced navigation capabilities (e.g. Fixed Radius Transition (FRT) & Radius-to-Fix (RF) Path Terminators) and flying techniques it may require an upgrade of the aircraft avionics.

Impact on Ground Systems

In an Advanced RNP environment, aircraft will operate within a route structure where the routes have been designed more closely spaced than today. As such, Air Traffic Controllers will be more heavily reliant on systems to support planning and decision making. Whilst in both the current (B-RNAV) and future (Advanced RNP) environments, controllers bear responsibility for vectoring and monitoring flight progress along ATS routes , the closer route spacing enabled by Advanced RNP envisages minimal vectoring and greater requirements for ATC to monitor performance and conformance via current ATM tools.

Regulatory Framework Considerations

At the regional level, EASA should provide:

- Certification and operational approval for RNP1
- Clarification on how operators who already have RNAV1 certification can migrate to RNP1
- Certification and operational approval for RF
- Clarify if and how aircraft without AP/FD could qualify for operations requiring RF
- Certification and operational approval for A-RNP
- Certification and operational approval for FRT

At State level:

- Qualified designers design the ATS routes to match the flows of traffic and to strategically de-conflict laterally wherever possible. Where not, de-conflict with as much vertical separation as is possible to minimise controller workload.
- Undertake PBN implementation as a team exercise and follow the recommended practices promoted in the Manual on the Use of Performance-based Navigation (PBN) in Airspace Design (ICAO Doc 9992) and EUROCONTROL's European Airspace Concept Handbook for PBN Implementation Edition 3.
- Establish an EGNOS working agreement with the ESSP for LPV operations (provided the State is within the Service Area of the APV; this is defined in the Service Definition Document (SDD), latest edition published September 2015.
- Ensure all ATS routes are correctly designated and are published within the AIP.
- Train controllers and pilots in all applicable operations and requirements.
- Provide oversight on non-nominal events, record, analyse and communicated.

Standardization Framework Considerations

At the global level ICAO should:

- Reintroduce into Annex 11, Appendix 1 the ATS route designator(s) for FRT
- The IFPP should provide clear FRT design criteria and guidance material on FRT use

- PANS OPS and PANS ATM provide guidance material to the airspace users and the controllers on the different types of waypoint transitions. With the FRT and RF, this guidance material should explain how the controller and pilot can facilitate their execution.
- PANS ATM should be amended to provide new ICAO flight plan codes for A-RNP, FRT and RF plus amendments to current codes.
- IFPP should provide guidance on how the ANSP will validate newly designed FRTs.
- ICAO should review its RTF phraseology in PANS ATM and provide new phraseology to cover FRT/RF capabilities

Considerations of Regulatory Oversight and Certification Activities

The impact on regulatory activities will primarily be to update policy, regulation and other working methods.

Solution Data pack

The Data pack for this Solution includes the following documents:

- GEN - 04.07.03-D27 This document encompasses the linkage between Free Route Airspace and Final Approach PBN functionality and applicability. The purpose of this deliverable is to provide a holistic view of SESAR Solution 10_Optimised Route Network using Advanced RNP, and OI Step AOM-0404.
- TS - 10.02.01-D88 The document contains the Step 1 ATC technical requirements for Trajectory Management. Part of them are related to the ATC system needs to support the new PBN operational procedures, allowing the PBN operation and reduction of route lateral separation to be supported.

Intellectual Property Rights (foreground)

The foreground is owned by the SJU.