Release 4 SESAR Solution #51

Enhanced terminal operations with LPV procedures

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.

Improvement in Air Traffic Management (ATM)

The SESAR Solution "Enhanced terminal operations with LPV procedures" consists of an innovative Required Navigation Performance (RNP) approach procedure to Localiser Performance with Vertical Guidance (LPV) minima.

The SESAR Solution focused on the initial and intermediate approach segments:

- A-RNP or RNP APCH (RNP values from 1 to 0.3NM) with Radius to Fix (RF) legs for lateral navigation in preference to fly-by or fly-over waypoints, and, where appropriate, the provision of an RF leg in the Intermediate Approach Segment joined directly to the LPV Final Approach Segment.

The SESAR Solution can be integrated with the following operations:

- Continuous Descent Approach (CDA), where possible, for the vertical profile with barometric vertical reference;
- Final Approach Segment (FAS), with the shortest appropriate length based on Satellite Based Augmentation System (SBAS) with geometric vertical reference (RNAV GNSS approach operation down to LPV minima). Alternatively the FAS could be defined as Baro VNAV where vertical guidance is based on barometric altitude information (RNAV GNSS approach operation down to LNAV/VNAV minima);
- Missed Approach Segment based on RNP navigation with values from 1 to 0.3 NM and, as an option, the provision of RF leg(s) in the final phase of the Missed Approach.

Traditionally there have been two different types of approach procedure, Precision Approach (PA) and Non-Precision Approach (NPA) procedures. Precision approaches are considered the safest and practically all aircraft equipped for instrument flight have Instrumental Landing System (ILS) capability, which is the most commonly used PA. However, it is not possible to install ILS equipment at all runway ends, either for economic viability or other practical reasons. Additionally, on those occasions when ILS systems are out of service due to technical faults, maintenance or airport/infrastructure work, NPA has traditionally provided the required redundancy to the primary approach facility, although the use of a NPA as a 'fall-back' approach usually degrades airport accessibility due to (often significantly) higher approach minima.

Implementing SBAS approaches with vertical guidance procedures will provide approach minima much closer to those of ILS, which provides an improvement in terms of safety and airport accessibility that does not require the installation of any equipment at the airport. The approach procedure is based on position data obtained from Global Navigation Satellite Systems (GNSS), and augmented for increased precision by the EGNOS Satellite Based Augmentation System (SBAS).

Improvements to safety are achieved by more accurate positioning of the aircraft during the approach and the provision of geometrical vertical guidance during the final approach segment reducing risk of Controlled Flight Into Terrain (CFIT) events.

Improvements in airport accessibility are delivered through reduced approach minima with respect to conventional NPA procedures which enable successful approaches to be performed in conditions that may otherwise cause a disruption event (delay, diversion or cancellation).In addition, RNAV approaches can be easily implemented at runway ends equipped with suitable non-precision approach lighting at low cost whilst providing a safe approach capability to runway ends which have no existing published instrument PA, and possibly not even a published NPA.

In this Advanced APV solution an RF leg may connect directly to the final approach segment enabling a curved intermediate segment (this possibility was previously limited to RNP AR operations). This increased flexibility in procedure design may allow shorter approach paths that will result in fuel savings, and may also be used for avoiding environmentally sensitive areas (e.g. populated areas with noise restrictions).

Operational Improvement Steps (OIs) & Enablers

- AOM-0605: Enhanced terminal operations with automatic RNP transition to ILS/GLS/LPV. Only the RNP transition to LPV part of the OI Step is covered by this Solution.
- A/C-07 Flight management and guidance for RNP transition to ILS/GLS/LPV

Background and validation process

The SESAR Solution has been validated through a series of activities including a Fast Time Simulation, four Real Time Simulations, and a Flight Trial, focusing on a range of objectives from the (ground/ATC) acceptability of the Advanced APV (Advanced Approach Procedure with Vertical guidance) procedures by ATCOs, to the (airborne) flyability and acceptability by Pilots. A high level summary of each validation is presented hereafter:

- Fast Time Simulation: Evaluation of Advanced APV procedure for Palma de Mallorca (LEPA) with respect to targeted Key Performance Areas (KPA) of predictability, airspace capacity, efficiency and environmental sustainability, as compared to existing ILS approach. The scenario was based on segregated mode runway operations.
- Real Time Simulations:

1. Application of Advanced APV, based on SBAS, through Advanced Cockpit Simulator and focused on aircraft categories C (Airbus A320) and D (Boeing 747) scenarios; assessed the suitable coding and flyability of advanced Instrumental Approach Procedures developed for different airport scenarios: Torino Caselle (LIMF), Kristiansund (ENKB), Palma de Mallorca (LEPA) and Bristol (EGGD).
2. Assessment of the ATC operational feasibility of implementing the Advanced APV procedure in a medium traffic/medium complexity scenario based on the Bristol Terminal Approach airspace for Bristol Airport (EGGD).
3. Assessment of fly-ability and Flight Crew workload of the Advanced APV procedure for Torino Caselle (LIMF), based on a simulated regional aircraft (ATR-42-600), including a Flight Management System software model, GPS receiver, HMI (Primary Flight Display / Navigation Display) and Flight Control System solutions.
4. Assessment of the applicability, from an ATC perspective, of RNP approach procedures in high density/high complexity terminal airspace, based on an RNP arrival procedure at Luton Airport (EGGW) in the London TMA. It notably addressed the main recommendation from previous EXE-05.06.03-VP-623 that a redesign of the surrounding Terminal airspace would be required to accommodate higher levels of traffic on RNP profiles.

- Flight Trial: Flight trial exercise using an ATR-42-600 regional aircraft equipped with upgraded avionics, using the Torino Caselle Advanced APV procedure (LIMF RNAV (GNSS) Runway 18). Validation of the flyability of the Advanced APV procedure by means of the prototyped airborne solution developed for regional aircraft. Additionally, operational acceptability and feasibility from ATCO perspective in light traffic were assessed.

Results and performance achievements

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

- From Pilots' point of view, for regional and mainline aircraft:
  - The Advanced APV procedure is deemed easily flyable;
  - Work is properly shared between Pilot and Co-pilot, and workload is acceptable;
  - RF leg directly to FAP, with a 3NM FAS length as a minimum, is deemed operationally acceptable;
  - Availability of LPV is crucial to get full benefits of the CDA without excessive Flight Crew workload.

- From ATCOs' point of view:
  - The ATCOs understood the concept of Advanced APV and felt it was intuitive;
  - The concept is viable at airports in light traffic while it may be more difficult to manage in moderate and heavy traffic;
  - The main safety concern relates to the difficulty of integrating aircraft using the Advanced APV against non-APV equipped aircraft flying conventional approach

procedures, or possibly different APV procedures (coming from a different Intermediate Approach Fix (IAF), even during light traffic periods;
- 100% RNAV equipage is required to make RNAV/RNP based approach procedures feasible in high density, high complexity terminal airspace;
- ATCO workload may be high due to the extensive monitoring and concentration required, particularly where specific guidelines/procedures to ensure that separation is guaranteed are not available. This was observed in all traffic levels.

The following potential benefits have been identified:

- Reduced track mileage, resulting in less fuel consumption and associated CO_2 emissions,
- Increased ground track predictability and repeatability for air traffic controllers and pilots,
- Increased noise mitigation, through avoiding periods of excessive level flight, particularly at low altitude and the ability to concentrate noise distribution to specific non-sensitive areas where appropriate;
- Increased airport accessibility through the provision of Instrument Approach Procedures to runway ends with no existing published instrument approach, and offering reduced approach minima compared to NPA;
- Provides the benefits of having curved approaches with RNP down to 0.3, without the cost and burden of the aircraft approval and Flight Crew training requirements of RNP AR.

Recommendations and Additional activities

No further validation of the concept is necessary.

Actors impacted by the SESAR Solution

Actors are Airspace Users (Pilots) and TMA Controllers.

Impact on Aircraft System

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

Where the Initial/Intermediate segments are based on the use of the RNP APCH Navigation Specification, compliance with EASA AMC 20-27 is required.

Impact on Ground Systems

This solution does not envisage impacts on ground systems.

Regulatory Framework Considerations

Detailed information on regulatory framework considerations can be found in the regulatory overview part of the solution datapack.

Standardization Framework Considerations

Detailed information on standardization framework considerations can be found in the regulatory overview part of the solution datapack.

Considerations of Regulatory Oversight and Certification Activities

Detailed information on regulatory and certification aspects can be found in the regulatory overview part of the solution datapack.

Solution Data pack

The Data pack for this Solution includes the following documents:

- Regulatory overview;
- SPR - 05.06.03-D38 Edition 00.01.04 (21.09.2015). The document contains the safety and performance requirements for the ADV-APV (Advanced Approach Procedures with Vertical Guidance) procedures;
- INTEROP - 05.06.03-D41 Edition 00.01.01 (03.12.2014). The document contains the interoperability requirements of the advanced APV concept;
- TS: 09.09-D25 Edition 00.01.01 (20.01.2015). This document refines the functional analysis of the “RNP to xLS” operational concept (including the “advanced LPV” operational concept);
- TS: 09.10-D26 Edition 00.01.01 (27.01.2015). This document refines the functional analysis of the “advanced LPV” operational concept.

Intellectual Property Rights (foreground)

The foreground is owned by the SJU.