PJ01 EAD Final Project Report

Deliverable ID:	D7.2
Dissemination Level:	PU
Project Acronym:	PJ01 EAD
Grant:	731864
Call:	H2020-SESAR-2015-2
Topic:	SESAR.IR-VLD.Wave1-12-2015
Consortium Coordinator:	NATS
Edition date:	17 Mar 2020
Edition:	03.00.00
Template Edition:	02.00.01

Founding Members
EUROPEAN UNION
EUROCONTROL
SESAR JOINT UNDERTAKING

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Document History

Edition	Date	Status	Author	Justification
00.01.00	01/11/2019	Draft	D Gogna	Internal Draft
00.02.00	02/12/2019	Draft	D Gogna	Internal Draft
00.03.00	09/12/2019	Draft	D Gogna	Review with SLs
00.05.00	16/12/2019	Draft	D Gogna	Final Draft for Review
01.00.00	20/12/2019	Issued	D Gogna	For Submission
02.00.00	20/01/2020	Issued	D Gogna	For Final Submission
02.01.00	18/02/2020	Issued	D Gogna	Corrected corrupt file For Final Submission
03.00.00	17/03/2020	Issued	D Gogna	Updated against SJU Comments

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PJ01 EAD

FINAL PROJECT REPORT

This Final Project Report is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 731864 under European Union's Horizon 2020 research and innovation programme.

Abstract

PJ01 EAD addressed the development of concepts, tools and precision to increase the capacity of Extended TMAs (E-TMAs) to meet forecast traffic growth in a safe, cost effective and environmentally sustainable manner. This will be achieved by taking advantage of the latest technological developments from both and airborne and ground system perspective and through secure sharing of data.

PJ01 Enhanced Arrivals and Departures focused on operational improvements to the flow of arriving and departing traffic within the E-TMA that aim to increase airspace capacity and cost efficiency, improve safety and predictability and provide greater fuel efficiency and environmental sustainability. To progress these operational improvements, PJ01 EAD had the overall objective during Wave 1 of the SESAR 2020 Programme to:

- Undertake validation of operational improvements to provide evidence of the impact of the improvements on the key performance areas defined for SESAR 2020.

This will be achieved through the development and validation of the concepts defined in the operational improvements to achieve a V2 or a V3 maturity.

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Executive Summary

GENERAL

The main objective of PJ.01 was to focus on operational improvements to the flow of arriving and departing traffic within the E-TMA that aim to increase airspace capacity and cost efficiency, improve safety and predictability and provide greater fuel efficiency and environmental sustainability. To progress these operational improvements, PJ01 EAD had the following overall objective during Wave 1 of the SESAR 2020 programme:

- To undertake validation of operational improvements to provide evidence of the impact of the improvements on the key performance areas defined for SESAR 2020

Specific overall objectives for the project were:

- Objective A: Investigation of Benefits of Extended Queue Management techniques
- Objective B: Investigation of Benefits of the use of Arrival and Departure information for Traffic optimisation within the E-TMA
- Objective C: Investigation of Benefits of Dynamic use of Routes within the E-TMA
- Objective D: Investigation of Benefits of Required Navigation Performance (RNP) for Parallel Approach Operations
- Objective E: Investigation of Benefits of better integration of Rotorcraft and General Aviation (GA) operations in the TMA
- Objective F: Investigation of Benefits of Airborne Sequencing and Merging and Assisted Visual Separation

These were to be achieved through the development and validation of the concepts defined in the operational improvements to achieve a V2 or a V3 maturity level.

The Project addressed a total of 12 Operational Improvement steps in Wave 1 within the Project's 7 Solutions as listed below:

- Solution PJ.01-01: Extended Arrival Management with overlapping AMAN operations and interaction with DCB
- Solution PJ.01-02: Use of Arrival and Departure Management Information for Traffic Optimisation within the TMA
- Solution PJ.01-03A: Improved Parallel Operations
- Solution PJ.01-03B: Dynamic E-TMA for Advanced Continuous Climb and Descent Operations
- Solution PJ.01-05: Airborne Spacing Flight Deck Interval Management

- Solution PJ.01-06: Enhanced Rotorcraft operations in the TMA
- Solution PJ.01-07: Approach Improvement through Assisted Visual Separation

The project has completed the work against its objectives. All seven solutions completed their work. All solutions have been through their Maturity Gates.

The project has developed concepts for enhancements of Arrivals and Departures concepts.

- PJ01-01 has achieved V2 ongoing
- PJ.01-02 has achieved V2 in some areas, other areas are V2 ongoing
- PJ01-03A has achieved V2
- PJ01-03B has achieved V2 ongoing
- PJ01-05 has achieved V2
- PJ01-06 has achieved V3. Also, HMD, as an optional enabler in this solution, has reached V3.
- PJ01-07 has achieved V2

1 Project Overview

GENERAL

PJ01 Enhanced Arrivals and Departures focused on operational improvements to the flow of arriving and departing traffic within the E-TMA that aim to increase airspace capacity and cost efficiency, improve safety and predictability and provide greater fuel efficiency and environmental sustainability.

Solution PJ.01-01: Extended Arrival Management with overlapping AMAN operations and interaction with DCB

This Solution investigated the interaction between multiple extended Arrival Management (AMAN) systems, the Network and Airport Demand-Capacity Balancing (DCB) in medium and high density/complexity E-TMA environments.

Solution PJ.01-02: Use of Arrival and Departure Management Information for Traffic Optimisation within the TMA

This Solution investigated the use of arrival and departure management information to 'identify and resolve complex interactions in the E-TMA'. This Solution covers medium and high density/complexity E-TMA environments, including TMAs with multiple airports

Solution PJ.01-03A: Improved Parallel Operations

This Solution investigated closed loop routes and operating methods to improve operations with PBN/RNP parallel approaches, focussing on the approach area. It provided alternative options for independent parallel operations in medium to high density TMAs, taking account of improving safety, cost effectiveness, capacity and environmental impact.

Solution PJ.01-03B: Dynamic E-TMA for Advanced Continuous Climb and Descent Operations

This Solution investigated advanced continuous climb and descent operations and dynamic route structures. PJ.01-03B will investigated the facilitation of Continuous Climbs and Continuous Descents through route structure and use of controller & pilot assisted tools.

Solution PJ.01-05: Airborne Spacing Flight Deck Interval Management

This Solution assesses the use of Airborne Spacing – Flight Deck Interval Management (ASPA-IM) manoeuvres in a Systemised TMA environment. The main challenge is to consolidate and potentially increase TMA capacity and runway throughput while keeping the arriving (and departing) traffic streams on the fixed routes.

Solution PJ.01-06: Enhanced Rotorcraft operations in the TMA

This Solution developed the integration of rotorcraft into the RNP route structure in a range of TMA environments. The solution looked specifically into the Advanced PinS concept based on new procedure design requirements (e.g. curved segments, lower RNP) and on new enablers (Helmet

Mounted Display System (HMD), (Synthetic Vision System (SVS), Attitude Heading Reference Systems (AHRS), Satellite Based Augmentation System (SBAS)).

Solution PJ.01-07: Approach Improvement through Assisted Visual Separation

This Solution addressed the improvement of descent and approach operations, in high density/complexity TMA environments, mostly on flight efficiency aspects thanks to the CAVS operation which is an extension of visual separation. This operation allows flight crews to continue a visual separation operation even in case of loss of visual contact (due to rising or setting sun, or against a background of city lights at night) thanks to the display of traffic information in the cockpit, thus avoiding go around.

1.1 Operational/Technical Context

Solution PJ.01-01: Extended Arrival Management with overlapping AMAN operations and interaction with DCB

Complex interacting arrival and departure traffic flows in the E-TMA need to be actively managed to meet safety, capacity, fuel efficiency/environmental sustainability and predictability targets.

This affects the E-TMA on a daily basis, including arrival flows into multiple airports in the same vicinity, and the En-route environment serving multiple TMAs, where traffic is managed by the AMAN within an extended eligibility horizon and with overlapping horizons of several independent TMAs.

The extension of the AMAN horizon also means that several airports which were previously outside the AMAN horizon will now be inside the horizon, resulting in aircraft which are still on the ground needing to be taken into consideration as the arrival sequence is established.

When traffic sequence and target time of arrival of traffic are assessed using the AMAN tool, the initial 4-Dimensional (i4D) capabilities via Extended Projected Profile (EPP) downlink and the use of CTA are meant to provide support for traffic synchronisation. However, there is not yet the confidence in the operability of CTA in a dense environment due to the variability and lower predictability of speed behaviour. Moreover, the combined use of CTA and lateral changes is desired for flexibility of traffic management but requires enhanced air-ground coordination to be operable and efficient.

Multiple AMAN systems place a demand to manage traffic in En-route with potentially conflicting resolutions in order to meet the different AMAN advisories.

The need to coordinate in real time with several ATC units upstream puts a demand on information management to support this.

Solution PJ.01-02: Use of Arrival and Departure Management Information for Traffic Optimisation within the TMA

In today's operation, arrival and departure information is handled in a disparate fashion by a number of systems such as Arrival Managers (AMAN) and Departure Managers (DMAN). Such systems employ traffic optimisation/synchronisation processes which typically act at a single-airport level, creating a lack of a higher TMA level of optimization. The introduction of a Demand-Capacity Balancing (DCB) Extended-TMA (E-TMA) management tool should resolve the issue of information residing in a number of systems by bringing together the information and considering the optimisation of traffic flows at an E-TMA level. The various AMAN, DMAN, existing DCB and local flow management tools will all feed information into this E-TMA level tool, aiming at a more holistic optimization of traffic flows. The E-TMA will be managed as an individual node, comprised of a series of smaller nodes (e.g. airports).

The existing limitations are most acutely felt at High Density, High Complexity terminal areas where complex interacting flows occur. Such areas typically contain major hub airports, including capacity-constrained hubs. Additionally, in less dense/complex terminal areas, the maximum efficiency and environmental sustainability may not be achieved in today's operation.

The need to manage interacting climbing and descending traffic in the E-TMA, flying to/from several nearby airports and considering the maximum application of Advanced Continuous Descent Operations (A-CDO) and Advanced Continuous Climb Operations (A-CCO), puts a demand on sequencing and conflict resolution, as well as airspace configuration and management thereof.

The solution produced prototype tools which demonstrated a partially common set of agreed operational and functional requirements. However, the two threads used differing approaches to resolve Demand-Capacity Imbalance and will therefore deviate from each other in some functions.

Solution PJ.01-03A: Improved Parallel Operations

PJ.01-03A is aiming at addressing today's limitations in many dense TMAs in Europe involving platforms with existing or planned parallel approaches/runways. Beyond existing high-level surveys, these limitations needed to be analysed in detail in specific environments, with the aim to be extended and generalised to other environments.

The scope of solution 01-03A is "improved parallel approach operations using PBN" and relates to the OI step AOM-0606.

The Solution uses PBN transitions to final to replace in particular vectoring to final intercept with closed loop routes and associated operating methods.

ATM improvements brought by the solution are expected in the following areas:

- Safety by reducing the likelihood of blunders between aircraft performing simultaneous parallel approaches
- Capacity: once Safety targets are met or exceeded, a Capacity increase may be unlocked.
- Environmental Sustainability by allowing more optimal vertical profiles
- Environmental impact by increasing the predictability of the noise footprint

The trade-off between these KPAs may vary depending on the environment.

The solution is based on the combination of:

- PBN route structures to facilitate path stretching/shortening (airspace capacity)
- PBN transitions connecting to the final approaches, designed to provide safety, environmental impact and flight efficiency benefits.

Note: The solution is providing a first level of benefits for the medium term, without imposing stringent requirements in terms of NAV capabilities. From that perspective, it can be considered as an intermediate Solution. Ultimately, the goal should be to remove the need for lateral and/or vertical separations between arrival procedures for parallel runways. This is however not within the scope of the Wave1 work and may require costly aircraft equipment and aircrew certification. This is expected to be fully addressed in further research work.

Solution PJ.01-03B: Dynamic E-TMA for Advanced Continuous Climb and Descent Operations

PJ.01-03B will address a change in the method of managing traffic in the E-TMA. In today's operation, aircraft are often subject to open loop radar vectors, resulting in a lack of predictability, inefficient climb and descent profiles and high controller workload. The introduction of systemised airspace and new ways to facilitate CCO/CDO, building on the work achieved in PJ.01-02, will enable a more efficient and predictable systemised environment.

The work in PJ.01-03B will be closely related to the work performed in PJ.01-02 and will focus on advanced continuous climb/descent and dynamic PBN routes aspects of the Solution. The majority of the work will be performed in Next R&D phase, with some initial V2 work being performed in Wave 1.

The concept is investigated for medium/high density/complexity environment. Whilst keeping in mind the overall objective of the SESAR 2020 concept of operations about improving high density operations' efficiency, PJ01-03B aims at taking advantage of the previously described features to improve flight efficiency in all situations, focusing on medium density and complexity operations, with the objective to achieve solutions applicable to situations as close to high density and complexity operations as possible.

Solution PJ.01-05: Airborne Spacing Flight Deck Interval Management

Interval Management (IM) is a concept that improves the precision and consistency of inter-aircraft spacing over non-IM operations. The precise spacing allows for higher throughput and more efficient aircraft operations. The objective and resulting benefits of IM are achieved by tasking the controller to assign an Assigned Spacing Goal to the flight crew, who relies on the on-board Flight-deck Interval Management (FIM) system to provide IM Speeds to meet that goal. The Assigned Spacing Goal is selected by the controller to provide the operationally required spacing between the IM Aircraft and Target Aircraft while meeting other operational constraints and considerations.

This Solution is based on ADS-B in traffic presentation on the CDTI, combined with an aircraft-based FIM application providing information that enable pilots to manage their spacing with another aircraft. The Solution builds on both ground and airborne capabilities and focusses on operations in a Trajectory Based TMA environment.

The rationale for flying PBN procedures in a Trajectory Based TMA environment, includes continuous descents (improving fuel efficiency and reducing emissions), less noise impact for the environment and predictable routes of the traffic flows; the Solution is aiming at the consolidation and growth of TMA arrival capacity and runway throughput while utilizing these PBN procedures to the maximum extent possible.

Given the aim, as a step towards TBO in terminal airspace, to reduce the use of radar vectors and keep aircraft on defined routes, speed control is the remaining means to ensure that the operationally-required spacing at the beginning of the final approach and subsequently at the runway threshold is achieved. The two main speed control options are flight crew managed spacing (i.e, IM) and controller managed spacing. The advantages of IM are that it provides more precise inter-aircraft spacing through closed-loop, precise guidance within the flight deck, and it reduces controller task load by relieving the need to communicate multiple speed instructions. The disadvantages of ASPA-FIM are the cost to install airborne equipment and the level of equipage needed to obtain performance benefits for the ATM system. Therefore, besides an operational performance assessment, a cost-benefit assessment is considered crucial.

The Solution requires ground as well as airborne tools, there is a need for ATC (voice) communications between controllers and flight crews and for information exchanges between aircraft through Automatic Dependent Surveillance – Broadcast (ADS-B). Consequently, harmonization at European and global level is needed.

Solution PJ.01-06: Enhanced Rotorcraft operations in the TMA

Integration of rotorcraft operations in dense / constrained airspaces is limited and their access to busy airports is reduced considering that IFR Rotorcraft are currently constrained to use same approach/departure procedures as fixed-wing aircraft, resulting in a lack of rotorcraft specific noise abatement and fuel saving procedures.

Rotorcraft operations require specific meteorological (MET) and aeronautical (AIM) information unique to the specific operational constraints imposed which is not necessarily available or shared today. As such a common operating picture between rotorcraft operations and other operations is often missing and PJ.01-06 aims to define this common operating picture and the information needs to support this. PJ.01-06 provides a solution to remove IFR Rotorcraft from active runways by using Rotorcraft specific independent IFR procedures to/from FATO, as well as making rotorcraft operations less dependent on environmental factors, such as weather, by providing easier rotorcraft access to IFR.

As these PinS procedures (departure and approach) are usually designed to be located in dense/constrained airspaces, and sometimes in mountainous areas and/or with multiple obstacles, PJ.01-06 proposes to evaluate the improvement to flight performance and safety brought by an on-board Head-Mounted Display; VFR-to-IFR transitions during take-off and IFR-to-VFR during approach, which are usually high-workload phases for the rotorcraft pilot, should be facilitated and secured by displaying heads-up and conformal to the landscape the PinS information (trajectory, point-in-space location…) and the primary flying data.

Solution PJ.01-07: Approach Improvement through Assisted Visual Separation

Flight efficiency can be negatively impacted when preceding/following aircraft are flying the same procedure. PJ.01-07 aims at improving approach operations by helping to reduce go-arounds thanks to improved procedure of visual separation. It applies between an aircraft equipped with ADS-B IN capability and a preceding aircraft equipped with ADS-B OUT capability, both on approach to the same runway, in Visual Meteorological Conditions (VMC). The ATC is not informed about the CAVS capability of the aircraft. It gives visual separation clearance to the aircraft as per today use.

The solution evaluated the operational acceptability of CAVS by flight crews and the usability of the cockpit function proposed respectively for business aircraft and mainline aircraft.

An additional issue explored was the convergence between US and European operations whenever dealing with delegation of separation responsibility.

1.2 Project Scope and Objectives

Solution PJ.01-01: Extended Arrival Management with overlapping AMAN operations and interaction with DCB

Objective of PJ.01-01 was to investigate the use of queue management techniques that are extended further from the arrival airport, more integrated with airport and network-wide demand and capacity balancing and make use of more accurate and predictable arrival timings. The Project must assess the impact on the En-route sectors of multiple arrival management systems operating out to extended range and consider how to balance the needs of those involved. The methods for sharing data between systems and reconciling the constraints of different systems must also be addressed.

The scope of the Solution is to investigate the interaction between multiple extended Arrival Management (AMAN) systems, the Network and Airport Demand-Capacity Balancing (DCB) in medium and high density/complexity E-TMA environments.

Solution PJ.01-02: Use of Arrival and Departure Management Information for Traffic Optimisation within the TMA

Objective of PJ.01-02 was to investigate the use of information from departure management systems from multiple airports and the integration of this information with information from arrival management systems, to optimise the flow of traffic within the E-TMA. The various sources of demand information must be combined to adjust the departure sequence, first manually and then with automated support, to provide more consistent delivery of traffic through constrained points within the TMA and into the En-route phase of flight.

The scope of the Solution is to assess the use of arrival and departure management information to 'identify and resolve complex interactions in the E-TMA'. This Solution covers medium and high density/complexity E-TMA environments, including TMAs with multiple airports.

Solution PJ.01-03A: Improved Parallel Operations

Objective of PJ.01-03A was to investigate the improvement of parallel approach operations through the application of PBN/RNP navigation specifications and the development of enhanced ATC procedures.

PJ.01-03A involves improved independent parallel approaches supported by PBN. PJ.01-03A investigated closed loop routes and operating methods to improve operations with PBN/RNP parallel approaches.

Solution PJ.01-03B: Dynamic E-TMA for Advanced Continuous Climb and Descent Operations

Objective of PJ.01-03B was to investigate the dynamic use of routes within the E-TMA to improve the utilisation of airspace as well as to enable the maximum use of continuous descent and continuous climb operations and efficient connections to Free Route operations. The Project must develop appropriate methods of decision support for the selection of suitable routes which will bring maximum benefits according to differing traffic and capacity constraints, e.g. ranging from dense and complex E-TMAs to low demand E-TMAs. Methods will also need to be developed to expediently share these elements of the ATC plan with aircraft.

PJ.01-03B involves advanced continuous climb and descent operations and dynamic route structures. PJ.01-03B will investigate the facilitation of Continuous Climbs and Continuous Descents through route structure and/or use of controller & pilot assisted tools.

Solution PJ.01-05: Airborne Spacing Flight Deck Interval Management

Objective of PJ.01-05 was to investigate the use of techniques that enable pilots to manage their spacing, sequencing and merging with other traffic, including by providing detailed traffic information in the cockpit. The use of this information to maximise the ability of aircraft to maintain visual separation should also be investigated. The opportunities, offered by the various potential applications of delegation of spacing and assisted visual separation to the cockpit, must also be understood. Equally, the interactions between these applications and the potential challenges and benefits must be clearly defined.

The scope of the Solution is to assess the use of Airborne Spacing – Flight Deck Interval Management (ASPA-IM) manoeuvres in a Systemised TMA environment.

Solution PJ.01-06: Enhanced Rotorcraft operations in the TMA

Objective of PJ.01-06 was to examine methods that enable better integration of Rotorcraft operations in the TMA, while reducing the potential impact of these operations on other airspace users. These methods must provide arrival and departure routes that do not conflict with other airspace users, including in poor weather and low visibility, to remove rotorcraft from active runways using rotorcraft specific procedures and improve access to and from landing sites at both airports and remote locations.

The scope of the Solution is to develop the integration of rotorcraft into the RNP route structure in a range of TMA environments. The solution takes into account the Advanced PinS concept based on new procedure design requirements (e.g. curved segments, lower RNP) and the Helmet Mounted Display

System (HMD), Synthetic Vision System (SVS), Attitude Heading Reference Systems (AHRS), Satellite Based Augmentation System (SBAS)).

Solution PJ.01-07: Approach Improvement through Assisted Visual Separation

Objective of PJ.01-07 was to investigate the acceptability and the interest of the use of the CAVS cockpit function developed to support visual separation thanks to the display of traffic information (available thanks to ADS-B IN capability) the goal of this function being to maximise the ability of aircraft to maintain visual separation. The scope of the Solution is to address the improvement of descent and approach operations, in high density/complexity TMA environments, mostly on flight efficiency aspects due to the enhancement of the information presented to flight crews on the cockpit displays.

This Solution also aimed at addressing US/EU convergence for operations based on airborne Traffic Situational awareness.

1.3 Work Performed

Detailed plan of work for all solutions are available in the VALR documents. See related Datapack listed in Section 1.5 Technical Deliverables.

Solution PJ.01-01: Extended Arrival Management with overlapping AMAN operations and interaction with DCB

Solution PJ.01-01 activities focused on safety, performance and technical requirements derivation of the interaction between multiple extended Arrival Management (AMAN) systems, the Network and Airport Demand-Capacity Balancing (DCB) in medium and high density/complexity E-TMA environments. Specifically, the solution addressed the interaction between Traffic Synchronisation and DCB, including the identification of integration needs, and CTA in high density/complexity TMA.

Work was performed over six exercises (2 FTS, 1 Modelling Analysis and 3 RTS). The exercises conducted assessed:

- the benefit of changes to the E AMAN to facilitate the sequencing and metering of aircraft into systemised airspace PBN main and ‘offload’ arrival routes as determined by the Systemised Airspace Manager (SYSMAN) developed in solution PJ.01-02
- the interaction between multiple extended AMAN systems and Network DCB. A simplified Network Management and AMAN algorithm is used to examine the effect of synchronization and continual re-planning
- characterising the arrival management process and identifying any potential interactions with network management measures, at a macroscopic level
- handling non-coordinated AMAN advisories from multiple airports in an Extended AMAN context. The Focus of the simulation was to evaluate the effect on En-route sectors when

implementing non-coordinated AMAN advisories. The sequence was implemented with either TTG/L or with use of CTA for equipped flights. It used an AMAN prototype supporting i4D/CTA and E-AMAN for multiple airports. Also used was a business jet simulator connected to the Real-time simulation. The simulation evaluated possible benefits in Predictability and Capacity. It also evaluated Safety and Human Performance aspects of the concept. The sub-operating environment addressed is 'High Complexity' en-route

- validation of the inclusion of various DCB parameters published in the Airport Operations Plan into an E-AMAN. These included NM-approved airport TTAs and may also include other items such as planned runway direction and expected landing rate, plus aircraft destination terminal for consideration when AMAN has to create landing sequences for more than one runway. The RTS environment included 'systemised airspace' and was cognisant of the airspace management tools developed in PJ.01-02

Solution PJ.01-02: Use of Arrival and Departure Management Information for Traffic Optimisation within the TMA

One Fast Time Simulation (FTS) and two Real Time Simulations (RTS) were conducted in high density and complexity TMA/E-TMA environments. Originally four exercises were planned for V2 but the ENAV exercise was not undertaken. Its impact to the solution was evaluated through an Impact Assessment. The exercises conducted assessed:

- the integration of Systemised Airspace Management data into an E-AMAN for route balancing purposes in systemised TMA/E-TMA airspace. The execution of the FTS helped identify the potential benefits of using a SYSMAN tool to facilitate systemized airspace design built on PBN-based design principles within a terminal airspace environment. This exercise was performed in conjunction with PJ01.01, recognising the importance of the interaction between Extended AMAN (E-AMAN) horizon processes and SYSMAN.

- the operational feasibility of distributing traffic across primary and alternative (offload) routes to reduce bunching of aircraft and reduce route and stack over demand. The validation was conducted in collaboration with PJ.01-01. The Systemised Airspace Management prototype tool 'SYSMAN' was assessed in the Very High Complexity multi-airport Extended Terminal Manoeuvring Area (E-TMA) in Southeast of the UK. The validation covered the Operational Improvement (OI) step TS-0307 – "Integrated Arrival Departure Management for traffic optimisation within the TMA and Extended TMA Airspace"; aiming at a more regular and homogenous flow of arriving aircraft. OI step TS-0302 – "Departure Management from Multiple Airports; ensuring a more consistent delivery of departures into the TMA" was originally planned to be assessed during this validation exercise. However, due to limitations, departures use cases were not assessed as part of this exercise.

- the Step 2 V2 mock-up for the OI-Step TS-0307 at the DFS premises in Langen, Germany to balance the sector load by predicting sector entry times for all relevant traffic and controlling the sector entry times. The validation was run using a new mock-up with new functionalities and HMI called 'Advanced CMAN'. The simulation campaign covered an E-TMA and TMA in

German airspace. The mock-up consisted of individual E-AMANs and functions. Proposed HMI was based on suggestions from the SESAR 1 validation activities and several HMI workshops. The display was structured in four columns; from left to right they present information on:

- Inbounds to the major airport Dusseldorf (DL)
- Inbounds to the major airport Cologne (DK)
- Inbounds to all other airports (Others)
- Departures from all airports

Solution PJ.01-03A: Improved Parallel Operations

In the V1 maturity phase, the validation exercises consisted of cockpit and ground real time simulations. Work was performed over two exercises. The exercises conducted assessed:

- controllers' acceptability of the point merge option in a generic environment. The exercise investigated design properties to facilitate acceptability and feasibility. It involved 6 to 7 controllers from LFPG for each session for a total of 9 days (end 2016-early 2017). This consisted of a series of three ground real time prototyping sessions using EUROCONTROL's ESCAPE simulator

- feasibility / acceptability issues and identify showstoppers (if any) related to the axis merge option from a pilot perspective. This consisted of three sessions involving crews from Airbus, Easyjet and Air France and used a series of real time simulations using the EUROCONTROL A320 cockpit Simulator to address

In the V2 phase, the validation exercises consisted of two Real Time Simulations and one Fast Time Simulation. Work was performed over three exercises. The exercises conducted assessed:

- the approach environment on Paris Charles De Gaulle (CDG). This was done via a series of 4 iterative controller real time sessions conducted by EUROCONTROL and DSNA/CDG on the ECTL ESCAPE platform at the EUROCONTROL Experimental centre (EEC).

- the applicability of solution 01-03A "improved parallel approach operations using PBN" for the merging to a point option. It consisted of a small-scale Fast Time Simulation (FTS) conducted on A. S. Madrid-Barajas airport (LEMD) approach environment using the ENAIRE TAAM tool.

- Axis Merge by evaluating FMS Course Intercept function in a range of different aircraft types equipped with different FMS systems. This was done via a series of pilot real-time cockpit simulator sessions with a series of flight simulations using the ECTL Cockpit simulator at EEC.

These exercises are described in D3.1.020 – PJ01-03A V1 VALP.

Solution PJ.01-03B: Dynamic E-TMA for Advanced Continuous Climb and Descent Operations

As well as Expert Working Groups and Workshops, one RTS exercise and one FTS exercise were conducted within this Solution. The exercises conducted focused on:

- the facilitation of Continuous Descents Operations through dynamically assigned routes. This was a V2 Real Time Simulation conducted by DSNA/AIRBUS/Thales, based on a Paris ACC (E-TMA) and Orly approach.
- the facilitation of continuous climb and descent operations though the clearance of optimised Rate of Climb/Rate of descent. This was a V2 Fast Time Simulation conducted by ACG (COOPANS)/ENAIRE, based on Stockholm TMA and focused on departures and arrivals from/to Arlanda (ESSA) and from Bromma (ESSB) airport.

These exercises are described in D3.2.020 – PJ01-03A V2 VALP.

Solution PJ.01-05: Airborne Spacing Flight Deck Interval Management

There were 3 FTS and 2 RTS exercises undertaken in this solution:

- FTS at Amsterdam Schiphol (very high complexity TMA, very large Airport) to assess the performance of ASPA-IM (Airport Capacity, Predictability, Fuel Efficiency, Noise, Safety, Communication Task Load, etc) in nominal conditions, using NLR's Traffic Manager (TMX) tool
- RTS at Amsterdam Airport Schiphol (very high complexity TMA, very large Airport) to assess the controller perspective of ASPA-FIM addressing the Human Performance, Safety, Cost Efficiency and TMA Capacity KPAs in nominal conditions. In addition, several other KPAs were addressed such as Airport Capacity and Predictability, using the validation platform NLR's ATC Research Simulator (NARSIM)
- FTS at Málaga Airport (medium complexity TMA, medium Airport) to assess the performance of ASPA-IM (Airport Capacity, Predictability, Environment) in nominal conditions, using the validation platform is RAMS Plus. RAMS Plus uses NEST to upload the input of the traffic forecast for 2025. The behaviour of the human actors (controllers and pilots) was modelled in RAMS Plus by using a set of internal rules.
- FTS to assess the performance of ASPA-IM (Airport Capacity, Predictability, Fuel Efficiency, etc) in nominal conditions using optional routing to enable delay absorption in the TMA. The Schiphol implementation represents a medium complexity airport environment without advanced metering tools, using NLR's Traffic Manager (TMX) tool.
- RTS at Amsterdam Airport Schiphol (very high complexity TMA, very large Airport) to assess both controller's and pilot's perspective of ASPA-FIM addressing the Human Performance, Safety and TMA Capacity KPAs in non-nominal or disturbed conditions. In addition, several other KPAs were addressed such as Airport Capacity, Predictability and Fuel Efficiency., using NLR's ATC Research Simulator (NARSIM). Two ACC sectors were manned by executive controllers. The FDR/DCO position, APP Planner position and ARR position for runway 36R were manned by APP controllers. NARSIM uses BADA 3 aircraft modelling.

Solution PJ.01-06: Enhanced Rotorcraft operations in the TMA

The Solution conducted the following three exercises:

- RTS by DLR (AT-ONE) and THALES Avionics, in the DLR generic cockpit simulator (GECO). The RTS exercise was set prior to the flight trials in Braunschweig as this exercise was needed to verify the functional setup and provide further test scenarios that cannot be conducted in the flight trials. Additionally, the generic and safe environment of a simulator allowed multivariate testing under controlled conditions what allowed a better statistical analysis. The scenario layout in the means of the approach and departure path has been the same as for the flight trials.

- Flight Trial campaign performed by DLR (AT-ONE) and THALES Avionics at Braunschweig airport against IFR Advanced Point-in-Space (PinS) procedures. An EC135 research helicopter was equipped with its standard avionics suite, completed with a TopEagle Head Mounted Display and real-time simulated Flight Management System and Navigation Display. The scenarios assessed the navigation performance, human factors, and workload under day conditions for a single pilot IFR configuration, considering the traffic, in particular its impact on crew workload. This validation exercise aimed to cover the use case titled "Advanced PinS procedure using HMD" in nominal and abnormal conditions, with the helicopter being flown manually (without autopilot coupling).

- Flight Trials at Airbus Helicopters that included flight testing of IFR Advanced Point-in-Space (PinS) approaches to Donauwörth heliport with BK117 D-2 and EC135 helicopter equipped with a Helionix integrated avionics suite (Head Down Display). The scenarios included assessment of the navigation performance, human factors and crew workload. The basis of the validation assessment was flight test data analysis and crew feedback in the form of post-flight test reports. This validation exercise aimed to cover activities in nominal and abnormal conditions, with and without autopilot coupling.

Solution PJ.01-07: Approach Improvement through Assisted Visual Separation

The Solution conducted two exercises to assess the CAVS operation supported by the business A/C and mainline A/C airborne functions towards V2 maturity, and also to progress towards V1 maturity for a few other operational aspects tested during those two exercises. Real prototypes were developed for the mainline A/C real time simulation (RTS) and a software mock-up was developed to support the business A/C RTS:

- For Business A/C function, The V2 part of the exercise was performed on Honeywell facilities to investigate the impact and validate the feasibility of the CAVS operation procedure; validate the CAVS human-machine cockpit interface on the human performance during normal and degraded conditions; and for V1 maturity performed on the same Honeywell facilities to assess new procedures derived from the CAVS definition, using the same "CAVS capable" airborne equipment.

- The cockpit function developed for CAVS allows supporting flight crews in executing CAVS operations. From the evaluation outputs, the cockpit function helps pilots in achieving and maintaining visual separation from a traffic. The benefits for airborne actors in terms of decreasing the risk for a loss of separation have been confirmed by crews. During the evaluations, the workload in the cockpit was shown as not highly impacted.

- CAVS operation is feasible with the cockpit function developed for CAVS, however the operation when flight crew loses the visual contact from the preceding aircraft should be carefully checked, in particular whenever the traffic to follow is no longer qualified for CAVS.

- For Mainline A/C function, the exercise was performed on Airbus A320 integration cockpit simulator to validate the ATSAW+ cockpit function as relevant to support the flight crews in executing CAVS operation and confirm the feasibility of the CAVS operation with such support so as to demonstrate V2 maturity; assess the possibility of using the ATSAW+ function for other operations than CAVS where it could facilitate existing operations or enable new operations. V1 maturity was targeted for those other operations.

1.4 Key Project Results

Detailed results for all solutions are available in the VALR documents. See related Datapack listed in Section 1.5 Technical Deliverables. Performance and Safety Assessments outputs are available in the OSED document within the related Datapack.

Solution PJ.01-01: Extended Arrival Management with overlapping AMAN operations and interaction with DCB

The results from this solution were as follows:

- There was positive feedback from the RTS on the potential benefits and operational feasibility of the concept of using DCB information within an E-AMAN. In particular, for the arrival terminal and stand allocation, while DCB information within the E-AMAN was also used to enable the E-AMAN to be able to make automatic Tactically Enhanced Arrival Management (TEAM) arrival selections, reducing the workload of the Group Supervisor Airports (GSA). Additionally, the participants of the RTS liked the idea of the E-AMAN making automatic re-route decisions for the offload routes concept using DCB information provided by the PJ.01-02 E-TMA Management tool in the joint PJ.01-01 & PJ.01-02 RTS validation exercise.

- The FTS exercises also indicated that the concept of utilising both Extended-TMA Manager flow rate DCB information and AOP DCB terminal information would be likely to increase both the airspace throughput and predictability within a systemised PBN airspace structure. Furthermore, the validation exercises assessed the benefit of the integration of information from multiple arrival management systems operating out to extended range into en-route sectors with local traffic/sector information. The traffic synchronization interaction between network DCB (Demand-Capacity Balancing) within the extended horizon was addressed and potential information integration requirements and balancing mechanisms was investigated and developed.

- The FTS validation activities also covered a simplified operation of local Network Management DCB and E-AMAN at several airports across the ECAC region, focused on the synchronization of Extended AMAN and Network DCB constraints in a European traffic scenario. A synchronisation algorithm (ASoNA) was developed as part of this exercise. ASoNA was connected to the fast time simulation through an interface and calculated the synchronisation between Extended AMAN and Network Manager in case of conflicting constraints. In order to reduce the complexity of the model used for the fast-time simulations, especially for the 24 airports equipped with E-AMAN as mentioned above, some simplifications had to be made. Hence, it is the first and very important step in analysing the effects of synchronised use of E-AMAN and Network Manager in a complete 24 hours European air traffic and airspace scenario, especially the benefit and potential side effects of it.

- Main important findings from the above can be summarized as follows:

    - The number of flights affected by the different stakeholders (E-AMAN and Network Manager) is relatively low. This could be explained with the limited horizon of the E-AMAN, which was set to 200NM.

    - The synchronization process significantly reduces the holding delay of the affected flights. The negative outcome is that the overall holding delay of all the flights is slightly increased.

    - It is observable that the traffic demand in certain airspaces in the reference scenario reaches or exceeds the sector capacity.

    - The AMAN and Network Manager DCB distribute the traffic demand maintaining the capacity of the airspaces

- The modelling analysis reveals potential interaction between arrival management and network management measures. Network management measures should be integrated by the arrival management process to avoid generating traffic overflows. With such an integration, flight efficiency benefits (shift from terminal delay towards ground delay) is less than without integration but is still positive. This raises the question of trade-off and level of performances expected in terms of capacity limits (tolerance).

- Further Real Time Simulations focused on the concept of E-AMAN and CTA into multiple airports, which was assessed in the aspect of human performance, safety, efficiency, accuracy and capacity. It was concluded that the concept supports an acceptable increase in workload and working method that does not seem interfering or limiting the aspect of human performance. No negative impact on safety was detected for the evaluated conditions even if further analyses are still needed to fully evaluate the safety aspects. The concept allows the ATCO to choose the most appropriate procedure for each situation and thereby safety shouldn't be compromised. The ATCOs are expected to cancel CTAs in due time and shift to conventional TTL/G method when they feel it's necessary to maintain safety and control over the situation.

- Efficiency analysis was out of the scope of the above exercises, given that the Solution interest is mainly focused on what happens in the en-route phase, excluding other flight phases and, as such, limiting the data inputs that could be considered in the analysis. However, some results of a fuel efficiency analysis, achieved during the real time simulation, indicate improvements in fuel efficiency utilizing i4D-CTA with vectoring/retain CTA over a fully vectored method to meet an equivalent TTL.

- Due to several difficulties various complications, only two of the KPI's were able to be assessed from all of the solution's validation activities; however, the solution was able to attribute FEFF1 benefits of 0.945 to 1.547 kg fuel/flight to TS-0315 equating toFEFF2 benefits of 2.976 to 4.870 kg CO2/flight. The predictability PRD1 KPI stemming from TS-0315 and TS-0109 was assessed to be -0.846mins2 to 1.345 mins2 in the en-route and 0.524 mins2 in the TMA.

Maturity Assessment:

The review team's assessment is that the solution as a whole has not achieved full V2 maturity and is therefore assessed as V2 ongoing. However, some elements have achieved results that can be considered as non-blocking for V2.

Solution PJ.01-02: Use of Arrival and Departure Management Information for Traffic Optimisation within the TMA

From the EXE-01.02-V2-VALP-02-FTS, despite the limitations in the model, results consistently show that there is capacity in the airspace with 2025-projected traffic growth to reroute flights to resolve some bunching. Confidence in the results is not high enough to quantify the proportion of the bunching that is resolvable via this method. See the Validation Report for further details of results.

During the validation of EXE-01.02-V2-VALP-2b-RTS, the prototype required several workarounds to suppress or filter data to make it function, resulting in limited realism and therefore a lack of confidence in any quantitative data measured. Therefore, results focused on the qualitative feedback of the concept, including operational feasibility, human performance and safety. Feedback from the validation was still positive, indicating that an E-TMA Management tool (such as SYSMAN) would be required in order to handle the increased traffic levels and therefore flow rate of aircraft delivered to the STARs. The concept of rerouting flights onto offload arrival routes was regarded by all participants as feasible, however the criterion used during the RTS to identify excess demand along a route (six aircraft in a 10-minute interval) was shown to be too simplistic. SYSMAN technical feasibility was not able to be fully proven, as the prototype did not comply with all the technical requirements due to late delivery and technical issues with the prototype. The participants commented how the concept and SYSMAN tool has great potential and could be used to reduce the workload of the tactical controller by balancing the flow of traffic across routes.

During the validation of EXE-01.02-V2-VALP-3-RTS, the concept was successfully validated as feasible in a 10-day validation campaign in a human-in-the-loop real time simulation with controllers. The validation was using a new mock-up with new functionalities and HMI. The simulation campaign covered an E-TMA and TMA of German airspace. The new tool/functions were well understood and allowed the controllers to balance the demand and capacity of a sector (sector load) within the E-TMA while considering various inputs. Advanced CMAN (A-CMAN) balances the demand and capacity of a sector (sector load) within the E-TMA and considers various inputs to assess how many aircraft will be in the sector overall within a look-ahead time of approximately one hour in order to find mitigating solutions as required. One of these mitigating solutions is the prioritization of an Arrival Stream, either via adjusting the flow into one airport or via balancing the flows through the sector for both airports without changing the overall flows. In addition, it is possible to re-schedule a specific aircraft and to hold one or several aircraft on the ground.

The technical feasibility of A-CMAN was successfully demonstrated. A later implementation into this system environment is considered possible. No malfunctions or any undesired technical behaviours were observed.

Confidence in quantification of results was low, however some performance improvements can be expected in:

- Human Performance (Workload reduction, Increase in Situational Awareness)
- Flight Efficiency
- Predictability (2% reduction in variance of block to block flight time)
- Capacity (better balance of existing capacity, avoiding overloaded sectors in approach

These performance improvements were obtained in an environment where there was no measurably adverse effect on safety.

Maturity Assessment:

The review team's assessment is that the solution as a whole has not reached V2. However, some elements have achieved V2.

Elements that have achieved V2 (maturity V2 with some elements being partial non-blocking):

- A-CMAN – arrival management for two airports using prioritization of flows to avoid overload of an E-TMA sector – this concept builds on (and supersedes) SESAR 1 solution 8 but uses prioritization of flows strategy.
- Ground delay from departures of the airports with the AMAN (main airports) and smaller airports (associated enabler APP ATC 110): concept has been described and the A-CMAN prototype tool allowed ATCOs to allocate ground delay, but ground delay actions were not addressed in measured validations. Process is described end to end (there is no change in the implementation of the ground delay with respect to today's departure release process). There is an enabler: APP ATC 62. This element is not fully V2, but it is not blocking.

Elements that have not achieved V2, and current (maturity is V2 partial blocking)

- SYSMAN – reroute of arrivals (in one of three routes to reduce workload in the sector) – the reviewers note that this concept is not described end-to-end, only the FMP aspect has been described and addressed. The FMP aspect, and was partially addressed in the validations and maturity is currently V2 ongoing, and the ATC aspect has not been addressed.

- Reroute or ground delay from departures of the airports with the AMAN (main airports) – concept not described and not addressed in validations. There is an enabler: APP ATC 62
- Reroute or ground delay from departures of the nearby (smaller) airports with no AMAN (smaller airports) – concept not described and not addressed in validations; it has an associated enabler (APP ATC 110).
- In-horizon departures – there is some related concept in operation todays, but this has not been addressed by the solution and has no enabler in the MP.
- Synchronization of departures/coordinated allocation of SIDs from nearby airports – this aspect has been addressed at conceptual level, but not in the validations. The feasibility may be limited with the current accuracy of the prediction of the TTOTs. Reviewers recommend that this is discussed early in Wave 2 solution 8.

Solution PJ.01-03A: Improved Parallel Operations

In the V1 phase, the main results were as follows (See D3.1.030 - PJ.01-03A: V1 VALR):

- The pilot sessions enabled an initial feasibility assessment of both options (axis merge and point merge) including the confirmation that flight crews supported the idea of PBN to final, and the identification of aspects to be further clarified especially regarding axis merge.
- The controller sessions enabled the identification of key characteristics in a generic environment in terms of minimum distance for merge point, and angle between downwind and base routes. Controller feedback and initial trend analysis showed that resulting route designs can facilitate sequencing even under high traffic peaks, drastically reduce vectoring (most of the aircraft staying on NAV mode until ILS interception) and keep trajectories away from the axis area prior the transition to final.

Building from the V1 phase results, the operability and performance assessments carried out in the V2 phase for the point merge option consisted of two main validation exercises (See D3.2.030 - PJ.01-03A: V2 VALR):

- EUROCONTROL and DSNA-CDG conducted a series of real time prototyping sessions and a final V2 RTS in LFPG environment, including the integration of crossing downwind procedures. This showed positive operability assessment and performance trends. Nevertheless, the design tested would need to be improved to progress beyond V2
- ENAIRE conducted an FTS in LEMD environment enabled, after an initial study of design options regarding the applicability for parallel arrival operations on runways 18R and 18L. The performance assessment showed positive trends.

Overall, In V2, the operability assessment and performance trends for the point merge option were positive, which shows the Solution's potential applicability in dense and complex environments. Nevertheless, one aspect of the specific design tested in the LFPG environment induced reservations from some controllers regarding acceptability and safety, so the design would need to be improved should it be implemented locally.

In addition, these validation exercises were enhanced by:

- Human Performance and Safety assessments, and a Cost Benefits Analysis (See D3.2.010 - PJ.01-03A: V2 SPR-Interop/OSED Part II and Part IV)

- As a follow up to findings from the V1 phase, a series of cockpit simulation sessions focusing on the feasibility of the "Axis Merge" option was conducted separately. This "axis merge" assessment confirmed that in the conditions studied in PJ.01-03A, a standard function is missing to implement the axis merge option with an acceptable workload on the cockpit side (See D3.2.030 - PJ.01-03A: V2 VALR)

Finally, a Safety assessment was conducted resulting in Safety related measurements showing potential for significant improvement, plus a set of requirements and recommendations, based on: Input from controllers (RTS), workshop with pilots and mathematical modelling (Collision Risk Model) for sensitivity analysis (See D3.2.010 - PJ.01-03A: V2 SPR-Interop/OSED Part II).

Regarding the axis merge option, as a follow up to findings from the V1 phase, a third exercise covered the 'axis merge' option. EUROCONTROL conducted a series of cockpit simulations on various aircraft/avionics types which confirmed that, in the conditions studied in PJ.01-03A (high density, intercept of an RNAV axis that is not the final), a standard function is missing to implement the axis merge option with an acceptable workload on the cockpit side (See D3.2.030 - PJ.01-03A: V2 VALR).

Maturity Assessment:

The Solution has achieved V2. It was clarified that the work against the Axis Merge option was not progressed, however this is no longer part of this solution.

Solution PJ.01-03B: Dynamic E-TMA for Advanced Continuous Climb and Descent Operations

RTS Exercise: For the RTS Concept, the overall maturity of the solution progressed on operational aspects:

- Improve management of high-altitude constraint

- Possibility to build a stable strategy and attribute routes to absorb the delays,

- Compromise between early attribution of route and potential need to change the sequence,

- Less active control, more monitoring, need for tools,

- Operational evaluation of PRT functionality

- Recommendations for technical or operational evolutions identified,
- Recommendations for improved validation context identified

However, Because of limitations (known before the exercise and accepted because of focus on operational feasibility) and unexpected issues (observed during the exercise or when analysing the results), few quantitative results (by essence, this experiment was an RTS (vs FTS)), limited confidence in quantitative results.

FTS Exercise**:** Although the FTS provided quantitative and qualitative performance benefits for the concept under assessment, a pure operational feasibility assessment will need to be performed using RTS or Live Trial techniques involving prototypes of the corresponding ground system enablers and air traffic controllers and pilots. Some of the main findings regarding the operational feasibility of the concept are:

- Improved situational awareness for Approach ATCO.
- The awareness of each aircrafts intended trajectory leads to less level outs.
- Essential is the availability of downlinked aircraft data and/or DPI from aircrafts still on ground.
- This data is to be processed by the ATC decision tool.

Maturity Assessment:

The Target maturity for Solution PJ.01-03B was to progress the concept towards V2 maturity but it was not expected to achieve full V2 during Wave 1. The Presentations were made with the appropriate documentation at the Maturity Review with the SJU. The project progress was accepted as good and in line with the expectations for V2-ongoing. The presented base for continuation to V2 is very clear with promising initial outcomes. It is noted that many useful recommendations have been proposed for future research. To achieve full V2 in the future phase the project will need to demonstrate quantitative benefits (particularly in-flight efficiency) and provide a robust CBA, SAF etc.

Solution PJ.01-05: Airborne Spacing Flight Deck Interval Management

The main results from the Solution exercises were as follows (for more details see SESAR Solution PJ.01-05 VALR for V2, D4.1.050, Edition 00.02.00, October 2019):

- Fast Time Simulations in the Amsterdam Airport Schiphol environment (very high complexity TMA, very large airport) demonstrated:
  - No runway throughput deterioration with fixed profile descents (FPD), which is an important result.
  - Preconditioning with 45-second delivery accuracy at the TMA boundary is sufficient.
  - A 10-second spacing buffer is achievable with IM (based on 5% under-separations on final approach), resulting in:

    - an increase of 5.1-6.2 landings per hour on fixed PBN TMA routes
    - an increase of 1.6-1.9 landings per hour compared to today's operations at major European airports, due to a spacing buffer reduction from 13.85 seconds (0.5 NM @ 130 kts groundspeed) to 10 seconds for IM
  - A total fuel benefit of 87-108 kg per (arriving) aircraft.
  - Time predictability is very good across the various conditions; the standard deviation of actual minus planned flight duration between TMA boundary and runway is always less than 25 seconds.

- Fast Time Simulations in the Malaga environment (medium complexity TMA, medium airport) demonstrated:

  - Up to 34 more ARR-DEP-ARR gaps along the day that could be used potentially by a departure.
  - From 48 to 51 operations/peak hour (21 to 24 departures).
  - TMA arrival predictability (standard deviation) is estimated to improve between 4% and 16%.
  - Negligible fuel benefits (2 to 19 kg).

- Fast Time Simulations testing several delay allocation methods demonstrated:

  - On fixed TMA PBN routes, Interval Management gives a significant landing runway throughput benefits (between 4 and 7 additional landings per hour) for various combinations of delay allocation and delivery accuracy at the TMA boundary.
  - When the objective is to maximize landing runway throughput, a fixed route network should be designed without delay allocation, with 45-second (3σ) delivery accuracy at the TMA boundary and with the use of Interval Management operations.
  - When the delivery accuracy at the TMA boundary is given, the route design and delay allocation method to be pursued should be:
    - For 60-second delivery accuracy at the TMA boundary, a fixed route network without TMA delay allocation.
    - For 90-second and 120-second delivery accuracy at the TMA boundary, a fixed route network with TMA delay allocation, and a default route that has a delay in the order of 1 minute.
    - Note 1: This route design and delay allocation method comes at a cost in terms of landing runway throughput (minus 1-3 landings per hour), fuel efficiency (plus 0.5-10 kg), predictability (plus 5-36 seconds standard deviation) and spacing performance (plus 1.5-7.5 sec, 95%) when compared to a fixed route network with a delivery accuracy of 45 seconds.

- First RTS mainly focused on Human Performance aspects from an Air Traffic Controller perspective and on supporting the findings of FTS#1. The main conclusions here are:

  - Neither safety issues nor major safety benefits have been identified

- One important Human Performance issue was identified: the communication burden in particular for the FDR controller is still too high. A further reduction or simplification of the overall phraseology is needed.
- In general, the performance gains support the findings of first FTS.

The focus of the combined second and third RTS exercises was on Human Performance aspects from both ATCO and flight crew perspectives and on supporting the findings of the FTS#1. One of the main topics was to check the robustness of the IM operations against disturbances, for that purpose a number of non-nominal conditions were tested (e.g. go-around, IM selection errors, unable IM, strong wind conditions).

The main conclusions from these RTS exercises are:

- The human performance issue related to the communication burden of the FDR/DCO, as identified in RTS#1, has been resolved. Changes in the overall R/T allocated to the FDR/DCO, by means of procedural changes, have alleviated the communication burden on the FDR/DCO position.
- The HMI of the ACC controller needs some improvement directly related to the FIM solution. The ground system shall have the capability to display to the ACC controller the status of the Target Aircraft ID instruction.
- It is strongly recommended to use data communications to transmit the Target Aircraft ID to the flight crew, but it is not a minimum requirement.
- No major human performance issues have been identified. All human performance indicators showed satisfactory or good scores, for both controllers and pilots.
- The Solution, including associated flight deck, controller-pilot and controller-controller procedures, is robust against the non-nominal conditions tested in the RTS.
- Neither safety issues nor major safety benefits have been identified.
- In general, the performance gains (runway throughput, predictability, fuel efficiency) support the findings of FTS#1.

Maturity Assessment:

Solution PJ.01-05 has achieved V2 with a number of acceptable risks due to a number of partial non-blocking criteria that were not fully met. In particular the Solution has relied on the EUROCAE Safety Assessment ED-195A and did not deliver a dedicated safety assessment according to the SESAR guidelines. While the failure approach was covered, the success approach was not covered. This gap needs to be covered in case of the future research. The solution demonstrated quantitative benefits and feasibility.

Solution PJ.01-06: Enhanced Rotorcraft operations in the TMA

Accessibility and Equity: PinS approaches including RF legs provide greater flexibility for helicopters to fly approaches in dense airspaces and constrained mountainous terrain. As demonstrated in the AHD flight trials, PinS approaches with RF legs were executed with high accuracy and low crew workload. These factors, coupled with greater design flexibility and smaller footprint of the advanced PinS procedures, contribute to enhancing accessibility and equity of helicopter in dense airspaces by de-conflicting with fixed wing traffic to runways (so called SNI procedures). Furthermore, accessibility to mountainous as well as noise-sensitive locations is greatly improved, thanks to the RF legs that help avoid crossing terrain and/or residential areas.

Capacity: A direct consequence of increased accessibility to dense airspaces is an increase in the capacity and throughout, by allowing rotorcraft to approach/depart in parallel of fixed wing traffic, and without additional infrastructural needs.

Predictability and Safety: The results of this exercise have shown that RF legs were accurately flown to the desired path following, and well within the RNP containment limits. The results from this exercise show that the autopilot coupled approaches had very low overshoot at leg transitions. Therefore, RF legs in the PinS procedures are predictable and repeatable. Consequently, safety is enhanced by the fact that the chance of proximity to obstacles is low when remaining on the desired path. Executing PinS approaches in uncontrolled airspace, where ATC may have very limited or no coverage, requires the flight crew to be vigilant and responsible for adequate separation to other VFR traffic encountered in VMC.

Maturity Assessment:

The Solution PJ.01-06 has achieved V3 including the optional HMD enabler.

Solution PJ.01-07: Approach Improvement through Assisted Visual Separation

The main results of the business ad mainline aircraft exercises are dealing with CAVS operation:

- The cockpit function developed for CAVS allows supporting flight crews in executing CAVS operations.
- From the evaluation outputs, the cockpit function helps pilots in achieving and maintaining visual separation from a traffic. The benefits for airborne actors in terms of decreasing the risk for a loss of separation have been confirmed by crews. During the evaluations, the workload in the cockpit was shown as not highly impacted.
- CAVS operation is feasible with the cockpit function developed for CAVS, however the operation when flight crew loses the visual contact from the preceding aircraft should be carefully checked, in particular whenever the traffic to follow is no longer qualified for CAVS.

Solution PJ01-07addressed operational efficiency, in particular fuel efficiency.

CBA result: can be negative or positive since it is very sensitive to the cost of a go around.

PAR result: negligible

CBA and PAR were built targeting fuel efficiency only.

Fuel efficiency was evaluated only based on the estimation of the amount of go arounds avoided and the results were found to be negligible.

Better results could be reached taking into consideration more precisely the go arounds at each airport: duration of the additional flight time, impact on the delay of the « go around » A/C for airlines (missed connections, delays) and for the other aircraft of the sequence.

Other benefits could be consolidated or demonstrated by complementary activities, provided a support is provided by the relevant partners:

- Safety: better situational awareness recognised by flight crews during evaluations
- Improve the adherence to declared airport capacity thanks to the reduction of go arounds
- Better flight efficiency: better speed management in final thanks to precise monitoring of the preceding aircraft behaviour
- Less emission thanks to better fuel efficiency
- Less noise due to the go around A/C flying at low altitude
- Facilitate acceptance of combination of visual approach and visual separation operations (not allowed today by some European airlines), thus allowing shorter flight time

Maturity V2 achieved with acceptable risks linked to some safety and security aspects and due to the CBA and performance assessment that have room for improvement.

1.5 Technical Deliverables

Reference	Title	Delivery Date[1]	Dissemination Level[2]
Description			
D1.1	D1.1 - PJ.01-01: V2 Data Pack	20/11/2019	PU
D2.1	D2.1 - PJ.01-02: V2 Data Pack	15/10/2019	PU
D3.1	D3.1 - PJ01-03A: V1 Data Pack	21/11/2017	PU
D3.2	D3.2 - PJ01-03A: Data Pack (V2)	11/07/2019	PU
D4.1	D4.1 - PJ.01-05: Data Pack (V2)	05/11/2019	PU
D5.1	D5.1 - PJ.01-06: Data Pack (V3)	21/10/2019	PU
D6.1	D6.1 - PJ.01-07: Data Pack (V2)	08/11/2019	PU
D7.2	D7.2 - Final Project Report	12/12/2019	PU

Table 1: Project Deliverables

[1] Delivery data of latest edition

[2] Public or Confidential

2 Links to SESAR Programme

2.1 Contribution to the ATM Master Plan

Code	Name	Project contribution	Maturity at project start	Maturity at project end
PJ.01-01	Extended Arrival Management with overlapping AMAN operations and interaction with DCB and CTA	Extended Arrival Management with overlapping AMAN operations and interaction with DCB integrates information from multiple arrival management systems, enabled by SWIM, operating out to extended ranges into En-route sectors using local traffic/sector information and balancing the needs of each AMAN. The solution addresses the interaction between Traffic Synchronisation and DCB, including the identification of integration needs, and CTA in high density/complexity TMAs. To facilitate the positive contribution En-route sectors make to arrival sequencing towards multiple TMA, the En-route ATSU INAP assesses the capability of the En-route sector to act on the delay requirement. The pre-determined delay absorption capacity is sent to the destination arrival management functions, which then provide the initial arrival sequences to be assessed by the local INAPs prior to distribution to the upstream En-route sectors to implement on a best effort basis.	V1	V2 ongoing
PJ.01-02	Use of Arrival and Departure Management Information for Traffic Optimisation with the TMA	Use of Arrival and Departure Management Information for Traffic Optimisation within the TMA sees TMA traffic managed in near real time, taking advantage of predicted demand information provided by arrival and departure management systems from one to multiple airports. This allows the identification and resolution of complex interacting traffic flows in the TMA and on the runway, through the use of AMAN and DMAN flow adjustments and ground holdings.	V1	V2 ongoing
PJ.01-03A	Improved Parallel Operations	Parallel Approach operations are improved through the application of RNP navigation specifications and the development of enhanced ATC procedures. Arrival and departure flows are strategically segregated as much as possible. Arrival flows feed 2 or more parallel runways through the new procedure, involving for each runway a dedicated	V0	V2

		route structure supporting path stretching followed by a PBN to xLS transition.		
PJ.01-03B	Dynamic E-TMA for Advanced Continuous Climb and Descent Operations	Dynamically attributed use of routes brings together vertical and lateral profile issues in both the En-route and TMA phases of flight, with a view to creating an end-to-end optimised profile and ensuring transition between free route and fixed route airspace. The solution will be supported by new controller tools and enhanced airborne functionalities. The solution includes: dynamically attributed departure/arrival routes (based on fixed, published, SIDs/STARs and transitions to final approach) and the development of enhanced ATC procedures.	V1	V2 ongoing
PJ.01-05	Airborne Spacing Flight Deck Interval Management	Airborne spacing flight deck interval management refers to new ASAS spacing interval management sequencing and merging (ASPA IM S&M) manoeuvres encompassing the potential use of lateral manoeuvres and involving more complex geometries where a designated target aircraft may not be flying direct to the merge point. The goal is to achieve and/or maintain a precise inter-aircraft spacing. IM is defined as the overall system that enables improved means for managing traffic flows and aircraft spacing. This includes both the use of ground and airborne tools. Precise speed guidance is provided within the flight deck to enable the flight crew to actively manage the spacing relative to the Target Aircraft.	V1	V2
PJ.01-06	Enhanced Rotorcraft operations in the TMA	Enhanced Rotorcraft operations in the TMA further develop the simultaneous non-interfering (SNI) concept of operations to allow RC to operate to and from airports without conflicting with fixed-wing traffic or requiring runway slots.	V2	V3
PJ.01-07	Approach Improvement through Assisted Visual Separation	Approach Improvement through Assisted Visual Separation refers to cockpit display of traffic information (CDTI) assisted visual separation (CAVS) and CDTI assisted pilot procedure (CAPP) applications that enable aircraft to separate each other visually in marginal visual conditions and that facilitate transitions from IFRoperations to CAVS.	V1	V2

Table 2: Project Maturity

2.2 Contribution to Standardisation and regulatory activities

PJ.01-01

No impact on regulation and standardisation activities.

PJ.01-02

No impact on regulation and standardisation activities.

PJ.01-03A

The following standards have been identified and assumed: The new procedure for IPAs from Solution PJ.01-03A is defined, published and operated in conformance with applicable ICAO and European standards, regulations and guidelines, including: ICAO PANS ATM, ICAO PANS OPS, ICAO SOIR, ICAO PBN Manual , ICAO PBN Airspace Design , EUROCONTROL TMA Design Guidelines, European Airspace Concept Handbook for PBN Implementation.

Reference documents are listed in SPR-INTEROP/OSED V2 [12].

No recommendations have been identified on regulation and standardisation aspects.

PJ.01-03B

No contribution to Standardisation and regulatory activities has been identified at this stage of the solution but ATN B2 standard has been assumed in the experiments. Nevertheless, some recommendations were identified.

Ground Side:

Regarding TOD and ETO sharing, it has been concluded that the technology is mature on-board but new tools might be needed on ground for EPP exploitation. However, depending on the real need and the planned usage on the ground, the EPP/FMS predictions definition might need to evolve (speed profile, recruise, PRT, etc.).

From a human performance perspective, it would help that a monitoring system displays the aircraft's present ROC/ROD as well as the planned/intended ROC/ROD when flying in the ATCOs sector of responsibility.

Regarding CTA/RTA usage, the behaviour of aircraft flying to a CTA/RTA was not easy to anticipate by the ATCO and thus led to an important monitoring activity. As a consequence, when using CTA/RTA, controllers will need a support tool to assist them in this monitoring activity.

Airborne Side:

Regarding the Top of Descent, the "when ready descend" instruction has been experimented in E-TMA (after a re-cruise procedure) during the exercise, thanks to EPP capability to provide the ToD from the FMS to the ground. It should be applied when possible for the ATCO as it certainly contributes to flight efficiency from pilots' point of view. They identified easily by comparing PAS@ATM simulators performance and FM Software predictions during the experiment, that the first aircraft of the sequence, generally not receiving speed advisory, had the best flight efficiency with the lowest quantity of fuel burned. Their recommendation to ATCO (as soon as all ATC constrains in terms of speed and altitude targets, at certain waypoints of the trajectory, is updated and accepted on board) will be to let the speed of the Aircraft under the hands of the crew when possible.

If an aircraft is asked to descend early to an intermediate level due to ATC constraints, it would be preferable to stay higher longer than to fly a shallow geometrical slope, hence it is preferable to level off and re-compute a new TOD with an idle descent slope.

Dynamic route should be sent early enough for different reasons. First, when the message UM#266 is used, the route must be loaded into the FMS before reaching the path extension point. Then, it impacts the position of the Top of Descent, and thus the energy management strategy that needs to be anticipated by the crew, ideally before the descent briefing. If the dynamic routes are coded in the Navigation Data Base, concept methodology was fine from pilot point of view. To cope with these delays and diversion, pilots recommended to use the “STAND BY” message to notify ATCO the crew is implementing the instruction received.

Regarding dynamic route design, the points shall not be too close to permit a correct trajectory computation by the FMS and reach the “time to lose” objective. Based on the tests performed for the experimentation preparation, 8 nautical miles seem to be sufficient. These investigations will surely explain the reason of “flight cut” due to short radius turn on alternative routes seen during the experiment (and highlighted in paragraph 4.2.8).

Additionally, in order to always fly the most optimized profile, even when an altitude constraint leads to an early descent, the on-board system should propose to the crew the point where an idle path permits to reach the next constraint. Hence, not flying a shallow path reduces the global thrust and thus the fuel consumption, by staying higher longer. Even if it is not intuitive, this partial CDA definition with a high level-off is more efficient than complete CDA that includes a slope that is not steep enough to fit aircraft performances.

Moreover, the EPP might need some evolutions to be compatible with new functions such as the Permanent Resume Trajectory. It could be a great support for the ATCOs in his/her tasks, in order to increase predictability through better air/ground intentions sharing. This would enable more and more transparency and lead to optimized operations. For instance, the controller reported that it could help to have the aircraft flyable PRT trajectory displayed on the ground side, which would be possible if the PRT virtual turning point was included in the EPP for instance. Maybe also the format of the EPP should evolve to meet ATCO needs, ATCO requirements for EPP report format should be well investigated prior to further investigate the concept.

For further investigation of the concept, a more operational methodology for EPP data sharing should be investigated, maybe a process “on demand” (to not overload communications).

Pilots also recommended to use CPDLC processes as soon as possible as it decreases their workload (avoiding confirming ATCO instructions by voice) and errors and/or incomprehension with ATCO

PJ.01-05

The project has identified the need for the IM aircraft to make available to the ground some specific IM application data elements. The project has worked with EUROCAE/RTCA standardisation committees to include this capability in the appropriate standards. The capability for the ground to interrogate the IM aircraft for specific IM application data elements will be included in the following standards that are currently in progress: ED-195B/DO-328B FIM SPR, ED-236A/DO-361A FIM MOPS and ED-73F/DO-181F Transponder MOPS. The project has monitored other proposed changes to the FIM SPR and FIM MOPS to ensure that those documents are at least in line with SESAR Solution PJ.01-05. The planning of EUROCAE/RTCA is to publish these standards in 2020. Thereafter, the regulators (EASA/FAA) have to develop and publish guidance material (e.g. TSOs) for the applicant to demonstrate the airworthiness of the FIM Equipment and its installation in aircraft and for the operator to get an operational approval to use the on-board FIM Equipment.

Finally, ICAO needs to amend a number of its documents. The Surveillance Panel Airborne Surveillance Working Group (AIRB WG) is currently working on Interval Management. The ICAO ANWP Job-card SP.010.01 provides an overview of the ICAO activities, it consists of amending the following ICAO document: Doc 9994 Manual on Airborne Surveillance Applications (add guidance material to support Interval Management procedures), Doc 4444 PANS-ATM (add operational procedure for Interval Management) and Doc 8168 PANS-OPS (add flight crew procedure to use on –board FIM equipment). In summary, ICAO will develop and standardize phraseology, procedures and pilot and controller training. It is anticipated that the amendments of the ICAO documents in support of Interval Management operations will not be completed before one or more large-scale operational demonstrations have been successfully carried out. This is one of the reasons for the recommendation to conduct a large-scale operational demonstration of the SESAR FIM Solution.

PJ.01-06

No impact on regulation and standardisation activities.

PJ.01-07

For the pilots, the use of the CDTI to operate visual separation raised questions about legal aspects. As a consequence, this comment was brought to ICAO AIRB working group asking to integrate the description of CAVS in the visual separation operations. This action is currently ongoing.

In the SPR section of the OSED document we mentioned two deviations with respect to the requirements defined in the CAVS SPR and MOPS standards:

- Capability to display ground speeds and horizontal range is required what is weaker than previous requirement to display this information in digits. There could be other means that can support pilots in distinguishing situation where the ownship is faster or slower than the preceding aircraft. Pilots shall be provided with an appropriate visualization or graphical representation of differential ground speed in the way, so they unambiguously anticipate if the ownership is faster or slower than preceding aircraft.

- “CAVS Minimum Range” alert is considered as nice to have and not a minimal requirement.

Those two deviations were discussed with Airbus certification experts and considered as acceptable since the justifications provided were confirmed by the flight crews during the operational evaluations executed on aircraft simulators with a good level of representativeness of the real operations.

3 Conclusion and Next Steps

3.1 Conclusions

Detailed conclusions and Next Steps for all solutions are available in the VALR documents. See related Datapack listed in Section 1.5 Technical Deliverables.

PJ.01-01 Conclusions

Simulations indicate that the concept of utilising both Extended-TMA Manager flow rate DCB information and AOP DCB terminal information would be likely to increase both the airspace throughput and predictability within a systemised PBN airspace structure.

Moreover, the validations assessed the benefits of the integration of information from multiple arrival management systems operating out to extended range into en-route sectors with local traffic/sector information. The traffic synchronization interaction between network DCB (Demand-Capacity Balancing) within the extended horizon was addressed and potential information integration requirements and balancing mechanisms, were investigated and developed.

Main findings can be summarised as follows:

- The number of flights affected by the different stakeholders (E-AMAN and Network Manager) is relatively low. This could be explained with the limited horizon of the E-AMAN, which was set to 200NM.
- The synchronisation process significantly reduces the holding delay of the affected flights. The negative outcome is that the overall holding delay of all the flights is slightly increased.
- It is observable that the traffic demand in certain airspaces in the reference scenario reaches or exceeds the sector capacity.
- The AMAN and Network Manager DCB distribute the traffic demand maintaining the capacity of the airspaces

The Modelling Analysis revealed potential interaction between arrival management and network management measures. Network management measures should be integrated by the arrival management process to avoid generating traffic overflows. With such an integration, flight efficiency benefits (shift from terminal delay towards ground delay) is less than without integration but is still positive. This raises the question of trade-off and level of performances expected in terms of capacity limits (tolerance).

The Real Time Simulations were focused on the concept of E-AMAN and CTA into multiple airports taking into consideration aspects of human performance, safety, efficiency, accuracy and capacity. It was concluded that the concept supports an acceptable increase in workload and working method that does not interfere or disturb the aspect of human performance.

No negative impact on safety has been detected for the evaluated conditions. The concept allows the ATCO to choose the most appropriate procedure for each situation and thereby safety shouldn't be compromised. The ATCOs are expected to cancel CTAs in due time and shift to conventional TTL/G method when they feel it's necessary to maintain safety and control over the situation. However, in order to consolidate the safety of the concept and to fully utilize the CTA capability, some suggestions were received, see recommendations.

There were indications that accuracy over MF is enhanced using the concept in comparing to standard method of TTL/G. It is concluded that the capacity is maintained using the concept.

Efficiency analysis is out of the scope of the report, however, Thales Avionics provided results of a fuel efficiency analysis (see appendix G section 3.2.8) which indicates improvements in fuel efficiency utilizing i4D-CTA with vectoring/retain CTA over a fully vectored method to meet an equivalent TTL.

Overall the during the validations some recommendations to further mature the concepts concerned were capture and following summarized:

- For further investigations, a wider range of E-AMAN to cope with overlapping E-AMAN ranges and a more detailed airport setup with regard to arrival and departure flows is recommended.
- Regarding potential interaction between arrival management and network management measures, the question of trade-off and level of performances expected in terms of capacity limits (tolerance) should be addressed by exchanges with network management related projects.
- Further investigations are needed to conclude the feasibility of new system support and technical improvements that are needed in order for the concept to fully utilize its potentials.

PJ.01-02 Conclusions

Thread 2 LTMs were receptive to the idea of rerouting flights to avoid bunching and felt that the tool showed potential. They felt that a tool like it or its underlying sector based iACM would be needed to support the anticipated traffic growth.

Thread 2 RTS concluded that the concept of alerting the user to bunching through simple count of flights through waypoints over a ten-minute period was not sophisticated enough, with the potential to provide both false-positive and false negative results. The concept of rerouting flights onto offload arrival routes is regarded by all participants as feasible.

In Thread 3 RTS, the following can be concluded: The concept was successfully validated in a 10-day validation campaign in a human-in-the-loop real time simulation with controllers. The validation was using a new mock-up with new functionalities and HMI. The simulation campaign covered an E-TMA and TMA of German airspace. The new tool/functions are well understood and allowed the controllers to balance the demand and capacity of a sector (sector load) within the E-TMA while considering various inputs. Only minor recommendations were identified to improve the concept further. Therefore, the concept is regarded as feasible.

Conclusions on technical feasibility

SYSMAN technical feasibility is not fully proven, as the prototype did not comply with all the technical requirements. Specifically, SYSMAN failed to calculate route merge conflicts, and it displayed counts of flights passing waypoints, without fully picturing the predicted load on all routes as needed by the concept. The "What-if" feature calculated and provided alerts at a sector level so was not very useful at providing feedback on the impact of proposed changes, beyond changing the count of flights through the reference locations. The prototype required a number of workarounds to suppress or filter data make it function.

The technical feasibility of CMAN was successfully demonstrated. The mock-up was used in a simulation environment that was stimulating a P2/ATCAS ATM-System that is also used for current operations in the desired geographical area. All inputs and interfaces that are currently known for this system have been available. A later implementation into this system environment seems to be possible. No malfunctions or any undesired technical behaviours were observed.

Conclusions on performance assessments

For Thread 2, capacity benefits are expected through implementation of the concept

For thread 3, performance improvements can be expected in:

- Human Performance (Workload reduction, Increase in Situational Awareness)
- Flight Efficiency
- Predictability
- Capacity (better balance of existing capacity, avoiding overloaded sectors in approach)

PJ.01-03A Conclusions

Conclusions on SESAR Solution maturity

The OI Step AOM-0606 reached V2 maturity level and the related Solution 01-03A is ready to be further investigated toward V3 maturity taking into account the recommendations listed in section 5.2.

Some open issues (see next paragraph for a brief description) are indicated as "partially achieved/not blocking" and documented in the MAT. As they do not prevent the concept to be considered as V2 mature, their investigation could be conducted in the context of V3 activities.

Conclusions on concept clarification

(See D3.2.030 - PJ.01-03A: V2 VALR)

The operational feasibility and applicability of the solution 01-03A (Point merge option) was assessed in Paris (LFPG) and in Madrid (LEMD) high density/complexity TMA environments (resp.EXE#1 and EXE#2).

Overall, the series of real-time prototyping sessions carried out in EXE#1 allowed to progress from initial generic options for the application to CDG/TMA environment, using V1 outcomes, and to gradually improve the procedure design and better support the operating method. After the last session, operability assessment and performance trends were positive, which shows the Solution's potential in dense and complex environments. Nevertheless, one aspect (FL management along initial route) of the specific design tested induced reservations from some controllers regarding acceptability and safety, so the design would need to be improved if it had to be implemented locally.

EXE#2 (FTS) shows the operational applicability of the “merge to point” option of solution 01-03A for LEMD South runway configuration.

The Human Performance Assessment [15] was conducted as part of the EXE#1. Most of the relevant arguments identified for the solution 01.03A scope have been assessed. The main changes related to new operating method have been addressed, and efficiently applied by the Air Traffic controllers. The major factors that can influence transition feasibility are potential loss of vectoring skills and reduced flexibility due to more structured procedures/operating method. This could be mitigated and/or overcome through training (initial and recurrent).

Exercise conducted on the operational feasibility of the "axis merge" option from the cockpit perspective (EXE#3), confirms the need for a standardisation of the minimum requirements for the FMS function to intercept an RNAV segment, which is not the Final Approach segment, if this function is required by ATC in a high-density traffic operation.

Conclusions on technical feasibility

N/A assuming standard/representative avionics.

The solution takes the form of a procedural change and relies solely on existing technologies especially existing Navigation and Surveillance infrastructures (e.g. enabling PBN/area navigation capabilities) and related avionics capabilities that are already in operations in a widespread manner.

Conclusions on performance assessments

(See D3.2.030 - PJ.01-03A: V2 VALR and D3.2.010 - PJ.01-03A: V2 SPR-Interop/OSED Part IV)

As stated in section 4.2, Human Performances and Safety assessments were conducted for the solution 01.03A [15].[13] All the relevant arguments have been identified and recommendation and requirements collected.

As described in 4.2, Environment/flight efficiency and capacity assessments show positive trends of the solution scenario compared to the baseline/reference scenario performed.

In addition, a Cost Benefit Analysis (CBA) [14] was conducted for the considered solution scenarios. The Solution Scenario alternatives for V2 focused on dependence of approach procedures and started exploring independence of approaches procedures as initial considerations The CBA was based on exercise validation quantitative results for the benefits assessment, and on values from reference documents and expert judgements for the costs assessment. As agreed during the PJ01 PMB (January 2018), the CBA provides an instantiation on Paris TMA and Paris-Charles-de-Gaulle Approach procedures and in addition a generic framework that can be reused for other environments.

Following the V2 validation activities related sections of the V2 SPR-INTEROP/OSED [12] have been updated.

PJ.01-03B Conclusions

Conclusions on SESAR Solution maturity

The OI Steps AOM-0608, 0702B & 0705B reached V2 ON Going maturity level and the related Solution 01-03B is ready to be further investigated toward V2 maturity taking into account the recommendations identified in Wave 2.

The solution has presented during SJU maturity review the good progress so far. This was in line with expectations for V2-ongoing. The presented base for continuation to V2 was very clear with promising initial outcomes. It is noted that many useful recommendations have been proposed for future research. The solution was reminded that to reach full V2 it will need to demonstrate quantitative benefits (particularly in flight efficiency) and provide a robust CBA, SAF etc.

Conclusions on concept technical feasibility

Overall maturity of the solution progressed on operational aspects

- Improve management of high-altitude constraint
- Possibility to build a stable strategy and attribute routes to absorb the delays,
- Compromise between early attribution of route and potential need to change the sequence,
- Less active control, more monitoring, need for tools,
- Operational evaluation of PRT functionality
- Recommendations for technical or operational evolutions identified,
- Recommendations for improved validation context identified

But, due to limitations (known before the exercise and accepted because focus on operational feasibility) and unexpected issues (observed during the exercise or when analysing the results), few quantitative results (by essence, this experiment was an RTS (vs FTS)), limited confidence in quantitative results

Although the FTS technique provided quantitative and qualitative performance benefits due to the concept under assessment. A pure operational feasibility assessment shall be performed using RTS or Live Trial techniques involving prototypes of the corresponding ground system enablers and air traffic controllers and pilots. Some of the main findings regarding the operational feasibility of the concept are:

- Improved situational awareness for Approach ATCO.
- The awareness of each aircrafts intended trajectory leads to less level outs.
- Essential is the availability of downlinked aircraft data and/or DPI from aircrafts still on ground.

- This data is to be processed by the ATC decision tool.

Conclusions on performance assessments

Human Performances assessments were conducted for the solution 01.03B and fully documented. All the relevant arguments have been identified and recommendation and requirements collected.

Flight efficiency assessments show positive trends of the solution scenario compared to the baseline/reference scenario performed but need to be quantified in Wave 2 when solution will reach full V2 maturity. At this stage a full Performance Assessment Report will be released thanks to a Cost Benefit Analysis (CBA) completed.

PJ.01-05 Conclusions

Conclusions on SESAR Solution maturity

The feasibility of the SESAR FIM Solution has been demonstrated during the PJ.01-05 Fast-Time Simulations (FTS) and Real-Time Simulations (RTS). Performance benefits have been demonstrated and no major/blocking human performance or safety issues have been identified.

Conclusions on concept clarification

The need for the IM aircraft to make specific information available to the ground domain has been confirmed in the RTSs. The controller will need information on specific FIM application data elements as used by the on-board FIM Equipment. Requirements supporting this capability have been included in the PJ.01-05 SPR-INTEROP/OSED and TS-IRS documents. Moreover, the project has worked together with EUROCAE/RTCA standardisation committees to include this capability in the FIM and transponder standards.

The need to simplify the overall controller-pilot communication has been addressed in both Real-Time Simulations. RTS#2 concluded that the controller-pilot communication in support of IM operations in a voice communications environment is feasible.

Conclusions on technical feasibility

Not applicable as the exercises were not performed with Industrial Based Prototypes (IBP). In itself no technical feasibility issues have been identified so far. It is recommended to develop both on-board and ground-based IBP and to conduct exercises with those IBPs in the V3 phase.

An overview of the technical requirements that have been evaluated during the V2 real-time simulations, i.e. exercises EX2 and EX5, and the outcome of the evaluations have been documented.

Conclusions on performance assessments

The main performance benefit of the SESAR FIM Solution to counteract reduced arrival runway throughput, on a fixed PBN (RNP1/RNAV1) route network in high density TMAs, and even improve the runway throughput has been demonstrated. As the SESAR FIM Solution enables the use of a fixed PBN route network in high density TMAs, the FIM Solution also enables the benefits related to a fixed route network (concentration of noise, better predictability both in time and horizontal path) and the FIM Solution enables more continuous descents or fixed profile descents on such a fixed PBN route network (less noise, less fuel, less CO2 emissions, better predictability of altitudes along the route).

Detailed figures on the performance gains at local level have been documented in the PJ.-01-05 V2 VALR. The performance assessment at ECAC level is documented in the PJ.01-05 V2 Performance Assessment Report (PAR).

The PAR shows that the Solution meets and even exceeds all overall Validation Targets set by PJ.19.

PJ.01-06 Conclusions

Based on the results of the simulation exercises and live trials, it can be concluded that the present solution, i.e. the inclusion of RF legs in the PinS approach, departure and missed approach segment, reaches V3 maturity. The maturity of the HMD is also considered to have reached a V3 level even if some industrialization issues have been identified.

Conclusions on concept clarification

The following conclusions are drawn regarding concept clarification:

- Rotorcraft tend to fly with nonzero slip angles. Slip angles are particularly high in side winds, which make it difficult to fly turns in this situation. Exercise #1 and #2 with HMD assistance but no autopilot showed that pilots need to turn their heads like in visual flight to allow a smooth transition from IMC to VMC. Exercise #3 showed that the autopilot is effective in following the desired path despite side winds.
- RF legs ending at the FAF/FAP and RF legs connected the IDF do not impose a safety issue, either with HMD assisted manual flight, or autopilot coupled flight. The technology and guidance in all exercises allowed a precise and reliable intercept of the glide path. Pilots reported time pressure during this transition, and therefore a short straight level-off segment between RF leg and final glidepath is recommended.
- Concerning the HMD only, there was a limitation on the guidance quality of the prototype. The HMD should have guided the pilot to a higher altitude than the minimum at the IDF and beyond. The concept of 3D pathway does not work optimal during the departure if it is designed to go along the lowest allowed altitude. If there is only a lower limit constraint to fulfil, the system should guide the pilot to climb at best rate to meet the level-off constraint as early as possible. This is considered as an industrialization issue to be fixed in the FMS that computes the desired altitude profile.
- Concerning autopilot-coupled head down display, pilots reported carefree handling and large spare capacity for the pilot to take on any other tasks, such as actively see and avoid other aircraft, or focus on communication when required. Descents during the RF legs, either as continuous descent, or stepwise descent, were also flown to a good level of accuracy. Lateral containment was always within RNP 0.3. Primary flight information, navigation information

overlaid on synthetic external view on the head down display (HDD) format was considered to be good feature for situation awareness during IFR to VFR transitions.

Conclusions on technical feasibility

Two different designs have been tested, an advanced flight director concept allowing an anticipation of the next change in the flight trajectory, and a conformal 3D display of the route to fly. A slight advantage has been shown in favour of the advanced flight director concept regarding the trajectory flight precision and the workload level. The qualitative results concerning the achieved RNP show that the limits can be met even in a high wind scenario, despite the fact that the HMD system installation was not optimal. The issue with the head tracker had a strong impact on the system usability and still all RNP limits were met besides some (one major) off track situation that can solely attributed to the head tracker issue. This head tracker issue has been demonstrated to be an integration issue on the DLR helicopter. The same head tracker has been successfully used in PJ03-04a and achieved there a V3 maturity level (see PJ.03-04a D4.060 §4.1 HMD enabler reaching V3 maturity level).

The technical feasibility of automating the RF legs can be established by means of a reliable autopilot and avionics installation. Both the FMS and autopilot which are capable of reading and executing the RF type of navigation fix from the navigation database, greatly contributed to the RNP containment limits, pilot workload, and pilot situation awareness. In terms of the onboard monitoring function, a similar level of monitoring and alerting as for standard PinS is considered sufficient.

It can be stated with confidence that a combination of HMD system and an autopilot coupling will further reduce pilot workload and greatly enhance situation awareness in A-PinS.

Conclusions on performance assessments

Capacity: An advanced PinS procedure can be designed with a smaller footprint and higher flexibility for approach and departure design. As a result there will be additional airports that could use this design concept to generate additional throughput. It allows rotorcraft to approach/depart in parallel of fixed wing traffic, and without additional infrastructural needs

Safety: The results of this exercise have shown that RF legs were accurately flown to the desired path following, within the RNP containment limits. RF legs allowed tighter path following by avoiding overshoot during leg transitions. Therefore, RF legs in the PinS procedures are predictable and repeatable. Consequently, safety is enhanced by the fact that the chance of proximity to obstacles is low when remaining on the desired path. The autopilot coupling and SVS on the HMD were found to ease workload and enhance situation awareness; all together they contribute to the safety.

Efficiency: An advanced PinS procedure can be designed with a smaller footprint and higher flexibility for approach and departure design. As a result the departure and approach can be designed shorter. Especially the described use-case of local HEMS missions will have shorter flight times and fuel consumption. This will be true for all flight with a rather short en-route phase.

Equity: It will be possible to design procedures for most airports or helidecks regardless of their location, especially dense airspaces and constrained mountainous terrain. By de-conflicting with fixed wing traffic, equity is enhanced. Besides some missing regulatory issues, e.g. limits due to the airspace category and surveillance limits, the advanced PinS would strongly improve the accessibility of IFR routes.

PJ.01-07 Conclusions

As both CAVS and visual separation operations are exactly the same from an ATC point of view (same operation, same procedure, same phraseology), the PJ01-07 evaluations focused on the airborne side. For the other use cases ("V1 use cases") where the ground operations could be impacted, the ground aspects could only be addressed via the air-ground communications as no ANSP was involved in the evaluations.

For this SESAR2020 PJ01-07 solution, we focused on the European airspace even if visual separation approaches are not commonly used. We demonstrated that such operations would be feasible on the airports selected for our use cases. The possibility of a wider use of this type of operations will have to be discussed with the ground actors.

The scenarios cover IFR and VFR approaches in VMC conditions. Either visual separation or manual "not closer than" distance spacing operations were performed.

Two types of scenarios were evaluated during both exercises:

- V2 maturity level scenarios for CAVS operation (visual separation supported by an onboard CDTI function), which has a clear and standardized definition, tested in Marseille, Copenhagen and Tel Aviv scenarios;
- V1 maturity level scenarios aimed at proposing operations derived from CAVS and possibly enabled by the on-board function developed for CAVS. The definition of these operations came out from two workshops (one organized at the end of SESAR1 in project 9.05 and one at the beginning of SESAR2020 PJ01-07 solution). They were discussed with airspace users (pilots, ATCos, staff associations, …) but are not as mature as CAVS.

The conclusions for the CAVS V2 scenarios are the following:

- The CDTI function defined for CAVS in the cockpit for business A/C and mainline A/C allows supporting flight crews in executing the CAVS operation i.e. it helps pilots in maintaining visual separation.
- The benefits for airborne actors in terms of decreasing the risk of loss of separation, thanks to the support brought by the CDTI function developed for CAVS, have been confirmed by the flight crews.
- The workload in the cockpit is not highly impacted by CAVS operation. A more detailed impact of the workload in the cockpit should be studied, in particular whenever visual contact with the preceding aircraft is lost.
- The function implemented to support CAVS in the business A/C cockpit does not adequately cover the situation when the designated traffic is no longer qualified for CAVS

(i.e. quality of ADS-B data is degraded and no longer sufficient to continue CAVS operation). Whenever the flight crew does not have the visual contact and the traffic is no longer qualified for CAVS, the flight crew shall interrupt the visual separation and do a go around or contact ATC, which was not the case in most of the scenarios tested during the business A/C evaluations: in exercise #1, even if the CAVS indications are lost due to degraded data, the flight crew continues the approach based on the standard ADS-B symbology on CDTI. Therefore, related criteria are assessed as NOK. Nevertheless, the operation procedure is defined correctly and pilots need more training to follow this procedure.

Note that this use case with degraded data was not tested in the mainline A/C scenarios.

The operations other than CAVS (at V1 maturity level) are briefly reminded hereafter:

- Operation, where ATC – flight crew communication contains specification of call sign of the preceding aircraft as well as "not less than" separation specification, at Copenhagen and Tel Aviv airports – tested in exercise#1.
- Visual separation enabled by a simplified phraseology (thanks to the onboard function developed for CAVS) at Charles-de-Gaulle airport – tested in exercise #2.
- Visual separation combined with a no overtake instruction in simultaneous dependent approaches onto parallel runways at Brussels airport – tested in exercise #2.

The main conclusions dealing with the operations other than CAVS (at V1 maturity level) are:

- all those "V1 operations" are feasible with the support of the CDTI function developed for CAVS;
- The CDTI function developed for CAVS allows the use of a simplified phraseology for the visual separation clearance;
- The CDTI function developed for CAVS allows the flight crew to execute visual separation from the preceding aircraft landing on the same runway, while not overtaking an aircraft landing on the parallel runway;
- Potential operational benefits brought by the operations enabled by the CAVS on board capability should be assessed by the ATC actors in Copenhagen and Tel Aviv. Due to the fact, that visual approaches are not commonly used at these airports and in European airspace in general, the ground side perspective is necessary;
- ATC perspective is definitively needed for the "V1 operations" since it is expected that ATC is aware of the CAVS on-board capability (through the aircraft flight plans). Especially benefits of "not less than" separation have to be assessed from an ATC perspective.

Conclusions on SESAR Solution maturity

From the results obtained in our real time evaluations, we assume that the proposed solution reaches the V2 maturity level for CAVS operations. These result yields are for airborne aspects since the evaluations performed for CAVS only covers on-board aspects as there are no impact on the ground side since it is pure visual separation from the ground perspective.

Concerning the other scenarios, they are at V1 maturity level.

Conclusions on concept clarification

For the CAVS scenarios, the concept is considered as clear.

For the scenarios other than CAVS, proposed during both exercises, it is necessary to further investigate the use cases and clarify the scope of use of the on-board function; more precisely: working jointly with air and ground actors would be necessary.

Conclusions on technical feasibility

The technical feasibility of the CAVS operation only deals with the on-board impacts.

The onboard function developed for CAVS does not present big technical challenges and the prototypes developed for the CAVS on board function for mainline aircraft and for business aircraft show that it is technically feasible.

Conclusions on performance assessments

The performances assessment is developed in the Cost and Benefit Analysis and the OSED part V (Performance Assessment Report).

The results found are that, at ECAC level, the benefits are considered as negligible. However, this function can be of interest for airlines having their hub or a big amount of traffic at busy airports since any CAVS-equipped aircraft could immediately benefit from this CAVs capability to avoid go-arounds, which has a direct impact not only on fuel efficiency but also on the flight delays (and their impact on the airlines operations).

3.2 Plan for next R&D phase (Next steps)

PJ.01-01 Plan for Next Phase

For further investigations, a wider range of E-AMAN to cope with overlapping E-AMAN ranges and a more detailed airport setup with regard to arrival and departure flows is recommended.

Regarding potential interaction between arrival management and network management measures, the question of trade-off and level of performances expected in terms of capacity limits (tolerance) should be addressed by exchanges with network management related projects.

Further investigations are needed to conclude the feasibility of new system support and technical improvements that are needed in order for the concept to fully utilize its potentials.

PJ.01-02 Plan for Next Phase

Recommendations will be separated by Thread; Thread 3 is closely aligned to work carried out in SESAR 1 P05.04.02 and thus its concept and tools are more mature than those in Thread 2.

Thread 2

This SESAR PJ.01-02 validation provided the first opportunity to test the SYSMAN concept. The validation activities provided useful information needed for further concept development. Recommendations are provided for both tool and concept development:

- Tactically rerouting flights to avoid high workload bunching will rely on accurate recognition of a problematic bunch. NATS operational TLPD displays predicted traffic in terms of numbers (e.g. sector occupancy), but also in terms of complexity. Future work should investigate following the same approach with SYSMAN, providing secondary measures/indicators of flow complexity.

- The SYSMAN prototype identified and recommended available capacity on offload routes by highlighting available capacity at the first merge point on the route, which was the entry point to UK FIR. As the offload routes in the airspace simulated have merge points further downstream, capacity at the first merge point is not an accurate indicator of available capacity at the second or third. SYSMAN should calculate route merge conflicts to ensure recommendations of offload options are appropriate. In a manual process, this could be achieved through providing a suitable route based "what-if" function, which the user could use to test solutions. In a more systemised way, SYSMAN could probe all flights and highlight the most suitable ones for offloading. Users expressed a preference for the second option, they would prefer to be offered a complete solution which they would be required to accept or reject, reducing their workload.

- The SYSMAN concept relies on upstream sectors (in the same ATSU or cross border) managing the entry into systemised airspace. The upstream elements of the SYSMAN concept could not be investigated in the validation environment. It is recommended that further work should take place to investigate how the upstream sectors will manage the entry into systemised airspace, for example through workshops and joint validation activities.

Thread 3

Although the basic functionality was successfully validated, the following functions or features could be improved in a next phase based on the final debriefing comments and the observations (see the details in B.3.6):

- HMI improvement suggestions should be addressed

- Regarding functionality, two improvements should be performed

    - further improvement of the AMAN acceptance through training and briefing in the next validation campaign

    - lessons learned from exercise execution should be considered in the next validation,

- It is recommended to transit to V3 phase.

Methodology Recommendations from SJU

The assessors recommend that the quantitative assessment methodology is reconsidered for the next phase, i.e. strengthen qualitative feedback though questionnaires, etc., use HP expert assessment to provide estimation of potential HP benefits, use metrics in simulations only to detect whether there were significant changes, e.g. to ensure that there were no adverse effects.

Enabler Change Request

Following this activity, a change request is being made to unlink enabler APP-ATC-62 (Demand and Capacity system enhanced to better handle departure flows out of the TMA) from the OI Step TS-0307 (Integrated Arrival Departure Management for traffic optimisation within the TMA and Extended TMA Airspace). This enabler will remain linked to TS-0302. Unlinking APP-ATC-62 from TS-0307 has been done to reflect the fact that the concepts tested during this activity were heavily arrivals focused.

PJ.01-03A Plan for Next Phase

(See D3.2.030 - PJ.01-03A: V2 VALR)

The implementation of PBN to ILS solution being very dependent on the local context, it is difficult to provide a generic set of recommendations.

In addition, during the V2 phase, a change in an ANSP partner's implementation strategy led to cancel the activities initially planned after the V2 phase (more details are available from Appendix E of VALR).

Nevertheless, in order to produce a complete view for any ANSP that may be willing to use the Solution's material for its own local assessment, the present section provides recommendations on the work that would have been necessary to further mature the solution, if the latter had been continued.

Point Merge option

To further mature the solution, the key recommendations would have related to investigate:

- Adaptation/refinement of the design using V2 findings, in particular:
    - remove potential hotspots / any systematic conflicting situations identified in V2
    - update procedure design and operating method to adhere to Safety requirements (e.g. relative positioning of IFs/FAPs etc)

- Assessment in highly realistic conditions (using full scale RTS), including relevant abnormal and degraded conditions, in particular to demonstrate:

- the applicability and feasibility of PBN to ILS design with point merge option for all local environment conditions and runway configurations;
- the applicability and feasibility in complex environment, including e.g. controlled departures (instead of replays), AMAN, adjacent airports, grouping/ungrouping of APP controller positions;
- the resilience of the PBN to ILS design and working method to abnormal/degraded situation (e.g. CBs, cross- wind, LVP).

- Confirmation/refinement of performance assessment, in particular of environmental impact, using e.g. FTS and model-based techniques to obtain statistically significant results.
- For any new TMA considering the Solution, instantiation and refinement of a local CBA based on the V2 CBA framework provided by the Solution.
- Specific ad-hoc design of operational procedure, to prepare local implementation of the solution, ensuring the investigation of, e.g.

  o Publication aspects of PBN procedures in approach environment (e.g. with some "open transitions" or fully closed loop);

  o Phraseology aspects (e.g. "descent to be level at").

Axis Merge option

On-board functions exist that can/may be used to join an RNAV axis that is not the final approach segment. However, on some aircraft types a large number of inputs in the FMS may be required. In the conditions studied in PJ.01-03A (high density, intercept of an RNAV axis that is not the final, independent parallel approaches), this will not enable implementing the axis merge option with sufficient safety gains and without creating additional workload on the cockpit side.

In addition, EUROCAE and RTCA Standards for intercepting an RNAV leg/segment exist but may need in the future to be updated – and incentive for development/equipage in conformity to be developed. The scope and decision-making process for this are broader than the sole context of use as envisaged in Solution PJ.01-03A.

Consequently, the Solution recommends to:

- discard the axis merge option for improved parallel approaches using PBN to xLS transitions in the short/medium term.
- in case an adequate on-board function is developed and broadly available in the longer term (possibly at no extra cost thanks to other possible usage), reconsider the possibility of using an axis merge option for parallel approaches with PBN to ILS transitions. This would include if/as necessary the development of adequate business case elements.

Recommendations for updating ATM Master Plan Level 2

For the record, the following Master plan update has been implemented during the V2 phase, and no further update is recommended.

OI step AOM-0606 from DS17B was split in DS18 to clarify the scope of the V2 activities:

- A revised AOM-0606: Enhanced Parallel Approach Operations using PBN/RNP transitions to xLS;
- A new AOM-0608: Enhanced Parallel Approach Operations using PBN/RNP transitions to RNP (for at least one runway).

The rationale for the split is that parallel approach procedures based on PBN/RNP to xLS may provide a first level of benefits, e.g. at a shorter term; while RNP final approach segments have the potential to bring additional benefits for parallel approaches in terms of safety, capacity, environmental impact and fuel efficiency – but may be more demanding in terms of aircraft capability and aircrew training.

Recommendations on regulation and standardisation initiatives

The following standards have been identified and assumed: The new procedure for IPAs from Solution PJ.01-03A is defined, published and operated in conformance with applicable ICAO and European standards, regulations and guidelines, including: ICAO PANS ATM, ICAO PANS OPS, ICAO SOIR, ICAO PBN Manual , ICAO PBN Airspace Design , EUROCONTROL TMA Design Guidelines, European Airspace Concept Handbook for PBN Implementation.

Reference documents are listed in SPR-INTEROP/OSED V2

No recommendations have been identified on regulation and standardisation aspects.

PJ.01-03B Plan for Next Phase

The Objective, through Wave 2 solution 8 thread B2 is to improve robustness of the PJ.01-03B concept by evaluating it in other TMAs, using enhanced vector where and when dynamic attribution of route is not possible to support anticipation of arrival traffic synchronization

The main areas of focus will be:

- Use of AMAN information to allow A/C to fly more predictable arrival routes, to manage energy and optimise the flight profile
- How to mitigate the uncertainty in the trajectory introduced by vectoring on descent profiles
- Contribute to improvements air/ground intentions sharing: AMAN planned times, distances to go, removal of planned constraints, EPP
- ATC method to support airborne improved descent profiles.
- Mitigation of the impacts of vectors on the trajectory

- Management of vertical constraints and ATC speed strategies to support improved descent profile

Concept definition should be reached by workshops to focus on concept elements & Real-time simulation runs involving ATCOs and pilots to evaluate feasibility of proposed solutions.

The expected Impacts should be on:

- Predictability, which will be enhanced by the use of AMAN info to sequence aircraft using closed routes & provision of accurate airborne data + means to mitigate trajectory uncertainty caused by vectoring
- Airspace capacity maintained, while CDO procedures will be facilitated, owing to use of an arrival and TMA route network, associated with ATC speed strategies & airborne management of vertical and extended speed constraints
- Environmental efficiency, which will be increased by seamless CDO, reducing low level flight
- Human performance, with extended air and ground awareness of each other's intentions

Special care will be applied to training when assessing such a new concept involving several major novelties (airspace design, procedures, link with AMAN, on-board new features, CPDLC, CTA/RTA), training is a key factor.

Wind must be simulated to validate this concept, as wind may have an influence on the AMAN's stability, on the difficulty for the controllers to anticipate the conflict situations, on the accuracy of information provided by the EPP data, but also on the potential interest of EPP data (provided it is sufficiently accurate and reliable). A sufficient level of wind simulation's realism will be needed.

PJ.01-05 Plan for Next Phase

The following activities related to validation exercises are recommended for the next V3 phase:

- Conduct one or more human performance related exercises to confirm that no major/blocking human performance issues are present in a medium complexity TMA/medium airport (as expected in this less demanding sub-OE)
- Conduct a real-time simulation with controllers-in-the-loop and ground-based IBP to validate technical, system-related performance and operational requirements.
- Conduct one or more operational workshops with controllers to validate remaining operational requirements, using simulation platforms (as needed) and to address training needs.
- Address Safety Case and subsequent Safety Requirements (as needed).

- Confirm KPIs by means of real-time simulation(s) with controllers-in-the-loop, address environments with differences in current operating method regarding inbound traffic in the TMA (e.g. Amsterdam, Heathrow, Frankfurt).
- Conduct a flight test with pilots-in-the-loop and airborne IBP to validate technical, system-related performance and operational requirements.
- Conduct real-time simulation(s) with pilots-in-the-loop and airborne IBP to validate remaining technical, system-related performance and operational requirements. Include manual implementation of the IM speeds (considered as minimum requirement).
- Conduct one or more operational workshops with pilots to validate remaining operational requirements, using simulation platforms (as needed) and to address training needs.

PJ.01-06 Plan for Next Phase

Promotion of Advanced PinS Approaches for Operational Deployment

As this exercise is aimed to contribute to V3 maturity that implies availability for operational use, it has been demonstrated that advanced PinS with adequate automation serves the purpose of enhancing helicopter access to dense airspaces and difficult terrain. However, it is found that the use of PinS procedures in helicopters is rather limited to a few operators. To further increase its operational use, it is recommended to actively promote the use of PinS procedures by supporting pilot use cases among rotorcraft operators.

Technology

In terms of the technology, further work is required to adequately define mitigation measures in the event of degradations of the navigation source. While it was possible to cope with downgrade of SBAS to GPS during RF legs before FAF, by automatic reversion to VNAV minima, the two degradations listed below will necessarily require a backup (or alternative) navigation source to allow continuation of the approach procedure:

1) SBAS downgrade after the FAF
2) Loss of GPS

Specific occurrences are reported when flying in GNSS “shadow” zones (e.g. valleys) or GNSS jamming triggered by miscreants.

Procedural Aspects

In mountainous terrain or small airspaces in the vicinity of busy airports, it may not always be possible to construct PinS or A-PinS strictly satisfying the PANS-OPS criteria. It may be necessary to reduce the lateral and vertical obstacle clearance zones and to allow greater flexibility in the approach procedures, such as large course changes ending at FAF, turns after the FAF, in order to avoid terrain or the glidepath of fixed wing traffic. It is therefore considered necessary to investigate the flyability and human factors of approaches beyond PANS-OPS criteria in the direction of RNP-AR.

Recommendations for additional work

IFR – VFR Transitions

Thanks to the use of HMD during Advanced-PinS, the opportunity arises to enhance pilot's awareness with respect to surrounding terrain, obstacles, traffic, and landing spot before and after the MAPt. Further investigations are needed to definitely identify appropriate symbology, display means and associated human factors on how to best support crew during IFR-VFR transitions, in particular during degraded visibility conditions.

Improving Automation and Situational Awareness

Due to the additional time pressure during approach and departure it is recommended to use as much automation as possible, and to use the HMD to enhance situation awareness with the automation. Automation refers to the use of automatic path following (autopilot) but also to automate other piloting tasks (e.g. radio frequencies, alerting for cooperative and noncooperative traffic).

Although HMD, as an optional enabler in this solution, has also reached V3, future symbology enhancements can be made as part of future R&D activities. This includes e.g. the integration of traffic display (both cooperative and non-cooperative) on the HMD to increase pilot situation awareness, as well as improvements in the design of flight guidance symbology.

Cooperative and non-cooperative traffic awareness

Many helicopters, and almost all EMS helicopters, operate in uncontrolled or partially controlled airspaces. During PinS procedures in VMC and even VMC-IMC borderline conditions, it is common to encounter other VFR traffic during precision approaches. With no ATC coverage in uncontrolled airspaces, maintaining adequate separations becomes the responsibility of the pilot, which leads to higher workload. The provision of assistive on-board functions, in communication and surveillance, as well optical eyes-out systems, which may allow the pilot to remain coupled on the approach procedure while actively seek and avoid other VFR traffic, needs to be explored in greater depth.

Due to the significant increase in drone usage, operators have raised the flag about the continued safety during PinS procedures, without the means to detect unknown/non-cooperative traffic by existing surveillance equipment (since these are currently not reported by transponders and difficult to spot by eyes). Therefore, special detection means by technology to detect and eventually avoid non-cooperative traffic, as well as the associated human factors and crew feedback during PinS approaches needs to be investigated.

PJ.01-07 Plan for Next Phase

- Further research should be conducted to extend CAVS operating method for degraded modes as these criteria were NOK ("ADS-B data" alert triggered and visual contact with traffic to follow is lost).

- Open discussion should occur in order to clarify the responsibility delegation in case of preceding traffic go around to the flight crew if the CDTI function is available for ownship (abnormal operations).
- Assess the head down impact of the CDTI function on the flight crew overall situation awareness. During the evaluation, no specific, nor critical impact of head-down time on situation awareness was observed. However, since the CDTI function monitoring might require that the flight crew spends more time head-down, a deeper analysis should be performed to confirm the situation awareness is not degraded and even improved.
- It is recommended to study how to better inform the pilot of a CAVS non-qualified traffic for which the CAVS function is not available. In case ADS-B data is not sufficient for CAVS, flight crew may try unsuccessfully to designate this traffic for CAVS. Feedback to inform the crew is recommended for them to understand that the function is not available.
- CAVS operation should be validated for ATC stakeholders for the airports where CAVS operation is expected to bring benefits for approach management and sequencing of traffic to be able to quantify these benefits.
- Further research should be conducted on CAVS+ operation (CAVS-like operation where call-sign of TTF and "not less than" separation specification is communicated from ATC to the FC) to identify whether providing pilots with the recommended minimum separation with the TTF ("No less than X NM") brings sufficient benefits to justify the increase in cognitive workload that it might bring.
- For all scenarios other than CAVS working with air and ground actors should be started in order to standardize phraseology and communication during visual separation procedure approaches with the CDTI function available (at least for flight crew).

4 References

4.1 Project Deliverables

Project	Del. Code	Deliverable Name	Delivery Date
PJ01 EAD	D1.1.061	D1.1.061 - PJ.01-01 Thread 3: V2 RTS Platform Final Availability Note (COOPANS)	19/06/2018
PJ01 EAD	D1.1.059	D1.1.059 - PJ.01-01 Thread 2: V2 RTS Platform Availability Note (ENAV)	05/04/2019
PJ01 EAD	D1.1.058	D1.1.058 - PJ.01-01 Thread 1: V2 RTS Platform Availability Note (NATS)	21/03/2019
PJ01 EAD	D1.1.020	D1.1.020 - PJ.01.01 VALP V2 (FINAL)	27/03/2019
PJ01 EAD	D1.1.050	D1.1.050 - PJ.01-01 TS/IRS V2 (FINAL)	30/07/2019
PJ01 EAD	D1.1.030	D1.1.030 - Final PJ.01-01 V2 VALR (FINAL)	02/08/2019
PJ01 EAD	D1.1.040	D1.1.040 - PJ.01.01 CBA V2 (FINAL)	06/09/2019
PJ01 EAD	D1.1.010	D1.1.010 - PJ.01-01 SPR-Interop/OSED V2 (FINAL)	06/09/2019
PJ01 EAD	D1.1	D1.1 - PJ.01-01: V2 Data Pack	20/11/2019
PJ01 EAD	D2.1.080	D2.1.080 - PJ.01-02 V2 RTS Platform Availability Note (DFS)	04/07/2018
PJ01 EAD	D2.1.020	D2.1.020 - PJ.01-02 Final V2 VALP	04/07/2018
PJ01 EAD	D2.1.025	D2.1.025 - PJ.01-02 ECTRL V2 Technical Note Final	18/09/2018
PJ01 EAD	D2.1.070	D2.1.070 - PJ.01-02 V2 RTS Platform Availability Note (NATS)	01/05/2019
PJ01 EAD	D2.1.090	D2.1.090 - PJ.01-02 V2 RTS (ENAV) Availability Note	13/05/2019
PJ01 EAD	D2.1.030	D2.1.030 - PJ.01-02 Final V2 VALR	01/07/2019
PJ01 EAD	D2.1.010	D2.1.010 - Final PJ.01-02 V2 SPR-Interop/OSED	29/07/2019
PJ01 EAD	D2.1.050	D2.1.050 - PJ.01-02 V2 CBA	31/07/2019
PJ01 EAD	D2.1.060	D2.1.060 - PJ.01-02 Final V2 TS/IRS	31/07/2019
PJ01 EAD	D2.1	D2.1 - PJ.01-02: V2 Data Pack	15/10/2019
PJ01 EAD	D3.1.010	D3.1.010 - PJ.01-03A: V1 SPR-Interop/OSED	20/11/2017
PJ01 EAD	D3.1.020	D3.1.020 - PJ.01-03A: V1 VALP	20/11/2017

PJ01 EAD	D3.1.030	D3.1.030 - PJ.01-03A: V1 VALR	20/11/2017
PJ01 EAD	D3.1	D3.1 - PJ01-03A: V1 Data Pack	21/11/2017
PJ01 EAD	D3.4.060	D3.4.060 - PJ.01-03B Task V2 (partial) Availability Note	04/02/2019
PJ01 EAD	D3.2.020	D3.2.020 - PJ.01-03A: V2 VALP	21/12/2018
PJ01 EAD	D3.4.020	D3.4.020 - Consolidated V2 (partial) VALP Deliverable	04/02/2019
PJ01 EAD	D3.2.010	D3.2.010 - PJ.01-03A: V2 SPR-Interop/OSED	29/03/2019
PJ01 EAD	D3.2.040	D3.2.040 - PJ.01-03A: V2 CBA Deliverable	05/04/2019
PJ01 EAD	D3.2.030	D3.2.030 - PJ.01-03A: V2 VALR	05/04/2019
PJ01 EAD	D3.4.030	D3.4.030 - PJ.01-03B V2 VALR	29/04/2019
PJ01 EAD	D3.4.010	D3.4.010 - PJ.01-03B SPR-Interop/OSED update (partial V2)	28/06/2019
PJ01 EAD	D3.2	D3.2 - PJ01-03A: Data Pack (V2)	11/07/2019
PJ01 EAD	D3.4.050	D3.4.050 - PJ.01-03B V2 (partial) TS/IRS	19/07/2019
PJ01 EAD	D4.1.010	D4.1.010 - PJ.01-05 V2 - Final Consolidated VALP	09/05/2019
PJ01 EAD	D4.1.030	D4.1.030 - PJ.01-05 Final CBA Deliverable	06/09/2019
PJ01 EAD	D4.1.005	D4.1.005 - PJ.01-05 SPR-Interop/OSED Final	07/08/2019
PJ01 EAD	D4.1.020	D4.1.020 - PJ.01-05 TS/IRS Document Final	22/08/2019
PJ01 EAD	D4.1.050	D4.1.050 - PJ.01-05 Final Consolidated VALR Report	19/09/2019
PJ01 EAD	D4.1	D4.1 - PJ.01-05: Data Pack (V2)	05/11/2019
PJ01 EAD	D5.1.020	D5.1.020 - PJ.01-06 Final V3 VALP	17/09/2018
PJ01 EAD	D5.1.060	D5.1.060 - PJ.01-06 Flight Availability Note - EDVE	01/10/2018
PJ01 EAD	D5.1.061	D5.1.061 - PJ.01-06 Flight Availability Note - EDPR	12/11/2018
PJ01 EAD	D5.1.050	D5.1.050 - PJ.01-06 TS/IRS	18/07/2019
PJ01 EAD	D5.1	D5.1 - PJ.01-06: Data Pack (V3)	21/10/2019
PJ01 EAD	D5.1.010	D5.1.010 - PJ.01-06 V3 SPR-Interop/OSED Document Final	18/07/2019
PJ01 EAD	D5.1.030	D5.1.030 - PJ.01-06 Final V3 VALR	24/05/2019
PJ01 EAD	D5.1.040	D5.1.040 - PJ.01-06-01 V3 CBA Deliverable	18/07/2019
PJ01 EAD	D6.1.19	D6.1.19 - PJ.01-07 V2 Validation Plan (Mainline + Business A/C)	03/07/2019

PJ01 EAD	D6.1.020	D6.1.020 - PJ.01-07 V2 Validation Report (Mainline +Business A/C)	03/07/2019
PJ01 EAD	D6.1.048	D6.1.048 - PJ.01-07 V2 SPR-Interop/OSED (OSED)	12/07/2019
PJ01 EAD	D6.1.072	D6.1.072 - PJ.01-07 V2 Availability Note (Mainline)	13/09/2019
PJ01 EAD	D6.1.073	D6.1.073 - PJ.01-07 V2 Availability Note (Business A/C)	13/09/2019
PJ01 EAD	D6.1.070	D6.1.070 - PJ.01-07 V2-CBA	14/08/2019
PJ01 EAD	D6.1.060	D6.1.060 - PJ.01-07 V2 TS/IRS	14/08/2019
PJ01 EAD	D6.1.071	D6.1.071 - D.01-07 V2: V2-datapack (OSED/SPR/Interop/TS/IRS/CBA)	04/11/2019
PJ01 EAD	D6.1.095	D6.1.095 - PJ.01-07 Technical note on visual operations EU/US convergence	25/09/2019
PJ01 EAD	D6.1	D6.1 - PJ.01-07: Data Pack (V2)	08/11/2019
PJ01 EAD	D7.14	D7.14 - QPR.Q4.2016	31/01/2017
PJ01 EAD	D7.1	D7.1 - Project Management Plan	31/03/2017
PJ01 EAD	D7.3	D7.3 - QPR.Q1.2017	28/04/2017
PJ01 EAD	D7.4	D7.4 - QPR.Q2.2017	31/07/2017
PJ01 EAD	D7.5	D7.5 - QPR.Q3.2017	31/10/2017
PJ01 EAD	D7.6	D7.6 - QPR.Q4.2017	31/01/2018
PJ01 EAD	D7.7	D7.7 - QPR.Q1.2018	30/04/2018
PJ01 EAD	D7.8	D7.8 - QPR.Q2.2018	31/07/2018
PJ01 EAD	D7.9	D7.9 - QPR.Q3.2018	12/11/2018
PJ01 EAD	D7.10	D7.10 - QPR.Q4.2018	04/03/2019
PJ01 EAD	D7.11	D7.11 - QPR.Q1.2019	30/04/2019
PJ01 EAD	D7.12	D7.12 - QPR.Q2.2019	03/09/2019
PJ01 EAD	D7.13	D7.13 - QPR.Q3.2019	04/11/2019
PJ01 EAD	D7.2	D7.2 - Final Project Report	12/12/2019
PJ01 EAD	D8.1	D8.1 - Final Deliverable H Requirement	31/03/2017
PJ01 EAD	D8.2	D8.2 - Final Deliverable POPD Requirement	31/03/2017
PJ01 EAD	D8.3	D8.3 - Final Deliverable of M Requirement	31/03/2017

PJ01 EAD	D9.1.029	D9.1.029 - PJ.01-03B V2 RTS Validation Report VALR	04/11/2019
PJ01 EAD	D9.1	D9.1 - PJ.01-03B: Activity Report (V2 Ongoing)	06/08/2019

4.2 Project Communication and Dissemination papers

Code	Name	Solution	Date
COM.121	PJ.01 NATS SESAR Walking Tour at WAC-2018 (PJ.01-01/PJ.01-02 focus)		07/03/2018
COM.128	PJ.01-01 COOPANS Simulation Visitors Day (RTS-a)	PJ.01-01	24/05/2018
COM.001	PJ.01-06 DLR Open Day During RTS	PJ.01-06	07/06/2018
COM.122	PJ.01-02 DFS Simulation Visitors Day for SJU and Solution members	PJ.01-02	13/06/2018
COM.010	PJ.01-06 Press Release/Blog post Following RTS	PJ.01-06	22/06/2018
COM.125	PJ.01-02 Eurocontrol Papers for ATIO Conference - An extended analysis of sequencing arrivals An extended analysis of sequencing arrivals - link	PJ.01-02	29/06/2018
COM.126	PJ.01-02 Eurocontrol Papers for ATIO Conference - Proximity versus dynamicity Proximity versus dynamicity: an initial analysis at four European airports - link	PJ.01-02	29/06/2018
COM.020	PJ.01-03A Promotion of Concept and Validation Work - ATIO 2018 Paper Presentation on V1 Outcomes - link	PJ.01-03A	29/06/2018
COM.127	PJ.01-06 Presentation together with PJ.02-05 SL at HeliTech Conference Amsterdam 16-18 Oct 2018	PJ.01-06	18/10/2018
	DLR Open Day During FT in Braunschweig (October 2018)	Pj.01-06	25/10/2018
COM.021	PJ.01-03A - Invitation to Partners and SJU for V2 CDG RTS	PJ.01-03A	25/10/2018
COM.088	PJ.01-07 SURV Open Days to Present SESAR work on airborne surveillance topics, including PJ.01-07	PJ.01-07	23/11/2018
COM.025	PJ.01-06 Press Release/Blog post/Paper for Rotor-craft Conference Following Flight Trial	PJ.01-06	30/11/2018
COM.030	PJ.01-01 Pitch Story to Trade Press on Extended Arrival Management Activities	PJ.01-01	14/12/2018
COM.132	PJ.01-06 Press Release/Blog post Following FT (EDVE)	PJ.01-06	08/01/2019
COM.131	PJ.01-03B Open/Visitors Day	PJ.01-03B	07/02/2019
COM.050	PJ.01 Presentation on PJ01 EAD Project Activities to World ATM Congress		13/03/2019
COM.117	PJ.01-05 Presentation at SESAR Walking Tour - WAC2019	PJ.01-05	13/03/2019

COM.089	PJ.01-07 Present Video on ATSAW+	PJ.01-07	13/03/2019
	PJ.01-05 NLR presentation at EUROCONTROL's Surveillance Modernisation Support Group (SMSG)	PJ.01-05	14/03/2019
COM.060	PJ.01-03A Video Footage or Blog Post on Validation Activities at WAC 2019 *(Link to video not available)*	PJ.01-03A	20/03/2019
	Presentation of PJ.01-06 results on World ATM Congress in Madrid	PJ.01-06	13/03/2019
COM.129	PJ.01-01 COOPANS Simulation Visitors Day (RTS-b) - link	PJ.01-01	11/04/2019
COM.115	PJ.01-05 NLR Open Day for RTS#2 & RTS#3	PJ.01-05	25/04/2019
COM.135	PJ.01-02 Eurocontrol Papers Accepted for Presentation at US/Europe ATM Seminar, Vienna, June 2019 ○ Vertical Efficiency in Descent Compared to Best Local Practices – link ○ Spacing and Pressure to Characterise Arrival Sequencing - link	PJ.01-02	19/06/2019
COM.123	PJ.01-02 NATS Simulation Visitors Day	PJ.01-02	19/06/2019
COM.134	PJ.01-01 Eurocontrol Paper Accepted for Presentation at AIAA ATIO conference, Dallas, June 2019 ○ Interaction between arrival management and network management when extending the arrival horizon - link	PJ.01-01	21/06/2019
COM.133	PJ.01-01 Eurocontrol Paper Accepted for Presentation at US/Europe ATM Seminar, Vienna, June 2019 Enroute Traffic Overflows versus Arrival Management Delays - link	PJ.01-01	21/06/2019
COM.136	PJ.01-02 Eurocontrol Papers Accepted for Presentation at AIAA ATIO conference, Dallas, June 2019 ○ Proximity versus dynamicity - an analysis of traffic patterns at major European airports - link ○ Adherence to best descent profiles - An analysis of the relative vertical (in)efficiency at four major European airports - link	PJ.01-02	21/06/2019
COM.137	PJ.01-03A Eurocontrol Paper Accepted for Presentation at the 13th FAA/Europe ATM R&D seminar, Vienna, June 2019 - link	PJ.01-03A	21/06/2019
COM.139	PJ.01-06 Presentation on ERF (European Rotorcraft Forum) 2019 - link 1 link 2	PJ.01-06	20/09/2019
	PJ.01-07 Presentation made on July 9th, 2019 to the RTCA SC186 / EUROCAE WG51 group about the results we got in the two exercises done in the frame of the Solution.	PJ.01-07	09/07/2019
COM.040	PJ.01-02 External Article Describing V2 Work	PJ.01-02	11/10/2019

COM.080	PJ.01-02 Media Release to SJU and NATS External Website on V2 Work Article on NATS External Blog - Link	PJ.01-02	11/10/2019
COM.138	PJ.01-03A Presentation of PJ01 Results at Eurocontrol SESAR Worshop in Brussels, October 2019 - link	PJ.01-03A	07/11/2019
COM.100	PJ.01 Potential Media Release from PJ01 EAD covering All Solutions	PJ.01	02/12/2019
COM.120	PJ.01-05 Potential Media Release	PJ.01-05	06/12/2019

Supplementary information

PJ.01-06 Communication and Dissemination papers

Lüken, Thomas (German Aerospace Center DLR) and Schmerwitz, Sven (German Aerospace Center DLR) and Halbe, Omkar (Airbus Helicopters Deutschland GmbH) and Hamers, Mario (Airbus Helicopters Deutschland GmbH) and Roland, Bonel (THALES Avionics) and Ganille, Thierry (THALES Avionics) (2019) *FLIGHT EVALUATION OF ADVANCED SBAS POINT-IN-SPACE HELICOPTER PROCEDURES FACILITATING IFR ACCESS IN DIFFICULT TERRAIN AND DENSE AIRSPACES.* 45th ERF, 17.-19. Sep. 2019, Warsaw, Poland.

In preparation:

> Halbe, Omkar (Airbus Helicopters Deutschland GmbH) and Hamers, Mario (Airbus Helicopters Deutschland GmbH) and Lueken, Thomas (German Aerospace Center DLR) and Schmerwitz, Sven (German Aerospace Center DLR) (2020) *Flight Evaluation of Curved Point in Space Helicopter IFR Procedures*, Journal of air transportation
>
> (https://www.aiaa.org/publications/journals/Journal-Scopes-and-Content)
>
> This journal is still under review process of SJU.

Appendix A Glossary of Terms, Acronyms and Terminology

A.1 Glossary of terms

Term	Definition	Source of the definition

Table 3: Glossary

A.2 Acronyms and Terminology

Term	Definition
ACAS	Airborne Collision Avoidance System
A-CCO	Advanced Continuous Climb Operations
A-CDM	Airport Collaborative Decision Making
A-CDO	Advanced Continuous Descent Operations
A-CMAN	Advanced-CMAN
A-DCB	Airport Demand Capacity Balancing
ADS-B	Automatic Dependent Surveillance – Broadcast
ADS-C	Automatic Dependent Surveillance – Contract
A/G	Air/Ground
AHRS	Attitude Heading Reference Systems
AIRB	Basic Airborne Situation Awareness
AMAN	Arrival Manager
ANS	Air Navigation Service
ANSP	Air Navigation Service Provider
ANWP	Air Navigation Work Programme
AOM	Airspace Organisation and Management
AOP	Airport Operating Plan
AoR	Area of Responsibility

ASAS	Airborne Separation Assistance System
ASPA	Airborne Spacing
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATM	Air Traffic Management
ATN B2	Datalink connection capability
ATSU	Air Traffic Service Unit
AU	Airspace User
CAVS	Cockpit Assisted Visual Separation
CB	Cumulonimbus
CBA	Cost Benefit Analysis
CCO	Continuous Climb Operations
CDA	Continuous Descent Approach
CDM	Collaborative Decision Making
CDO	Continuous Descent Operations
CDTI	Cockpit Display of Traffic Information
CHMI	Collaboration Human Machine Interface
CMAN	Centre Manager
CNSS	Communication, Navigation, Surveillance and Spectrum
CPDLC	Controller Pilot Data Link Communications
CTA	Controlled Time of Arrival
CVS	Combined Vision System
DCB	Demand Capacity Balancing
DMAN	Departure Manager
DPI	Departure Planning Information

DS	Dataset
EAD	Enhanced Arrivals and Departures
E-AMAN	Extended AMAN
EASA	European Union Aviation Safety Agency
EATMA	European ATM Architecture
ECAC	European Civil Aviation Conference
ECTL	Eurocontrol
EPP	Extended Projected Profile
ETA	Estimated Time of Arrival
E-TMA	Extended TMA
ETO	Estimated Time Over
EUROCAE	European Organisation for Civil Aviation Equipment
EWG	Expert Working Group
FAA	Feceral Aviation Authority
FAF/FAP	Final Approach Fix/Final Approach Point
FATO	Final Approach and Take-off Area
FDR	Final Director position
FIM	Flight-deck Interval Management
FM	Flight Management
FMS	Flight Management System
FPD	Fixed Profile Descent
FRA	Free Route Airspace
FTS	Fast Time Simulation
GA	General Aviation
GNSS	Global Navigation Satellite System

GPS	Global Positioning System
HDD	Head Down Display
HEMS	Helicopter Emergency Medical Service
HMD	Head Mounted Display system
HMI	Human Machine Interface
I4D	Initial 4-Dimensional
IBP	Industry Based Platform
ICAO	International Civil Aviation Organisation
IDF	Initial Departure Fix
IF	Initial Fixed Leg
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IM	Interval Management
INAP	Integrated Network ATC Planner
IR	Industrial Research
KPA	Key Performance Area
LEMD	Madrid Airport
LFPG	Paris/CDG Airport
LoA	Letter of Agreement
LTP	Linked Third Party
LVP	Low Visibility Procedures
MAT	Maturity Assessment Tool
MCMF	Multi Constellation Multi Frequencies
MET	Meteorological
MOPS	Minimum Operational Performance Standards

NOK	Not OK
NM	Nautical Miles
OI	Operational Improvement step
OSED	Operational Service and Environment Definition
PANS	Procedures for Air Navigation Services
PAR	Performance Assessment Report
PAS@ATM	Airbus simulator
PBN	Performance Based Navigation
PCIT	Project Content Integration Team
PMB	Project Management Board
PinS	Point in Space
PPM	Performance and Prediction Module
QM	Queue Management
R&D	Research and Development
RF	Radio Frequency
RNAV	Area Navigation
RNP	Required Navigation Performance
ROC	Rate of Climb
ROD	Rate of Descent
RPAS	Remotely Piloted Aircraft System
R/T	Radio Telephony
RTA	Required Time of Arrival
RTCA	Requirements and Technical Concepts for Aviation
RTS	Real Time Simulation
SAF	Safety

SBAS	Satellite Based Augmentation System
SESAR	Single European Sky ATM Research
SGA	Specific Grant Agreement
SID	Standard Instrument Departure
SOIR	Simultaneous Operation on Independent Runways
STAR	Standard Arrival Route
SJU	SESAR Joint Undertaking
SNI	Simultaneous Non-Interfering
SPR	System Performance Requirements
SVS	Synthetic Vision System
SYSMAN	Systemized Airspace Manager
TBO	Trajectory Based Operations
TCAS	Traffic Alert and Collision Avoidance System
TLPD	Traffic Load Prediction Device
TMA	Terminal Manoeuvring Area
TOD	Top of Descent
TS	Technical Step
TSO	Technical Standard Order
TTA	Target Time of Arrival
TTL/TTG	Time to Lose/Time to Gain
TTOT	Target Take Off Time
TWR	Tower
V1/2/3	Validation maturity level
VALR	Validation Report
VFR	Visual Flight Rules

VMC	Visual Meteorological Conditions (VMC)
VNAV	Vertical Navigation
WP	Work Package
XMAN	Cross Border Arrival Management

Table 4: Acronyms and technology