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Copyright Statement

ToBeFree

PJ06

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Abstract

The Free Routing concept enables Airspace Users to fly as close as possible to their preferred trajectory without being constrained by fixed airspace structures or fixed route networks. The objective of PJ.06 was to validate implementation of Free Routing Airspace within high & very high-complexity environments.

The project PJ.06 assessed and delivered two solutions:

- Solution PJ06-01 "Optimized traffic management to Free Routing in high and very high complexity environments". This solution consolidates R&D activities to support the implementation of a Free Routing Airspace (FRA) in all complexities, where Airspace Users can fly as close as possible to their preferred trajectories.
- Solution PJ06-02 "Management of Performance Based Free Routing in Lower Airspace". This solution assesses the possibility and benefits of extending FRA in lower airspace and TMA.

This Final Project Report aims at describing SESAR 2020 PJ.06 ToBeFREE project progress. It presents the key results of both of its Solutions It then provides high level conclusions and recommendations.

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Executive Summary

The Free Routing concept requires Airspace Users to be able to plan flight trajectories without reference to a fixed route network or published directs, so they can optimise their associated flights in line with their individual operator business needs or military requirements. Free Route Airspace (FRA) is one of the most important operational concept that overcomes flight efficiency, airspace capacity, congestion and environmental issues reducing consumption of fuel and emissions. It delivers important benefits to Airspace Users (AU) and Air Navigation Service Providers (ANSP) and brings them significant savings.

PJ06 (ToBeFree) Project validated implementation of structurally limited FRA[1] in high and very high complexity en-route airspace. The project PJ06 assessed, and delivered two solutions:

- Solution PJ06-01 "Optimized traffic management to Free Routing in high and very high complexity environments" developed and validated the Free Routing concept in upper en-route airspace within cross-border high & very high-complexity environment. This Solution supports the implementation of European Regulation IR No 716/2014 - PCP AF#3 - Free routing available at and above FL310 in ICAO EUR region. PJ.06-01 started its activities at V2 maturity level and has been brought to V3 maturity level.

- Solution PJ06-02 "Management of Performance Based Free Routing in Lower Airspace", addressed the benefit and impact of expanding the Free Routing concept to the lowest limit possible while accommodating all Airspace Users concerned. PJ.06-02 started its activities at V1 maturity level and has been brought to V2 maturity level.

The validation exercises results as well as the safety, performance assessments and cost/benefit analysis confirmed the positive impact of the Solutions. Some improvements in Fuel Efficiency, Predictability[2] with no negative impact on Safety and Capacity have been demonstrated.

[1] Structurally limited being kept to a minimum

[2] The validation results do not allow to confirm or infirm any possible benefits in term of variance or in term of KEP-KEA improvement. However, an improvement of the mean difference between flown and planned flight durations has been confirmed.

1 Project Overview

1.1 Operational/Technical Context

The Free Routing concept enables Airspace Users to fly as close as possible to their preferred trajectory, without being constrained by fixed airspace structures or fixed route networks.

PJ06 Project validated efficient implementation of structurally limited FRA in all the Single European airspace. It supports the deployment of the Free Routing concept in en-route airspace of high and very high complexity.

The project PJ06 "Trajectory based Free Routing" performed its industrial research activities in the frame of two SESAR Solutions:

Solution PJ06-01 "Optimized traffic management to enable Free Routing in high and very high complexity environments"

The aim of Solution 1 was to complete research supporting delivery of PCP AF#3 (Free routing available above FL310 in ICAO EUR region). More precisely, it focused on the improvement of Separation Provision to enable Free Routing operations within high and very high complexity cross-border environments in Upper En Route airspace. .

Solution PJ06-02 "Management of Performance Based Free Routing in Lower Airspace"

This Solution focused on the benefits and impacts of expanding the Free Routing concept to the lowest possible limit while accommodating all Airspace Users concerned. This was in order to support the objective to facilitate the access of Free Routing Airspace to all airspace users, and thus maximizing the possible benefits of the Solution. New algorithms to improve flight planning efficiency in a Free Route environment with special focus on small aircraft operators and general aviation have been developed and tested.

1.2 Project Scope and Objectives

The Free Routing concept was addressed within the SESAR 1 programme but additional R&D activities were required to support the implementation of FRA in High and very high complexity airspace.

To do so, PJ06:

- **Developed and validated concepts** enabling Airspace Users to plan flight trajectories without reference to a fixed route network or published directs within high & very high complexity;

- **Identified the additional infrastructure** to implement Free Routing Airspace within high & very high complexity environments. Controller workload associated with individual trajectory interactions is anticipated to increase within a non-published route airspace environment. As a result, in order to maximize the benefits of Free Routing operations, the definition of structural constraints on the airspace and/or the use of enhanced controller tool set might be necessary.

- **Supported the evolutions related to Demand & Capacity Balancing performed by other SESAR 2020 projects** by providing these projects with a reference operational environment description.

- **Supported the adaptation of separation management** tools in En-route in a Free Routing cross-border context.

- Considered **General Aviation** and **small aircraft operators** to ease their access to the Free Routing Airspace.

- **Addressed the safe and transparent integration of Civil RPAS** in non-segregated airspace, in a multi-aircraft and manned flight environment, guaranteeing the interoperability with the ATM system. Operational considerations specific to RPAS and technological needs, if any.

- **Considered cyber-security aspect**s through the assessment of the resilience of FR operations and the impact that data integrity issues may have on human performance and safety

1.3 Work Performed

The following section represents the work performed by both Solutions. It also gives a highlight on the communication activities of the project.

1.3.1 Solution PJ.06-01

The solution provided a description of high and very-high complexity cross-border Free Routing environment in upper airspace. It addressed optimized traffic management and focused its activities on the improvement of advanced Air Traffic Services (Free Route Airspace Design with the concept of “structurally” limited FRA, Separation Provision (airspace), Coordination and Transfer, Trajectory Conformance monitoring)

The objective was to demonstrate that implementing the solution would lead to an improvement of fuel efficiency, a reduction of CO2 emissions and an improvement of flights predictability with no negative impact on Safety and Capacity

PJ.06-01 contributes to AOM-0505 “Optimized traffic management to enable Free Routing in high and very high complexity environments”. The OI step is partially covered.

The Enablers supporting the SESAR solution are:

- ER APP ATC 78 (Update FDP to support 4D trajectory direct segments in free routing airspace beyond local AoR) - Required
- ER APP ATC 129 (Upgrade FDP and provide Controller Tools to provide assistance to ATC Planning for Preventing Conflicts in ER) - Required (Baseline)
- ER ATC 91 (ATC System Support for Advanced Conformance Monitoring in En-route Airspace) - Required
- ER ATC 157 (Enhanced ATC System Support to the Tactical Controller for Conflict Detection and Resolution in En-Route) - Optional
- ER ATC 157b (Enhanced ATC System Support the Planning Activity for Conflict Detection and Resolution in En-Route) - Optional
- PRO-046b (ATC Procedures for Using Advanced System Assistance to Medium Term Conflict Detection and Resolution) – Optional

Applicable Integrated Roadmap Dataset in DS19[3]

Operational and technical environment

PJ.06-01 Real Time Simulations were conducted through two validation threads:

- EXE-06.01-V3-VALP-001: Free Routing Concept development and assessment in very high complexity cross-border environment
- EXE-06.01-V3-VALP-002: Cross-FIR analysis of Barcelona FRA and Madrid FRA integration in high complexity environment.

These two threads, conducted through Real Time Simulations, allowed together to address both high and very high complexity cross-border environments in upper En-route airspace.
To support the validations exercises structurally limited Free Routing Airspaces have been designed respectively cross-ANSP (EXE 1) and cross-ATSU (EXE 2) borders.
For both threads, the Flight Data Processing (FDP) system was upgraded to support direct segments beyond the local Area of Responsibility (AoR) and ATCOs were assisted by either baseline or enhanced ATC tools to support Conflict Detection and Resolution.
The objective was to assess the impact of the Solution on fuel efficiency and predictability and confirm the absence of any negative impact on safety and capacity. Human Performance aspects were also assessed.

Further details about PJ.06-01 V3 validations can be found in D2.1.530 - PJ06-01 Consolidated VALR (V3) [1]

[3] Change requests, as outputs from the Solution's activities, have been proposed for DS20.

PJ.06-01 Deliverables

The following deliverables constitute the data pack delivered by PJ.06-01:

Reference	Title	Delivery Date[4]	Dissemination Level
Description			
D2.1.030	PJ.06-01 SPR-INTERP/OSED (V3)	23/10/2019	PU
SPR-INTEROP/OSED Part I describes the operational service, environment and assumptions that are applicable to the Solution and provides a list of operational, safety, performance and interoperability requirements to be fulfilled to implement the Solution. It also provides a reference operational environment description. SPR-INTEROP/OSED Part II Safety Assessment Report (SAR) contains the Safety Assessment for the implementation of Free Route Operations within the scope of SESAR PJ.06-01 solution. It defines Safety requirements derived from the Safety Criteria and Safety objectives, as defined by the SRM Methodology. It confirms the absence of negative impact of the Solution on Safety. SPR-INTEROP/OSED Part IV Human Performance Assessment Report (HPAR): consists in the HP assessment plan, the results of the HP activities conducted according to the HP assessment process, and the HP recommendations & requirements. SPR-INTEROP/OSED Part IV Performance Assessment report (PAR): covers the Key Performance Areas (KPAs) defined in the SESAR2020 Performance Framework and more particularly for PJ.06-01 Fuel Efficiency, and Predictability. This report extrapolates the solution performance assessment ECAC wide and at 2030/2035 time horizon.			
D2.1.110	PJ.06-01 Technical specification check (TRL6 – V3)	17/10/2019	PU
PJ.06-01 did not develop any prototypes and performed its validations using other SESAR 2020 wave 1 prototypes. PJ06.01 performed a review of the TS/IRS of the prototypes used, in parallel derived safety requirements from the safety assessment (at system level), and added few requirements in relation to the Area of responsibility This document reflects the technical requirements needed to cover the operational requirements identified in this solution. It provides the requirements specification, covering functional, non-functional and interface requirements related to SESAR Solution PJ.06-01			
D2.1.530	PJ.06-01 Consolidated VALR (V3)	27/09/2019	PU
This Validation Report provides individual results of both validation threads. The core part of the report integrates the results obtained and confirms the coverage status of the solution's validation objectives. A set of recommendations for the implementation of the solution is also provided.			
D2.1.200	PJ.06-01 CBA (V3)	18/10/2019	PU
This document describes the main elements and assumptions that have been used in the development of the CBA Model; identifies the impacted stakeholders groups and proposes countries and ANSPs for the deployment scenario approach. It provides a mechanism of the potential costs of the Solution for Air Navigation Service Providers (ANSPs); and a description, assessment and monetisation of the benefits.			

[4] Delivery data of latest edition

1.3.2 Solution PJ.06-02

The Solution PJ.06-02 is contributing to the improvement of air traffic management at local level to enable Free Routing in high complexity cross-border environments and Management of Performance Based Free Routing in lower airspace. It sees the application of FRA for airspace users beyond the PCP expectations (below FL310), improving predictability, efficiency and flexibility for a wider range of different airspace users. PJ06.02 Solution was not addressed by the previous SESAR study and the solution reached V1 maturity level at the first stage and then V2 maturity level.

The aim of this Solution was to perform research supporting future implementation of Free routing below FL310 across the European airspace. Moreover new algorithms to improve flight planning efficiency in Free Route environment with a special focus on small aircraft operators and GA was developed and tested.

PJ06.02 developed and explored the concept and supporting functionalities with a focus on performance, human performance, acceptability, operational feasibility and safety.

PJ.06-02 addresses AOM-0506 “Free Routing for Flights both in cruise and vertically evolving within high-complexity environments in Lower En Route airspace”.

According to the applicable version of EATMA there is one enabler linked to the PJ06-02 solution: ER APP ATC 78 – “Update FDP to support 4D trajectory direct segments in free routing airspace beyond local AoR”.

Applicable Integrated Roadmap Dataset is DS-19.

1.3.2.1 PJ06.02 V1 Maturity

1.3.2.1.1 Validation activities

Operational and technical environment

PJ.06-02 validation activities at V1 maturity level were conducted through two validation threads:

- Thread #1 - VP-06-02 #1: FTS – High level assessment of benefits stemming from cross-border FRA implementation at different horizontal and vertical scales.
- Thread #2 - VP-06-02 #2: Model Based Simulation – Verification of mathematical model for new flight planning algorithm.

VP-06-02 #01 was a model based simulation and was conducted on a set of EUROCONTROL NMD airspace and network design evaluation tools (SAAM and NEST) which allowed assessing the potential benefits and the impact of implementing FRA. The assessment was performed with FRA defined at different geographical and vertical scales. The potential benefits that the implementation of FRA could bring were measured in terms of the horizontal flight efficiency (HFE) which finally translates into fuel consumption savings.

VP-06-02 #2 was focuses on laying the groundwork for the definition and development of a new semi-automatic optimal flight planning algorithm, which could be used to efficiently and quickly plan

flight trajectories crossing FRA airspace segments. This validation thread was devoted to verification of developed mathematical model for new flight planning algorithm. The objective was to prove that chose model is appropriate to be used to store airspace and flight planning data needed for correct flight planning algorithm development.

The following deliverables constitute the data pack delivered by PJ.06-02 at V1 maturity level:

Reference	Title	Delivery Date[5]	Dissemination Level
Description			
D3.1.010	PJ.06-02 SPR-INTERP/OSED (V1)	26/02/2018	PU
PART I – SPR-INTEROP/OSED (Main part) led by PANSA SPR-INTEROP/OSED Part I describes the operational concept and defines the operational services and requirements. The OSED is used as the basis for establishing operational, safety, performance and interoperability requirements for the Management of Performance Based Free Routing in lower airspace. This document defines the Management of Performance Based Free Routing in lower airspace Concept. Other parts of the SPR-INTEROP/OSED have been developed at V2 stage. The SPR-INTEROP/OSED was produced with contributions from PRZ, ON and EUROCONTROL			
D3.1.030	PJ.06-02 Validation report (V1)	30/01/2018	PU
This Validation Report provides individual results of both validation threads performed at V1 maturity level. The core part of the report integrates the results obtained and confirms the coverage status of the solution's validation objectives. A set of recommendations for the implementation of the solution is also provided.			

1.3.2.2 PJ06.02 V2 Maturity

PJ.06-02 Operational and Technical Environment

PJ.06-02 validation activities at V2 maturity level were conducted through two validation threads:

- VP-06-02 #2: New flight planning algorithm validation,
- VP-06-02 #3: Assessment of impacts and benefits of FRA operations in lower airspace.
- VP-06-02 #4: Assessment of the impact of corrupted data on human performance and safety from the ATCO perspective in Free Route and fixed route network environments.

These three Real Time Simulations allowed complete assessment of different aspects of implementation of FRA in high complexity En-route airspace.

[5] Delivery data of latest edition

VP-06-02-02 was a RTS devoted to the assessment of a new flight planning algorithm for GA and BA users. Dedicated test platform was developed for execution of this validation.

Exercise VP-06-02-03 was an RTS devoted to check the feasibility of the cross-border FRA concept by assessing the impact on ATCOs and benefits of FRA operations in high complexity En-route lower airspace.

VP-06-02-04 was an RTS devoted to addressing the cyber security aspects which, due to the technical limitations, were executed two times (In Warsaw and in Vilnius). The simulations were executed on specially developed test platforms. Both platforms are based on the same prototype of the future ATM systems called iTEC, which are currently under development in both centres. In order to perform cyber-security focused simulations both platforms were temporary fitted with the special "corruptor" module prepared by INDRA exclusively for the purposes of this simulation. This module generated in a predefined way cyber-security driven threats and injected them into the test platform.

Data collected during execution of validation thread VP-06-02 #3 and VP-06-02 #4 were used to assess the impact of the Solution on fuel efficiency and predictability and prove no negative impact on safety including Human Performance aspects.

Further details about PJ.06-02 V2 validations can be found in D3.2.050 - PJ06-02 Consolidated VALR (V2).

PJ.06-02 Deliverables

The following deliverables constitute the data pack delivered by PJ.06-02 at V2 maturity level:

Reference	Title	Delivery Date[6]	Dissemination Level
	Description		
D3.2.010	PJ.06-02 SPR-INTERP/OSED (V2)	16/10/2019	PU
SPR-INTEROP/OSED Part I describes the operational service, environment and assumptions that are applicable to the Solution and provides a list of operational, safety, performance and interoperability requirements to be fulfilled to implement the Solution. It also provides a reference operational environment description. SPR-INTEROP/OSED Part II Safety Assessment Report (SAR) contains the Safety Assessment for the implementation of Free Route Operations within the scope of SESAR PJ.06-02 solution. It defines Safety requirements derived from the Safety Criteria and Safety objectives, as defined by the SRM Methodology. It confirms the absence of negative impact of the Solution on Safety. SPR-INTEROP/OSED Part IV Human Performance Assessment Report (HPAR): consists in the HP assessment plan, the results of the HP activities conducted according to the HP assessment process, and the HP recommendations & requirements.		

[6] Delivery data of latest edition

SPR-INTEROP/OSED Part IV Performance Assessment report (PAR): covers the Key Performance Areas (KPAs) defined in the SESAR2020 Performance Framework and more particularly for PJ.06-02 Fuel Efficiency, and Predictability. This report extrapolates the solution performance assessment ECAC wide and at 2030/2035 time horizon.			
D3.2.020	PJ.06-02 Technical specification check (TRL4 – V2)	16/10/2019	PU
PJ.06-02 did not developed any prototypes. PJ06-02 addresses only one Enabler: ER APP ATC 78. PJ.06-02 thus did not produce a standard TS/IRS, but performed a review of the TS/IRS of the addressed enablers. This document reflects the technical requirements needed to cover the operational requirements identified in this solution. It provides the requirements specification, covering functional, non-functional and interface requirements related to SESAR Solution PJ.06-02			
D3.2.050	PJ.06-02 Consolidated VALR (V2)	09/08/2019	PU
This Validation Report provides individual results of all three validation threads. The core part of the report integrates the results obtained and confirms the coverage status of the solution's validation objectives. A set of recommendations for the implementation of the solution is also provided.			
D3.2.030	PJ.06-02 CBA (V2)	16/10/2019	PU
This document describes the main elements and assumptions that have been used in the development of the CBA Model; identifies the impacted stakeholders groups and proposes countries and ANSPs for the deployment scenario approach. It provides a mechanism of the potential costs of the Solution for Air Navigation Service Providers (ANSPs); and a description, assessment and monetisation of the benefits.			

1.3.3 Project communication activities

The project actively communicated and disseminated its results according to the Horizon 2020 and SESAR 2020 expectations and guidelines.

Several communication activities took place during the PJ06 active period. Among them were the following:

- PANSA for PJ06-02 solution - Presentation for Scientific conference IRL2018 – Poland; April 2018;
- Participation at WAC - World ATM Congress 2018;
- Participation at WAC- World ATM Congress 2019 (Walking tours, Europe village ENAIRE)
- CBA methodology presented to SESAR Deployment Manager (SDM) on 27th February 2019;
- Presentation of PJ06 at Aero days - 27-28th May 2019 in Bucharest;
- PJ06-02 project presentation to the scientific community at Rzeszów University of Technology – October 2019.

Open days were also organised by both PJ.06-01 and PJ.06-02 to present the validation exercises activities

- Open day/Visitor day for EXE PJ06-01 #2; November 2018
- Open day/Visitor day for EXE PJ06-02 #3; December 2018
- Open day/Visitor day for EXE PJ06-02 #4 – Warsaw; February 2019
- Open day/Visitor day for EXE PJ06-02 #2; February 2019
- Open day/Visitor day for EXE PJ06-02 #4 – Vilnius; March 2019

As part of their communication activities, both Solutions also produced a contextual note after having completed each of their maturity phase:

- Contextual note solution PJ06-01 V3; December 2019 [14]
- Contextual note solution PJ06-02 V1; January 2018 [15]
- Contextual note solution PJ06-02 V2; October 2019 [16]

1.4 Key Project Results

1.4.1 Solution PJ.06-01

The results of the validation exercises as well as the subsequent safety, human performance, performance assessments and the cost/benefits analysis provided the following results:

Fuel efficiency, Environment

It has been demonstrated that the average fuel consumption per flight is reduced with the implementation of structurally limited Free Route concept. Extrapolated at horizon 2035 and at ECAC level, **PJ.06-01 is expected to deliver significant Environment / Fuel Efficiency benefits:** a reduction of 26,57kg per flight concerned by the solution has been calculated (which turns into a reduction of 83, 69 kg of CO2 emission).

Predictability

The validation results did not allow to confirm or infirm any possible benefits in term of local variance of flight times between planned and flown trajectories. However, the mean difference between flown and planned flight durations is improved in both validation exercises.

Nevertheless, some predictability benefits have been demonstrated, but in terms of local % of actual vs. planned wasted routes. These benefits will also depend on the airspace design of cross-border FRA at local level.

Safety, Capacity

The outcomes of the safety assessment conducted at SPR level and the V3 validation exercises results give confidence that **the PJ.06-01 Solution contributes to not adversely affecting the Safety and the Airspace KPAs with the implementation of structurally limited cross-border FRA in En-Route High and Very High Complexity operating environments**

With a traffic load representing the 2022 forecast supported by the adapted ATC tools, Controllers were able to work **safely and efficiently** in cross border structurally limited Free Route and the **capacity** was maintained.

The FRA structure Design has a crucial importance in order to maintain the complexity within manageable limits. Nevertheless, controllers indicated there is a high probability that capacity will be reduced during a transition phase from ARN airspace to Structurally Limited Free Route Airspace, until ATCOs have gained high proficiency in the new environment.

Human performance

ATCOs **situational awareness and cognitive workload** were considered adequate to perform their work both in high and in very high complexity environments. The adequacy was considered as being closely related to the use of advanced support tools in the FRA environment.

ATCOs reported that even if the **working principles and procedures** are not strongly modified in a cross-border FRA environment, given the higher variability of trajectories and the more random distribution of crossing points in the airspace (and consequently conflicts to be solved), the good accomplishment of conflict detection and resolution tasks by ATCOs is more dependent on good ATC support tools support.

No need has been identified to change the existing **Roles and Responsibility** distribution in the Team.

Cost benefit Analysis

The analysis' results show that the PJ.06-01 Solution would bring significant benefits to the Airspace Users and great improvement to the network performance. The overall CBA results of the PJ.06-01 show that the NPV is positive with a gain estimated at 797 M€. This result is supported by flight efficiency benefits evidenced in Validation Exercises and Fast Time Simulations performed by the Network Manager. The Solution's implementation is feasible in economic terms. Moreover, those results and the short-term payback period (5 years after IOC) decrease the risk level of the PJ.06-01 for potential investors.

1.4.2 Solution PJ.06-02

Fuel efficiency

This solution is expected to bring benefits from FRA implementation in terms of Fuel Efficiency KPAs. It is expected to bring benefits mostly for AUs, improving Operational Efficiency (fuel efficiency, cost effectiveness), while ANSPs and ATCOs are aiming to maintain Safety and airspace Capacity in FRA of high complexity. It has been demonstrated in the validations that on average planned routings are shorter thus average fuel consumption per flight is reduced within cross-border FRA area. Extrapolated to the horizon of 2035, a reduction of 13,15kg per flight concerned and of 9,98 kg fuel per flight at ECAC level by the solution has been calculated .

Predictability

PJ.06-02 tried to estimate and extrapolate at ECAC level potential benefits in PRD – Predictability by comparing the gap between KEP (planned) and KEA (actually flown) trajectories in reference and solution scenario. Rationale was based on historical data analysis and annual reports issued by EUROCONTROL such as the PRR 2016, where it is also possible to derive some average patterns that could be then extrapolated to other comparable ACCs. .

The methodology used for the estimation of the potential in PRD in PJ.06-02, based on KEP-KEA differences in REF and SOL Scenarios is not aligned with SESAR2020 programme - therefore results obtained could not be used for integration at programme level.

In accordance with the project addressing enhanced demand and capacity balancing, the following benefits from TTO/TTA should be obtained: improved efficiency of ATFCM measures due to increased predictability of entry times, 2-5% en-route capacity increase, improvement of in-block punctuality and departures predictability by 10-30% with TTA, with a significant reduction of reactionary delay. Free Route Airspace should have a positive effect on TTO/TTA as the FRA environment should increase the predictability of aircraft trajectories and decrease deviations from the flight plan.

Airspace Capacity

No Airspace Capacity assessment was done within the scope of this Solution. Through indirect assessment based on the impact on ATCOs workload it can be assumed there is no significant impact on Airspace Capacity. The ATCOs' feedback on traffic load and complexity showed that the traffic load has been perceived as high but still manageable within current levels of capacity.

The FRA design has a crucial importance in order to maintain the complexity within manageable limits.

Human Performance

The Human Performance related outcome of the simulations was strikingly positive. Even though it may seem obvious that increased complexity will have an impact on controllers' performance, the overall workload and situation awareness remained acceptable.

The simulation conducted indicates that FRA in high complexity lower airspace seems feasible, but improvement in some areas is required.

There was no need have been identified to change the existing **Roles and Responsibility** distribution in the Team.

Cost Benefit Analysis

The analysis' results show that the PJ.06-02 Solution would bring significant benefits to the Airspace Users and great improvement of the network performance. The overall CBA results of the PJ.06-02 show that the NPV is positive with a gain estimated at 444 M€. This result is supported by flight efficiency benefits evidenced in Validation Exercises and Fast Time Simulations performed by the Network Manager. The Solution's implementation is feasible in economic terms.

1.5 Technical Deliverables

Reference	Title Description	Delivery Date[7]	Dissemination Level[8]
Solution 1			
D2.1.530	D2.1.530 - PJ06-01 Consolidated VALR (V3) [1] Validation reporting aggregating results from threads #1 & #2 for the solution 06-01	09/10/2019	PU
D2.1.030	D2.1.030 - PJ06-01 SPR-INTEROP/OSED (V3) - Final version [2] Part I: Operational concept description of solution PJ.06-01 as well as the related Safety, Performance and Interoperability requirements. Part II : PJ.06-01 Safety Assessment Report, Part IV Human Performance Assessment report and Part V Performance Assessment Report	05/11/2019	PU
D2.1.110	PJ06-01 TS/IRS Check (V3) - Final version [3] Technical specification of prototypes develop in the frame of PJ06-01 solution	30/10/2019	PU
D2.1.200	PJ06-01 CBA (V3) - Cost Benefit Analysis [4]	18/10/2019	PU
D2.1	Solution PJ06-01 V3 Data Pack [5] Data Pack encompassing major deliverables (see above) produced in the frame of solution 06.01	20/11/2019	PU
Solution 2			
D3.1.030	PJ06-02 VALR (V1) [6] Validation report related to solution 06.02 in the phase V1	30/01/2018	PU
D3.1.010	PJ06-02 OSED (V1) [7] Concept developed within the solution 06.02 in the phase V1	26/02/2018	PU
D3.1	Solution PJ06-02 V1 Data Pack [8] Data Pack encompassing major deliverables produced in the frame of solution 06.02 in the V1 phase	28/03/2018	PU
D3.2.050	D3.2.050 - PJ06-02 VALR (V2) [9] Validation report related to solution 06.02 in the phase V2	09/08/2019	PU
D3.2.010	D3.2.010 - PJ06-02 SPR-INTEROP/OSED (V2) [10]	21/10/2019	PU

[7] Delivery data of latest edition

[8] Public or Confidential

	Part I: Operational concept description of solution 06.02 as well as the related Safety, Performance and Interoperability requirements. Part II: PJ.06-02 Safety Assessment Report, Part IV: Human Performance Assessment report and Part V: Performance Assessment Report		
D3.2.020	D3.2.020 - PJ06-02 TS/IRS (V2) [11] Technical specification of prototypes developed in the frame of PJ06-02 solution	21/10/2019	PU
D3.2.030	D3.2.030 - PJ06-02 CBA (V2)[12] Cost Benefit Analysis	21/10/2019	PU
D3.2	D3.2 - Solution PJ06-02 V2 Data Pack [13] Data Pack encompassing major deliverables produced in the frame of solution 06.02 for the V2 phase	07/11/2019	PU

Table 1: Project Deliverables

2 Links to SESAR Programme

2.1 Contribution to the ATM Master Plan

In accordance with the Grant, both PJ.06-01 and PJ.06-02 have progressed to their next V phase.

Code	Name	Project contribution	Maturity at project start	Maturity at project end
PJ.06-01	Optimized traffic management to enable Free Routing in high and very high complexity environments	To complete research supporting delivery of PCP AF#3 (by addressing Free routing at and above FL310 in ICAO EUR region)	V2	V3
PJ.06-02	Management of Performance Based Free Routing in Lower Airspace	To research the benefit and impact of expanding the Free Routing concept to the lowest limit possible (below FL310) while accommodating all Airspace Users concerned	None	V2

Table 2: Project Maturity

OI Steps addressed:

- PJ.06-01 partially addressed AOM-0505
- PJ.06-02 addressed AOM-0506

Several Change Requests have been submitted and endorsed to amend the content of both the OI steps and their associated EN. Reference Data Set is DS19.

The full set of updated data is available for possible inclusion in DS20.

2.2 Contribution to Standardisation and regulatory activities

As required by Regulation 716/2014 on the establishment of the PCP supporting the implementation of the European Air Traffic Management Master Plan and its ATM Functionality #3.2 Free Route, ATC systems adapted to operate in FRA shall support Free Routing and cross-border operations across Europe.

Besides, as required by Regulation 1032/2006 - Exchange of Flight Data Between ATC Units (and its amendment Regulation 30/2009 - Requirements for Automatic Systems for the Exchange of Flight Data Supporting Data Link Services), the OLDI protocol for co-ordination and transfer of current flight data between adjacent air traffic control units shall be in use by all ATC units providing service to general air traffic.

In this context, the list of ATC systems standards applicable to the Solution PJ.06-01are as follows:

- EUROCONTROL Specification for On-Line Data Interchange (OLDI), EUROCONTROL-SPEC-106, Edition 4.3 – in particular its Annex G: Evolution of the OLDI message exchanges and their application in FRA environment
- EUROCONTROL Extended MTCD Specification, EUROCONTROL-SPEC-139Edition 2.0 (STD-061)
- EUROCONTROL Monitoring Aids (MONA) Specification, EUROCONTROL-SPEC-142 (STD-062)
- EUROCONTROL Trajectory Prediction Specification, EUROCONTROL-SPEC-143 (STD-063)
- EUROCONTROL Area Proximity Warning (APW) Guidelines, EUROCONTROL-GUID-161 (STD-064)
- EUROCONTROL STCA Guidelines, EUROCONTROL-GUID-159

No need for new standards and/or regulations or update of the existing ones has been identified.

3 Conclusion and Next Steps

3.1 Conclusions

PJ06.01

It has been confirmed that the solution will bring significant benefits to Airspace users, with no negative impacts on Capacity and Safety. The positive net present value together with the short payback period will support a quick progress towards greener Air transportation

PJ06.02

Solution 2 successfully reached Maturity level V1 and the work continued in V2 Maturity phase.

The main objective of V2 maturity phase was to develop and explore the concept and supporting functionalities (addressed by enablers) until it can be considered feasible. At this maturity level the feasibility considered mainly the operational and transitional approach to the concept and provided initial elements for technical feasibility.

It has been confirmed that application of Free Routing Airspace to make Free Routing available for AUs in lower En Route Airspace is expected to improve time and fuel efficiency for short haul flights of propeller driven aircraft and raise automation level of flight planning and lessen workload of flight crew.

It is expected that Solution 2 will reach the V2 maturity level during the Gate. However, it has been decided that for the time being the solution will remain at V2 level without further continuation.

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

The solution 06-01 has successfully completed its V3 phase and is ready for the next phase (V4 industrialization).

Solution PJ06-02 has successfully completed its V2 phase. All the planned deliverables (described in section 1.5) are now available for the community.

4 References

4.1 Project Deliverables

Here is the list of the Data Pack deliverables provided by both solutions in the frame of their research activities

PJ.06-01 V3 Data Pack:

[1] D2.1.530 - PJ06-01 Consolidated VALR (V3) v00.01.01

[2] D2.1.030 - PJ06-01 SPR-INTEROP/OSED (V3) - Final version v00.03.02

[3] D2.1.110 - PJ06-01 TS/IRS Check (V3) - Final version v00.02.07

[4] D2.1.200 - PJ06-01 CBA (V3) v00.01.00

[5] D2.1 - Solution PJ06-01 V3 Data Pack

PJ.06-02 V1 Data Pack

[6] D3.1.030 - PJ06-02 VALR (V1) v00.01.00

[7] D3.1.010 - PJ06-02 OSED (V1) v6

[8] D3.1 - Solution PJ06-02 V1 Data Pack

PJ.06-02 V2 Data Pack:

[9] D3.2.050 - PJ06-02 VALR (V2) v00.01.00

[10] D3.2.010 - PJ06-02 SPR-INTEROP/OSED (V2) v00.01.00

[11] D3.2.020 - PJ06-02 TS/IRS (V2) v00.02.00

[12] D3.2.030 - PJ06-02 CBA (V2) v00.01.00

[13] D3.2 - Solution PJ06-02 V2 Data Pack

4.2 Project Communication and Dissemination papers

[14] Contextual note solution PJ06-01 V3; December 2019

[15] Contextual note solution PJ06-02 V1; January 2018

[16] Contextual note solution PJ06-02 V2; October 2019

Appendix A Glossary of Terms, Acronyms and Terminology

A.1 Glossary of terms

Term	Definition	Source of the definition
Air Traffic Flow and Capacity Management	A service complementary to Air Traffic Control (ATC), the objective of which is to ensure an optimum flow of air traffic to or through areas within which traffic demand at times exceeds the available capacity of the ATC system.	**ATM Lexicon**
Area of Responsibility	An airspace of defined dimensions within which an ATC unit provides air traffic services.	**ATM Lexicon**
Complexity	The number of simultaneous or near-simultaneous interactions of trajectories in a given volume of airspace. Note: Given complexity definition refers to ATM context. For automation, complexity is relevant only in terms of calculation effort, not the ability to solve a given set of problems. Beyond a certain level of complexity, humans can no longer oversee all the consequences of the interactions and automation support is required if traffic is to be handled safely and efficiently. See also **Density**.	**SESAR Integrated Dictionary**
Conflict	Converging of aircraft in space and time which constitutes a predicted violation of a given set of separation minima.	**ATM Lexicon**
Free Routing	The ability of an Airspace User to plan/re-plan route according to the user-defined segments.	**SESAR Integrated Dictionary**
Free Route Airspace[9]	A specified airspace within which users may freely plan a route between a defined entry point and a defined exit point, with the	**ERNIP Part 1**

[9] It is worthwhile noting that the term used to refer to a specified airspace where free routing operations are allowed is different depending on the source. It is called 'Free Routing Airspace' according to the SESAR Integrated Dictionary and 'Free Route Airspace' in the ERNIP Part 1 document. The underlying FRA concepts are nevertheless the same.

	possibility to route via intermediate (published or unpublished) way points, without reference to the ATS route network, subject to airspace availability. Within this airspace, flights remain subject to air traffic control.	
Key Performance Indicator	Current/past performance, expected future performance (estimated as part of forecasting and performance modelling), as well as actual progress in achieving performance objectives is quantitatively expressed by means of indicators (sometimes called Key Performance Indicators, or KPIs). To be relevant, indicators need to correctly express the intention of the associated performance objective. Since indicators support objectives, they should not be defined without having a specific performance objective in mind. Indicators are not often directly measured. They are calculated from supporting metrics according to clearly defined formulas, e.g. cost-per-flight-indicator = Sum(cost)/Sum(flights). Performance measurement is therefore done through the collection of data for the supporting metrics." 9.5.2013 EC Official Journal of Union definition: In the context EC Performance Implementing Regulation, Key Performance Indicator means specifically the performance indicators used for the purpose of performance target setting	**ICAO Doc 9883**
Performance Framework	Set of definitions and terminology describing the building blocks used by a group of ATM community Members to collaborate on performance management activities. This set of definitions includes the levels in the Global ATM Performance Hierarchy, the Key Performance Areas, a set of Process Capability Areas, Focus Areas, Performance Objectives, Indicators, Targets Supporting Metrics, lists of dimension objects, their aggregation hierarchies and classification schemes"	**ICAO Doc 9883**

Table 3: Glossary

A.2 Acronyms and Terminology

Term	Definition
ACC	Area Control Centre
AF	ATM Functionalities
AN	Availability Note
ANSP	Air Navigation Service Provider
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATFCM	Air Traffic Flow and Capacity Management
ATM	Air Traffic Management
ATS	Air Traffic Service
ATSU	Air Traffic Service Unit
AU	Airspace Users
CAP	Capacity
CBA	Cost Benefit Analysis
CCG	Communication Coordination Group
CDRT	Conflict Detection & Resolution Tools
CONOPS	Concept of Operations
DFL	Division Flight Levels
DS	Data Set
ECAC	European Civil Aviation Conference
EEC	EUROCONTROL Experimental Centre
EPMB	Extended Project Management Board
EXE	Exercise
FDP	Flight Data Processor

Term	Definition
FEFF	Fuel Efficiency
FIR	Flight Information Region
FL	Flight Level
FOC	Flight Operations Centre (in the context of AU Operations)
FR	Free Route
FRA	Free Route Airspace
FTS	Fast Time simulation
GA	Grant Agreement
GA	General Aviation
HFE	Horizontal Flight Efficiency
HMI	Human Machine Interface
HP	Human Performance
HPAP	Human Performance Plan
HPAR	Human Performance Assessment Report
IBP	Industry Based Platform
ICAO	International Civil Aviation Organization
INTEROP	Interoperability Document (Requirements)
IOC	Initial Operational Capability
IRS	Interface Requirements System
KEA	Key performance Environment indicator based on actual trajectory
KEP	Key performance Environment indicator based on last filed flight Plan
KPA	Kea Performance Area
KPI	Key Performance Indicator
N/A	Not available
NM	Network Manager

Term	Definition
OSED	Operational Service and Environment Definition
PAR	Performance Assessment Report
PC	Planning Controller
PCIT	Project Content Integration Team
PCP	Pilot Common Project
PI	Performance Indicator
PMB	Project Management Board
PMP	Project Management Plan
PRD	Predictability
PUN	Punctuality
QPR	Quarterly Progress Report
R&D	Research and Development
RPAS	Remotely Piloted Aircraft System
RTS	Real Time Simulation
SAC	Safety Criteria
SAF	Safety
SAP	Safety Assessment Plan
SAR	Safety Assessment Report
SDM	SESAR Deployment Manager
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SPR	Safety and Performance Requirements
SWIM	System Wide Information Model
TMA	Terminal Manoeuvring Area
TS	Technical Specification

Term	Definition
TSA	Temporary Segregated Area
VALP	Validation Plan
VALR	Validation Report
VALS	Validation Strategy
WAC	World ATM Congress

Table 4: Acronyms and technology

A.3 Final Project maturity self-assessment

191128 PJ06-01
Maturity Assessmen

191129 PJ06-02
Maturity Self Assess


dgac
DSNA


B4
CONSORTIUM


COOPANS
REAL COOPERATION, REAL RESULTS


ENAIRE


enav


EUROCONTROL


indra


LEONARDO


skyguide


THALES