Exploitation Plan

Deliverable D6.3

APACHE

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Dissemination level

This document is PUBLIC.

APACHE

ASSESSMENT OF PERFORMANCE IN CURRENT ATM OPERATIONS AND OF NEW CONCEPTS OF OPERATIONS FOR ITS HOLISTIC ENHANCEMENT

Abstract

This document is the Exploitation Plan of the APACHE project. Its purpose is to identify, describe and assesses the different exploitable results and foreground generated by the project.

The APACHE project proposes a new framework to assess European ATM (air traffic management) performance based on simulation, optimization and performance assessment tools that will be able to capture the complex interdependencies between KPAs at different modelling scales. In this context, a new platform (the APACHE Framework) has been developed in the project, which is the result of the integration (and enhancement) of different existing tools previously developed by some of the APACHE consortium members.

The importance of this report resides in the description of the exploitation of the project results, as they are the basis for future research. Each partner has provided its own exploitation intentions identifying exploitable services and all the exploitable results of the project, which are foreseen to be further developed in the future. Also, each partner has identified the research challenges from lessons learnt to take into account for their own research activities and services.

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1 Introduction

The APACHE Project covers the topic ER-11-2015 – ATM Performance within the area of ATM Operations, Architecture, Performance and Validation and proposes a new approach based on simulation, optimization and performance assessment tools, which aims to better capture performance in air traffic management (ATM), as well as the complex interdependencies and eventual trade-offs among different key Performance Areas (KPA).

1.1 Purpose, context and scope of the document

This Deliverable *D6.3 – Exploitation Plan*, as part of the work package (WP) 6: *WP6 – Dissemination, communication and exploitation*, and in particular *WP6.3 – Exploitation plan*, aims to identify, describe and assess the different exploitable results and foreground generated by the project (see Figure 1-1).
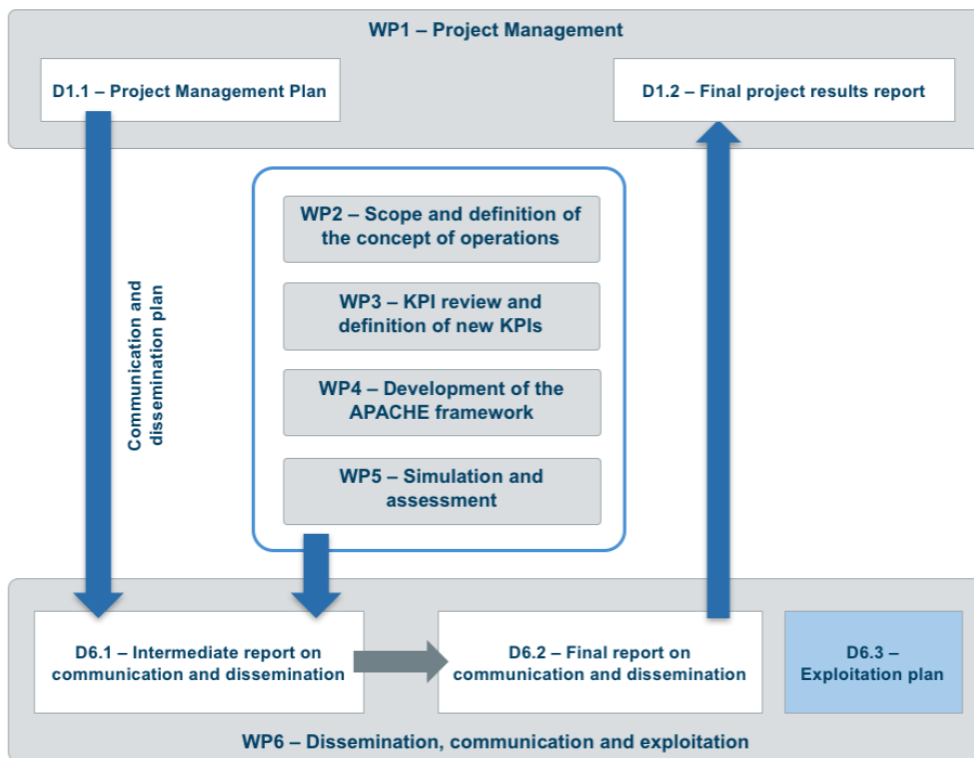

Figure 1-1. Context of deliverable D6.3

The exploitable information presented in this document has been obtained directly from each partner of the APACHE consortium, and reflects their main interests for further exploitation activities e.g. industrial or technological research activities; for developing new concepts or refining existing ones.

Moreover, joint exploitation activities have also been identified involving two or more APACHE consortium partners.

1.2 The APACHE Framework

The APACHE project revolves around a novel Performance Framework that is expected to compute advanced performance indicators (PIs) in a wide range of key performance areas (KPAs) aiming at bridging some gaps in state-of-the-art methodologies for ATM performance assessment. In this context, a prototype of an ATM simulator has been developed within the Project activities, which has had a double functionality:

- To support the implementation of novel (or enhanced) PIs, which require from some advanced functionalities (such as optimal fuel trajectories considering real weather conditions, optimal airspace opening schemes, large-scale conflict detection, etc.).

- To synthesize traffic and airspace scenarios representative enough of current operations; or emulating future operational concepts in line with the SESAR 2020 ConOps (i.e. one or more SESAR solutions enabled).

This simulator is able to generate optimal trajectories, considering the business models of the airspace users; optimal airspace configurations, considering air navigation service providers (ANSP) needs and constraints; and integrating both of them into an advanced air traffic flow management (ATFM) scheme. Furthermore, this enabling System can be configured to reproduce different modes of operation, representative of current ATM, or simulating (with certain limitations) the influence of future operational concepts. Hence, the global APACHE Framework can be considered as the foreground of the APACHE Project. Figure 1-2 below shows the overall concept of the whole APACHE Framework while more details can be found in APACHE Project deliverable D4.1 (APACHE Consortium, 2018).
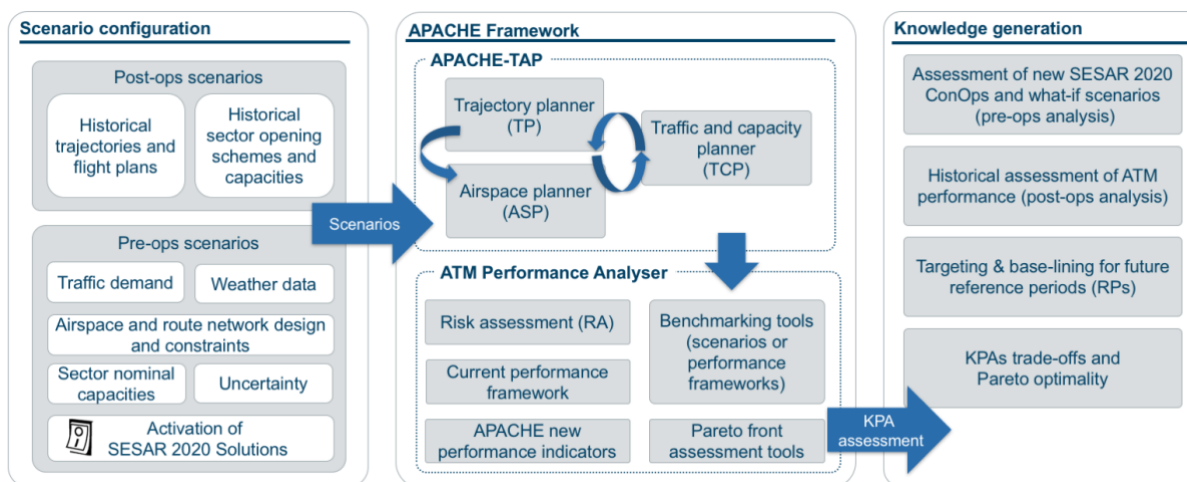

Figure 1-2. Context of the APACHE Framework within the APACHE Project

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1.3 Document structure

The document is structured as follows:

- **Section 1:** Introductory section that outlines the context and purpose of this deliverable, containing also a glossary of terms.
- **Section 2:** Presents the General exploitation objectives of the project, together with the exploitation plan as envisaged by each of the project partners and collaborators, as well as a joint exploitation plan.

1.4 Glossary

Term	Explanation
ACC	Area Control Centre
ALG	Advanced Logistics Group
ANSP	Air Navigation Service Provider
APATC	Division of Airports and Air Traffic Safety of the UB-FTTE
ASP	Airspace Planner (APACHE system component)
ATC	Air Traffic Control
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
AU	Airspace User
BADA	Base of Aircraft Data
CANSO	Civil Air Navigation Services Organization
ConOps	Concept of Operations
DAC	Dynamic Airspace Configuration
DCB	Demand and Capacity Balance
ECAC	European Civil Aviation Conference
ENAC	École Nationale de l'Aviation Civile
ER	Exploratory Research
FAB	Functional Airspace Block
FCA	Flight Centric ATC
FIR	Flight Information Region
FMS	Flight Management System
FP7	7th Framework Programme for Research and Technological Development
HPC	High-Performance Computing
ICAO	International Civil Aviation Organization
ICARUS	Intelligent Communications and Avionics for Robust Unmanned Aircraft – UPC Research Group

Term	Explanation
IPR	Intellectual Property Rights
KPA	Key Performance Area
KPI	Key Performance Indicator
PA	Performance Analyser (APACHE system component)
PBO	Performance Based Operations
PI	Performance Indicator
PRU	Performance Review Unit
R&I	Research & Innovation
RA	Risk Assessment (APACHE system component)
RPAS	Remotely Piloted Aircraft System
SES	Single European Sky
SESAR	Single European Sky ATM Research
SINA	Département Sciences et Ingénierie de la Navigation Aérienne
SJU	SESAR Joint Undertaking
TAP	Trajectory and airspace planner module (main component of the APACHE system)
TBO	Trajectory Based Operations
TCAS	Traffic alert and Collision Avoidance System
TCP	Traffic and Capacity Planner (APACHE system component)
TP	Trajectory Planner (APACHE system component)
TRL	Technology Readiness Level
UB-FTTE	University of Belgrade - Faculty of Transport and Traffic Engineering
UPC	Technical University of Catalonia (Universitat Politècnica de Catalunya)
WP	Work Package

Table 1-1. Glossary

2 Exploitation plan for APACHE

The APACHE Project has proven the usefulness of advanced simulation and optimisation tools to improve or define new performance indicators overcoming some of the current limitations in performance assessment and allowing assessment of interdependencies between different key performance area (KPA) and/or SESAR solutions.

General Exploitation objectives are to present the usability and applicability of the project and its results and outputs, including how each of the APACHE Consortium partners will materialise them into specific exploitation activities.

This Exploitation Plan aims to program the exploitation of project results and pave the way for this research to advance to the next step of the R&I pipeline.

The document sets out the plan for the use and exploitation of this knowledge by each project partner and will specify the major operational, technical and regulatory activities to be performed and their sequence in time, as well as the strategies to be undertaken by the different stakeholders to maximise the benefits achievable from the implementation of the project results. Besides joint exploitation activities, each partner has also identified research challenges, exploitable services and exploitable results of the project, which are foreseen to be further developed in the future.

2.1 Exploitation plan for UPC

2.1.1 Company

The *Universitat Politècnica de Catalunya* (UPC) (http://www.upc.edu), or Technical University of Catalonia, is a university with a consolidated worldwide reputation and an international vision that generates technological innovation and attracts talent. It is also the Spanish university with more strategic research projects funded by the European Union's Programme (FP7).

In APACHE, the ICARUS research group, as part of the UPC, is involved. ICARUS is a multidisciplinary research group focused in two big research areas: the automation and the integration of remotely piloted aerial systems (RPAS) into non-segregated airspace; and the improvement of air transportation efficiency, while reducing its environmental impact, focusing on optimisation strategies for aircraft operations and ATM processes.

2.1.2 Involvement in the APACHE project

UPC is the Coordinator of the APACHE project, with personnel with wide experience using robust Project management procedures and applying them to international research initiatives.

On the technical part, UPC has been one of the main contributors to the development of the APACHE Framework (see figure 1-2) and has lead the design and specification of this Framework. UPC has been in charge of generating (optimal) aircraft trajectories, as part of the Traffic Planner (TP) module; to develop a demand and capacity balance (DCB) algorithm following current practices, but also developing an advanced DCB tool, as part of the Traffic and Capacity Planner (TCP) module; and to jointly develop, together with UB-FTTE, the Performance Analyser module.

The airspace user (AU) planning capabilities used in this Project come from years on developing a trajectory optimisation/prediction tool (brought as background by UPC in the APACHE Project) able to generate trajectories taking into consideration a wide and comprehensive set of operational/ATM constraints and different AU business models.

In addition, UPC has contributed to the definition of new (or enhanced) performance indicators (PIs) that take advantage of this capability to generate different trajectory baselines. Namely, their contribution was mainly focused in the Environment, AU Cost-efficiency and Equity KPAs. They have lead the simulations done with the APACHE Framework during the validation activities of the project and finally, led the dissemination, communication and exploitation activities of the Project, with the support of all the Consortium partners.

2.1.3 Exploitation objectives

The Trajectory Planner (TP) component of the APACHE System could be further enhanced and used beyond the life of the APACHE project as integral part of the APACHE performance Framework and/or as a stand-alone tool. The usage of the TP as integral part of APACHE System is discussed in Section 2.5, as a joint Exploitation opportunity with the other partners of the APACHE Consortium.

As stand-alone tool, the TP component could be used to provide optimal trajectories in a service-oriented architecture to support the computation of advanced environment or AU cost-efficiency performance indicators, either for pre-ops or for post-ops analysis. Moreover, the TP could also be configured to synthesise realistic traffic (in different concepts of operations) to generate scenarios for *what-if* or different kinds of validation assessments. In APACHE, the TP has been developed using a high-performance computing (HPC) modular architecture, enabling the possibility to compute large sets of trajectories in a reasonable amount of time.

The TP component could also be exploited for other purposes beyond ATM performance. It could be used, for instance, to support AUs flight planning processes, or to enhance the trajectory predictors embedded in state-of-the-art flight management systems (FMS).

Regarding the TCP component, the development performed in APACHE opens the door to UPC to further research in advanced DCB algorithms and strategies. The maturity level of the TCP component is low, so the exploitation of this component is foreseen at research level. This could be, for instance, the topic for new PhD researchers or the focus of a new SESAR exploratory research (ER) project in the field of Network Management.

The environmental, AU cost-efficiency and equity indicators developed in APACHE only require the TP module, which provides the optimal trajectory baselines needed to compute these indicators. The maturity level of these indicators is high and could eventually be considered for inclusion in new releases of the SESAR2020 Performance Framework or in the SES Performance Scheme. Moreover, these could be provided in a service-oriented approach providing a centralised PI computation services

that could be used by other research institutions or by the different SESAR solutions in their validation exercises (avoiding them to develop their own and individual PIs and also preventing from divergences in these implementations).

Finally, although is not the main activity at UPC, consultancy services are also provided by UPC researchers. APACHE brought a very detailed knowledge, on one hand, of SESAR2020 innovative concepts such as TBO and PBO (Trajectory Based Operations and Performance Based Operations); and, on the other hand, of the room for improvement in the current ATM performance framework and the complex interdependences existing among the different KPAs. This knowledge will add to the experience that UPC is able to provide to its consultancy clients.

2.1.4 Exploitation plan and future activities

Exploitable results	Optimal trajectories in a service-oriented architecture
Future activities	• Provision of trajectories to enable the computation of advanced environmental, AU cost-efficiency or equity performance indicators • Provision of large sets of trajectories to recreate realistic scenarios for ATM assessment, validation activities or research purposes.
Sector(s) of application	• SESAR Solutions, SES PRU. • ANSPs • Other SESAR ER projects. • Research institutions
Timetable for use	Short-term
Potential barriers	Additional funding required to develop the web-service front-end (back-end already developed within the framework of APACHE). Agreement needed with Eurocontrol to extend the BADA 4.x license (needed to compute trajectories). IPRs are not an issue, since trajectories are provided as web-service and UPC background/foreground is not disclosed.

Table 2-1. UPC exploitation activity #1

Exploitable results	Trajectory optimisation/planning for Airspace Users and aeronautics industry
Future activities	• Enhancement of state-of-the-art trajectory planning tools at dispatch level. • Enhancement of state-of-the-art trajectory predictors embedded in FMS or provided in electronic flight books.
Sector(s) of application	• Airspace Users • Industrial sector commercialising trajectory planning tools either for dispatch or for tactical trajectory computation. • Aircraft manufacturers and suppliers.
Timetable for use	Medium to long term, depending on the sector of application
Potential barriers	Additional funding required to higher the TRL of the current algorithms. Certification aspects for on-board applications.

Table 2-2. UPC exploitation activity #2

Exploitable results	Algorithm for advanced demand and capacity balance
Future activities	• Academic research (Master or PhD thesis, for instance). • Embryo for the topic of a future SESAR Exploratory Research project in the area of the Network Manager.

Sector(s) of application	• Academia • Network Manager • Airspace Users
Timetable for use	Long-term
Potential barriers	Additional funding to continue this incipient research. Availability of detailed information regarding AUs preferences. Computational issues (need to devote research to improve the efficiency of the algorithms).

Table 2-3. UPC exploitation activity #3

Exploitable results	New and refined performance indicators in the KPAs of environment, AU cost-efficiency and equity.
Future activities	UPC is contributing in a "white paper" on the vision of the future performance research in SESAR, led by SESAR PJ19.04 and with the collaboration of the Coordinators of all ER-1 projects in ATM performance (APACHE, AURORA and INTUIT) and ALG. The most relevant results of the three projects are summarised and their potential applicability is identified. This "white paper" is addressed to the SESAR Scientific Committee to take the upmost advantage of the work done so far within the ER projects and proposes different activities to evolve current Performance Framework and highlights existing opportunities to up-take ER results to industrial research.
Sector(s) of application	• Air Traffic Management performance framework • SES PRU
Timetable for use	Short-time
Potential barriers	As SESAR performance framework is used by multiple and diverse projects, the new performance indicators should be relevant and applicable to all of them. The PJ19.4 defines the performance framework and ensures the performance indicators it includes can be measured by all projects and do not require specific tools to be measured. In addition, SESAR has a strategic and political component, which hinders the iterative changes in the performance framework. In projects of such magnitude as SESAR, often changes are not recommended in order to avoid confusions and to ensure all members always apply the correct reference material.

Table 2-4. UPC exploitation activity #4

Exploitable results	Performance Indicators in a service-oriented architecture
Future activities	• Provision of PIs in a web-based service oriented architecture (environment, AU cost-efficiency and equity indicators).
Sector(s) of application	• SESAR Solutions, SES PRU. • ANSPs • Other SESAR ER projects. • Research institutions
Timetable for use	Short-term
Potential barriers	Additional funding required to develop the web-service front-end (back-end already developed within the framework of APACHE). Agreement needed with Eurocontrol to extend the BADA 4.x license (needed to compute trajectories for certain PIs). IPRs are not an issue, since PIs are provided as web-service and UPC background/foreground is not disclosed.

Table 2-5. UPC exploitation activity #5

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Exploitable results	Increased knowledge and expertise on ATM performance.
Future activities	Consulting activities, participation in exert groups. Support to SESAR performance framework.
Sector(s) of application	ATM performance research and consultancy services ANSP consultancy services Performance Frameworks (SES, SESAR2020, CANSO, etc.) Other SESAR ER projects
Timetable for use	Short-time
Potential barriers	No relevant issues have been identified for this exploitation activity

Table 2-6. UPC exploitation activity #6

2.2 Exploitation Plan for ALG

2.2.1 Company

Advanced Logistics Group (ALG) (http://www.alg-global.com/) is an international consulting specialised in transportation and logistics, part of the IBC-Indra Group. ALG has extensive experience in aviation, particularly in ATM operations, having worked with regulators, airlines, ANSPs, and airports. ALG team has been involved since the beginning of SESAR Programme. Within SESAR1 mainstream programme ALG participated in more than 30 projects, mainly in WP6 (Airport Operations) and WP12 (Airport Systems), but also in transversal projects such as C.3 (Standardisation and Regulatory Roadmaps), 16.06.06 (Cost Benefit Analysis and Business Case) and B4.2 (Concept of operations). Currently, ALG is involved in SESAR2020 transversal projects PJ19 Content Integration, where ALG is involved in WP2 (maintenance of CONOPS and related architectural elements) and in WP4 in the development of performance assessment methodologies and tools; PJ20 Master Planning, in which ALG is involved in the Master Plan Level 2 maintenance and update and in the development of Cost benefit Analysis; and PJ22 Validation and Demonstration Engineering contributing to the requirements management for V&V platforms.

2.2.2 Involvement in the APACHE project

As the APACHE project is encompassed within the SESAR 2020 framework, ALG has ensured the direct link and proper alignment with the SESAR programme, including the jargon and related documentation thanks to its involvement in SESAR Programme since its beginning.

Under the APACHE project, ALG has been involved in the definition of concept of operations implemented in the ATM simulator of the APACHE Framework, providing support in identifying the link with the SESAR Solutions, whose concepts have been addressed by APACHE. ALG's main contribution to the project has consisted in the definition of the performance framework and the analysis of the performance assessment. Based on its expertise in ATM performance, ALG has contributed to the analysis of the existing European performance frameworks, the definition of new and refined performance indicators and to the performance assessment of the results obtained through the APACHE System simulations. In addition, ALG has contributed to the definition of the simulation scenarios to reflect the new concepts' benefits. In parallel to all these activities, ALG has contributed to the dissemination activities and led the definition and production of this exploitation plan.

2.2.3 Exploitation results and objectives

ALG as consulting company has as main asset its human expertise. To that aim, APACHE brought a very detailed knowledge, on one hand, of SESAR2020 innovative concepts such as TBO and PBO; and, on the other hand, of the room for improvement in the current ATM performance framework and the complex interdependences existing among the different KPAs. This knowledge will add to the experience that ALG is able to provide to its clients, being able to further develop similar performance assessments developed under the framework of this project. Moreover, the development of the performance framework and analysis including new and enhanced performance indicators developed under the project has demonstrated the solid capacity of ALG in this field and further expanded the methodology applied to carry out this type of tasks and assessments.

As ALG has active presence in SESAR2020 transversal projects, both PJ19 and PJ20, it will ensure the ATM performance related results of the APACHE project will be reflected in the performance related tasks. APACHE's results might useful in the validation targets definition as they provide an indication of the achievable benefits through the implementation of new concepts in terms of TBO and PBO, in the performance framework as well as in the performance assessment.

In addition to that, the active participation in the dissemination activities has provided ALG with a very wide view of the current research initiatives as well of the industry trend in the ATM operational and strategic field.

2.2.4 Exploitation plan and future activities

Exploitable results	Increased knowledge of ATM performance framework definition and assessment
Future activities	Further detail on performance indicators and the interdependencies among them
Sector(s) of application	Air Traffic Management performance research and consultancy services Air Navigations Service Provider consultancy services
Timetable for use	Short-time
Potential barriers	No relevant issues have been identified for this exploitation activity

Table 2-7. ALG exploitation activity #1

Exploitable results	New and refined performance indicators
Future activities	ALG is contributing in a "white paper" on the vision of the future performance research in SESAR, led by SESAR PJ19.04 and with the collaboration of the Coordinators of all ER-1 projects in ATM performance (APACHE, AURORA and INTUIT). The most relevant results of the three projects are summarised and their potential applicability is identified. This "white paper" is addressed to the SESAR Scientific Committee to take the upmost advantage of the work done so far within the ER projects and proposes different activities to evolve current Performance Framework and highlights existing opportunities to up-take ER results to industrial research. As part of SESAR2020 transversal projects members, ALG will ensure these results are considered and reflected in the PJ19 and PJ20 activities.
Sector(s) of application	Air Traffic Management performance framework
Timetable for use	Short-time

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Potential barriers	As SESAR performance framework is used by multiple and diverse projects, the new performance indicators should be relevant and applicable to all of them. The PJ19.4 defines the performance framework and ensures the performance indicators it includes can be measured by all projects and do not require specific tools to be measured. In addition, SESAR has a strategic and political component, which hinders the iterative changes in the performance framework. In projects of such magnitude as SESAR, often changes are not recommended in order to avoid confusions and to ensure all members always apply the correct reference material.

Table 2-8. ALG exploitation activity #2

2.3 Exploitation Plan for UB-FTTE

2.3.1 Company

The Univerzitet u Beogradu – Saobracajni Fakultet or University of Belgrade – Faculty of Transport and Traffic Engineering (UB-FTTE) (http://www.bg.ac.rs/en/), has an experience of 58 years of dealing with various issues in the field of air transport and traffic, both in academic work and as consultants. The core research activity of the Division of Airports and Air Traffic Safety (APATC) is system and operations modelling in: airport operations, airspace management, traffic flow management, traffic complexity, risk and safety analysis, and airline operations.

APATC has become a centre of academic and professional activities, including conferences, workshops, summer schools, seminars, etc., covering different topics, such as: transport economics, volcanic ash crisis, automation in air transport system, safety assessment and risk analysis, etc.

2.3.2 Involvement in the APACHE project

UB-FTTE has led the review of the state of the art in ATM performance assessment and the activities focused with the definition of new (or enhanced) PIs. Jointly with UPC, has developed the Performance Analyser component of the APACHE Framework and has been responsible for developing the safety risk assessment module (see Figure 1-2). UB-FTTE has not only wide knowledge of the current ATM Performance framework but is particularly focused on safety risk assessment, which has been used in the performance indicators definition and assessment under the scope of this project. UB-FTTE leads the benchmarking of case studies and performance schemes done in the validation exercises of the Project and was responsible for all activities related with stakeholder consultation and organisation of workshops with experts.

The safety and risk assessment capabilities used in this Project come from many years on developing of framework for airspace planning and design based on conflict risk assessment (brought as background by UB-FTTE in the APACHE Project) able to calculate safety risks in a given airspace and for a given traffic.

2.3.3 Exploitation objectives

2.3.3.1 Risk Assessment module

Risk Assessment module developed under APACHE is meant to be further used twofold: a) for research purposes, and b) for practical (consulting) applications.

a) Related to research purpose, an enhancement of developed model is foreseen in following areas:

- **Validation** of developed RA module using the real-life traffic data as inputs and comparing the RA outputs (TCAS events discovered) with real-life TCAS events for certain country. Current experience is that countries are rarely willing to share those data. Only validated model can be used for model accreditation (official certification that a model is acceptable for use for a specific purpose).
- **Replacing** TCAS v7.0 with TCAS v7.1 algorithms and also to perform its validation.
- **Enabling** RA module to perform stochastic simulation of flights using different random variables, such as e.g. departure time, sector entry time, cruising speed, etc. Enabling different input data (other than APACHE), RA module can become useful standalone tool.
- **Investigating** further possibilities for speeding up search for the conflicts and calculation of safety PIs, e.g. using different optimization/heuristic algorithms, using parallel processing, etc.

All mentioned enhancements are expected to enable usage of RA module for further research projects related to Pre-OPS safety performance assessment and prediction of safety occurrences (events) at network level or level of certain airspace (e.g. FIRs, FABs) as well as projects related to assessment of safety benefits of certain changes in the ATM system.

b) Related to practical (consulting) applications further enhancements are expected relative to Post-OPS safety performance assessment. In this sense, above mentioned enhancements related to validation of RA module, replacement of TCAS algorithms and development of standalone RA application are beneficial but are also necessary to enable RA module to use real-life radar tracks or coordinated position reports of realized flight trajectories.

Such enhancements will enable Post-OPS safety performance assessment at network level or level of certain airspace.

Some interests in such applications are already expressed from certain European stakeholders (informal talks during the SESAR innovation days 2016 and 2017).

2.3.3.2   Performance Analyser

Performance Analyzer (PA) is part of the APACHE System which should serve to analyze the outputs of different system components and calculate performance indicators.

A possible enhancement of PA could be the visualization module for producing interactive and non-interactive plots, charts, maps etc. Some enhancements in the area of automation of certain tasks and processes are also foreseen but further use is restricted to the interaction with other APACHE System components.

2.3.4 Exploitation plan and future activities

Exploitable results	Safety Risk Assessment module
Future activities	• Validation of developed RA module using the real-life traffic data as inputs and comparing the RA outputs (TCAS events discovered) with real-life TCAS events for certain country. Only validated models can be used for model accreditation (official certification that a model is acceptable for use for a specific purpose).

	• Replacing TCAS v7.0 with TCAS v7.1 algorithms and also to perform its validation.
Sector(s) of application	ATM safety related projects Air Navigation Service Providers safety monitoring
Timetable for use	Short-time
Potential barriers	Availability of real TCAS events data. Additional funding required to continue this research.

Table 2-9. UB-FTTE exploitation activity #1

Exploitable results	Safety Risk Assessment module
Future activities	Enabling RA module to perform stochastic simulation of flights using different random variables, such as e.g. departure time, sector entry time, cruising speed, etc. Enabling different input data (other than APACHE), RA module can become useful standalone tool.
Sector(s) of application	ATM safety related projects
Timetable for use	Long-time
Potential barriers	Additional funding required to continue this research.

Table 2-10. UB-FTTE exploitation activity #2

Exploitable results	Safety Risk Assessment module
Future activities	Investigating further possibilities for speeding up search for the conflicts and calculation of safety PIs, e.g. using different optimization/heuristic algorithms, using parallel processing, etc.
Sector(s) of application	ATM safety related projects
Timetable for use	Long-time
Potential barriers	Additional funding required to higher the TRL of the current algorithms.

Table 2-11. UB-FTTE exploitation activity #3

Exploitable results	Safety indicators and post-ops safety performance assessment
Future activities	Practical (consulting) applications a further enhancement relative to post-ops safety performance assessment.
Sector(s) of application	ATM safety related projects Air Navigation Service Providers safety monitoring
Timetable for use	Short-time
Potential barriers	Availability of real traffic data for safety assessment (e.g. radar tracks).

Table 2-12. UB-FTTE exploitation activity #4

Exploitable results	The Performance Analyzer (PA)
Future activities	Enhancement of PA for the visualization module for producing interactive and non-interactive plots, charts, maps etc. Some enhancements in the area of automation of certain tasks and processes are also foreseen.
Sector(s) of application	ATM performance related projects Air Navigation Service Provide performance monitoring
Timetable for use	Long-time
Potential barriers	Further use of the results could be restricted to the interaction with other APACHE system components.

Table 2-13. UB-FTTE exploitation activity #5

2.4 Explotation Plan for ENAC

2.4.1 Company

The École Nationale de l'Aviation Civile (ENAC) (http://www.enac.fr/) or Civil Aviation National School is a genuine university whose mission is to provide ab-initio and further, training courses and international training for the executives and main players of the civil aviation world. ENAC offers a favourable environment for research activities where on the same campus Pilots, Controllers, Engineers and Researchers, experts in various academicals disciplines, are gathered. All of ENAC's competence fields have a single common denominator: aeronautical applications.

ENAC Research is organised in academic teams and a set of cross domain programs to develop applied research. The OPTIM team, as a part of the Research laboratory, was involved in the APACHE project. The core research activity of SINA/OPTIM (Dynamical systems and combinatorial and continuous optimization - maiaa.recherche.enac.fr) includes application of the methods from the field of mathematics, computer science and automatics on ATM and Air Transport in general.

2.4.2 Involvement in the APACHE project

ENAC has wide experience in airspace organization and management mainly focusing on optimising the airspace sectors and configurations. Based on its airspace planning capabilities (capacity and sectorisation), ENAC has been responsible for the development of the Airspace Planner (ASP) module being a part of the APACHE Framework (see Figure 1-2), and has contributed in the definition of novel (or enhanced) PIs, mainly focusing in the capacity, ANSP and passenger-centric cost-efficiency and predictability KPA, having a key role also in the integration activities of the APACHE Framework and during the simulations and assessment of results.

The airspace planning capabilities used in this Project come from many years on developing a CONF optimizer tool (brought as background by ENAC in the APACHE Project) able to provide optimal sector opening scheme in the given ACC taking into account sector capacity, number of available controllers and wide range of operational constraints.

2.4.3 Exploitation objectives

The Airspace Planner (ASP module), developed as a part of the APACHE Framework for the Performance assessments of the ATM system, could be further used beyond the life of the APACHE project as integral part of the APACHE performance framework and/or as stand-alone tool.

The use of the ASP module as integral part of APACHE Framework is considered as a main exploitation opportunity of ASP module. Different tool for airspace sectorisation already existed before APACHE project, as for any module of the APACHE Framework, but what did not exist before is a platform that integrates all the modules into the single system being able to reproduce decision making process of the ATM system.

Multiple research opportunities of an integral tool are discussed in Section 2.5, among further assessment of the SESAR 2020 solutions. This however requires additional research on integration of the DAC in the APACHE System. Different measurements of sector load and capacity between ASP module in the DAC and TCP represented a limitation for the full integration of the DAC in the APACHE

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workflow. This will require further investigation, that could be part of new exploratory research project where interdependency of the Capacity management and Demand managements will be studied.

APACHE results exploitation in the terms of industrial project, as explained in Section 2.5, requires further development of the APACHE modules, where modules would be integrated in the more collaborative manner. ASP module should be further linked with TP and TCP modules in the fully collaborative decision making process, where through an iterative process, airspace capacity and demand would be managed concurrently. Furthermore, as a part of the long-term search, different SESAR solution dealing with airspace management could be studied, in particular Flight centric ATC (FCA).

All this future research opportunities are tangible and requires a small investment compared to the work already done in the APACHE project.

ASP module could be also exploited as a stand-alone tool in different industrial and operational projects. The resulting optimal opening scheme that minimizes number of active sectors could be used: for dimensioning operation rooms in the Area Control Centres based on the forecasted traffic increase in the coming years, for planning of the controller shifts based on the maximal demand during a day, as well for planning of the actual opening schemes at pre-tactical level. For latest purpose, further development of the ASP module is needed, where different tactical and ad-hoc FMP decision would be modelled and taken into account by the optimization algorithm.

2.4.4 Exploitation plan and future activities

Exploitable results	Airspace Planner module as integral part of APACHE Framework
Future activities	The definition of a platform that integrates all the modules into a single system being able to reproduce decision making process of the ATM system. ASP module will be further linked with TP and TCP modules in the fully collaborative decision making process, where airspace capacity and demand would be managed concurrently. Study of different SESAR solution dealing with airspace management: DAC, FCA, etc.
Sector(s) of application	ATM research, ATM performance research ATM and ANSP industrial and operational projects ANSP capacity planning and monitoring
Timetable for use	Long-time
Potential barriers	Insufficient financing and effort available from the different APACHE project members as it requires further development of all the APACHE modules, where modules would be integrated in the more collaborative manner.

Table 2-14. ENAC exploitation activity #1

Exploitable results	Airspace Planner module as integral part of APACHE System
Future activities	Integration of the DAC in the APACHE System for further assessment of SESAR 2020 solutions. The limitation for the full integration of the DAC in the APACHE workflow is the different measure of sector load and capacity between ASP module in the DAC and TCP. This will be further investigated to be solved.
Sector(s) of application	ATM research, ATM and ANSP industrial and operational projects ANSP capacity planning and monitoring
Timetable for use	Short-time

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Potential barriers	The inadequate or insufficient financing could hinder the further development of the ASP module.

Table 2-15. ENAC exploitation activity #2

Exploitable results	Airspace Planner as individual module
Future activities	ASP module exploited as a stand-alone tool to use the resulting optimal opening scheme that minimizes number of active sectors for: • Dimensioning operation rooms in the Area Control Centres based on the forecasted traffic increase in the coming years • Planning of the controller shifts based on the maximal demand during a day • Planning of the actual opening schemes at pre-tactical level.
Sector(s) of application	ATM and ANSP industrial and operational projects ANSP capacity planning and monitoring
Timetable for use	Long-time
Potential barriers	Availability of detailed information for the airspace structure and design. The difficulty of simulating the human component in ATC can lead to over dimensioning opening schemes or to reduced airspace capacity.

Table 2-16. ENAC exploitation activity #3

2.5 Joint exploitation plan

As mentioned throughout the present document, the APACHE framework enables proactive and predictive analysis of the current and future overall ATM system, as a first step towards Performance Based Operations. The project has proven the **usefulness of advanced simulation and optimisation tools to improve or define new performance indicators** and **allowing the assessment of interdependencies between different KPAs and/or SESAR solutions.** This is only possible if the **whole APACHE Framework is used.** Thus, some joint exploitation activities are presented here, involving all APACHE consortium members.

The benefits that the APACHE System could bring to the SESAR community could be materialised through the **simulation capabilities** demonstrated under the project. APACHE framework is a step forward in simulating new concepts, which could be used for validation activities for new SESAR solutions being able to quantify benefits and assess different environments. On one hand, this could support V1 and/or V2 validation activities, before building more advanced prototypes; and on the other could support the validation targets definition as it could identify the maximum benefit a new concept (or several) could bring.

Moreover, based on the experience gained so far, there is a possibility to develop a standalone PA application that will be independent from APACHE System. Such an application would have a potential to be used in different research projects related to ATM performance assessment.

Regarding the PIs proposed in APACHE, some still require **further (short-term) research** to refine certain models, to gather the appropriate input data or to envisage alternatives to avoid requiring confidential or proprietary data. Examples of this category of indicators are some flexibility indicators; ANSP cost-efficiency indicators; and certain environment and AU cost-efficiency indicators for post-ops assessment.

Moreover, the APACHE project also identified some indicators that would require **long-term research** and were just mentioned, but not implemented in the APACHE Framework prototype. These include

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indicators requiring complex or very specific models (global warming models, for instance) and indicators requiring a deeper understanding of certain stakeholders' behaviour or a complex set of input data (to derive, for instance passenger-centric metrics), see (APACHE Consortium, 2017).

Exploitable results	APACHE System simulation capabilities
Future activities	APACHE framework and its capabilities will be also included in the "white paper" mentioned above, which could be considered for the next wave of Industrial Research projects. APACHE framework provides a new method for validation purposes by simulating the new concepts and measuring the potential benefits they could provide. On one hand, this could support V1 and/or V2 validation activities, before going to building more advanced prototypes; and on the other could support the validation targets definition as it could identify the maximum benefit a new concept (or several) could bring.
Exploitable product(s) or measure(s)	APACHE System
Sector(s) of application	SESAR2020 Industrial Research projects Other SESAR ER projects
Timetable for use	Long-time
Potential barriers	APACHE System is modular and requires effort and involvement of several members. The APACHE Project has been a very step towards a potential integrated module or interface that would allow having access to each one of the tools remotely and being able of obtaining the desired simulations. This indicates the need for further research, under one or several Wave2 - SESAR2020 solutions.

Table 2-17. Joint exploitation activity #1

Exploitable results	The Performance Analyzer (PA)
Future activities	Development of a standalone PA application that might be independent from the other tools within the APACHE System. Inclusion of new performance indicators.
Sector(s) of application	ATM performance related projects Air Navigation Service Providers performance monitoring
Timetable for use	Long-time
Potential barriers	Lack of data at the level of detail required by the module.

Table 2-18. Joint exploitation activity #2

3 References

APACHE Consortium. 2017 (Oct). Review of current KPIs and proposal for new ones. Technical report (Deliverable D3.1). Version 01.01.00.

APACHE Consortium, 2018 (May). Report on the availability of the APACHE framework. Technical report (Deliverable D4.1). Version 00.01.00.

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