Concept, Scenarios and Validation Plan

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PACAS

PARTICIPATORY ARCHITECTURAL CHANGE MANAGEMENT IN ATM SYSTEMS

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Abstract

PACAS WP5, the validation package, is a transversal work package aimed at validating all the steps (or “Activities”) of the project and to guide, support and integrate the results of all the Validation Workshops of PACAS. The objectives of this work package range from the definition of the concept to the analysis and validation of the outputs of all the phases of the project. This deliverable defines the high-level PACAS concept, the overall approach to validation, including planned Workshops and their corresponding objectives, the evaluation criteria and indicators. Furthermore, it deals with the process that leads to the identification of a suitable Advisory Board (AB) of stakeholders for the project and the design phases to build the reference validation use case and scenarios. Finally, this deliverable describes the plan for the end-to-end inclusion of the AB in the validation process.
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Executive summary

The PACAS project aims at introducing a participatory design process to deal with changes in Air Traffic Management (ATM) systems. The process will be supported by a proof-of-concept tool (or "platform") that aims to tackle the complexity and deal with the high non-linearity of the changes and their propagation within the ATM domain, exploiting the use of game elements and that of automated reasoning techniques.

The validation of the PACAS project will mainly investigate the added value of managing ATM changes in a participatory way, also assisted by a tool (platform), built together with the end-users, which will guide and keep track of the decision process. The validation process will be two sided, focusing both on the process and the platform, making use of a tailored use-case declined in ad-hoc scenarios. Furthermore, as it will be fully explained in the next sections, the end-to-end inclusion of the Advisory Board (AB) into the PACAS iterative validation process will ensure a continuous confirmation and consolidation of the process and platform at each step of the project.

The objective of this document is to provide a detailed description of the PACAS concept, to explain the validation subjects, objectives and criteria (i.e., what is to be validated in PACAS, what do we want to test, and how we plan to test it) and to provide the schedule for the Validation Workshops and their content. Finally, starting from the results of the first Validation Workshop (also called Workshop #1 or WS1), the last part of this document is dedicated to the description of the Validation Use Case and Scenario, which will be used to test the output of the research project.
1 Introduction

1.1 PACAS Overview

ATM systems are complex systems-of-systems that are managed via a layered architectural model, which includes operational, organisational, and technical layers to ease handling complexity. Due to strong interdependencies in an ATM system, any change introduced in any of these layers might trigger changes both within the same layer and in the other layers. Understanding all possible consequences of a design decision in ATM systems is a challenge due to the complexity of these systems and the existence of tight interdependencies within the ATM architecture. A careful consideration of possible changes together with their implications on the entire ATM system is crucial to support decision-making, while making sure that the ATM system does not suffer from any issues with respect to functionality, safety, security, performance, cost efficiency, or other desired characteristics of a well-functioning ATM system. PACAS is about supporting change management in ATM systems from an architectural point of view, relying on the end-to-end inclusion of ATM domain stakeholders through gamification. The project constructs a platform that facilitates understanding, modelling and analysis of changes in the ATM system at different layers of abstraction. The approach to finding optimal solutions is based on a novel participatory design process to handle change management. The process relies on the provision of multiple views (to accommodate the expertise of the various domain stakeholders), as well as the representation and analysis of multiple objectives, namely those related to economical, organizational, security, and safety concerns (Figure 1).

Figure 1: Multi-view multi-objective gamified participatory design process for ATM architectural change management
1.2 Relationship with other deliverables

This deliverable (Concept, Scenario and Validation plan) describes:

(i) the PACAS concept and how it has been detailed during the initial activities of the project;
(ii) the plan to validate it and the Validation Workshops so far;
(iii) the selected validation use case and scenarios built with the help of PACAS AB members.

The description of the initial validation Workshops (hereafter named WS0 and WS1 respectively) and that of their results are provided here in an extended version compared to the preliminary analysis that was included in the deliverables D2.1 and D3.1, resulting in the needs/requirements in large-scale systems design and modelling methodologies for the ATM domain. Yet the baseline for the validation of the PACAS concept will rely on the gap analysis and requirements elicitation for the decisional processes in ATM (D2.1), the gamification techniques (D2.2), as well as multi-objective reasoning mechanisms (D4.1), with a special focus on the needs stressed by the results contained thereby.

The purpose of this document is to describe in detail the PACAS validation methodology and its implementation, paving the way for exploitation and dissemination (see deliverables D6.2 and D6.1 respectively) by a careful description of all the validation Workshops planned for the whole project duration. Results of such validations will help tailoring the application of the PACAS process and tool as for Validation WS1, here described, which contributed to D2.2 First release of the platform and guidelines.

1.3 Structure of this document

This document is structured as follows:

- Section 1 is dedicated to the introductory aspects and contextualises this deliverable among the other deliverables of the project.
- Section 2 clarifies the PACAS concept as it was refined during the preliminary activities of the project and summarised in the elevator pitch. Moreover, it introduces how we plan to validate the concept.
- Section 3 focusses on the plan to accomplish the Validation Workshops, the strategy and the timeline of validation activities and workshops, as well as the limitations of the project.
- Section 4 aims at describing the use case evolution and final scenario developed for the validation of the project, redesigned as the result of the first validation activity to make it compliant with the PACAS scope and the SESAR framework.
- Section 5 provides some concluding remarks.
2 The PACAS concept

2.1 The concept evolution

PACAS (Participatory Architectural Change management in ATM Systems) is a Horizon 2020 project in the framework of the SESAR Research and Innovation Action (RIA). Started in March 2016, PACAS will last 24 months. PACAS aims at better understanding, modelling and analysing the propagation of changes at different layers of an Air Traffic Management (ATM) system. Moreover, it will actively support change management while capturing how architectural and design choices influence the overall ATM system. Finally, it will develop an innovative participatory change management process wherein heterogeneous stakeholders actively participate in the architectural evolution of the ATM system.

The novelty and expected impact of PACAS relies on three main pillars: 1. Impact propagation techniques, 2. Gamified platform, 3. Domain-specific modelling languages. These are the key components of the participatory design process together with the end-to-end inclusion of ATM domain stakeholders, each having a different view of the system depending on their expertise, namely economic, organizational, security and safety. PACAS will develop a platform that will play a crucial role in establishing and maintaining consistency among the different architectural layers and the different views of the system.

The elevator pitch

Before the start (Kick off Meeting) of the project it was asked to all the members of the PACAS Consortium to summarise what was the main focus of the project from their point of view, i.e., to sketch a personal elevator pitch. They were asked to reason about who they intended as the end-users of the PACAS concept, what they thought were the needs to be targeted by the project and the main feature of the project to address such needs.

As expected, all the partners where highlighting different aspects of the project, depending on their personal contribution. All these elevator pitches where discussed during the Kick off Meeting (KoM) and merged together to set and state a definitive shape of the project clearly. The final result of the merging and integrating process is reported below. As such the PACAS project is:

a) Useful for ATM stakeholders (target customer), who have to (re)design the ATM architecture to support change management for European ATM Systems Design (customer need);

b) PACAS is an automated change management platform (marketing category) that relies on the active involvement and collaboration of domain experts (one key benefit);
c) Unlike traditional enterprise architectures and change management processes (competition), PACAS relies on the active participation of ATM stakeholders, incentivized through gamification techniques, the use of tailored multi-view modelling techniques and multi-objective automated reasoning for trade-off analysis (unique differentiator).

The definition of the elevator pitch stressed already the main difficulty encountered during the preliminary phases of the project, which will be discussed in several Sections of this deliverable, in particular, the identification of the targeted level of the decisions where to apply the PACAS concept. This same difficulty was faced during the Activity that leads to the WS1 about the use case and scenario definition, and will be extensively discussed later in this document.

2.2 Validating the PACAS concept

The validation of the PACAS concept will aim at demonstrating its soundness, generality and potential for extended versions which might support additional strategic perspectives affecting ATM change management. The validation will be end-to-end assisted by an external AB, composed of ATM domain experts, and will focus on a number of strategic objectives concerning economical, organizational, security and safety aspects. The AB will be a critical resource in PACAS, for it will provide assistance and feedback not only for the final validation of the project outputs, but all the way through, including the design phases for the creation of the PACAS decisional process and platform.

The methodology adopted for validation will be based on the European Operational Concept Validation Methodology (E-OCVM) [1], the reference methodology used in SESAR, adapted to the specific Exploratory Research context on the basis of the experience of the consortium members gained on past SESAR WPE projects (e.g., NINA, ELSA, SPAD). This will ensure compatibility and comparability with the results of the other SESAR R&D activities.

For the validation of PACAS, we identified two main subjects: a) the PACAS process for managing changes in the ATM in a participatory fashion, and b) the PACAS platform to assist participatory decision processes.

a) The PACAS Process:
When not properly assisted by a computer, it is hard for humans to find solutions in very complex systems with many alternatives, conflicts and nonlinear relations between the different aspects of the system itself. On the other hand, decisions in a complex system can never be purely automatic or completely computer-driven. In such systems, indeed, a holistic view is often needed to tackle changes, sometimes including aspects "not implementable", e.g., which only human experience and expertise can provide. Moreover, in complex systems the best solutions might not always be the optimal ones, as some compromises among the different decisional roles and their goals might lead to a more widely accepted solution, which might be, in some cases, even more advisable than the best one.

The PACAS project aims at delivering an innovative ATM participatory change management process where stakeholders participate actively to the architectural evolution of the ATM system. The design phases of such innovative decisional process proposed by PACAS are illustrated in Figure 2.
This novel approach to managing changes relies on benefits brought by the inclusion of different ATM domain stakeholders during the whole duration of the project to:

- Deepen the understanding of the proposed changes by analysing the description of its most-likely effects and impacts as described from the various stakeholders’ perspectives.
- Increase efficiency and acceptance (i.e., the success) of the solutions found by both ensuring the end-to-end inclusion of the stakeholders to the decision process and by tracing the decision stream that brought to the change itself.
- Significantly raise participation, motivation and commitment to the decisional process by the use of gamification elements.
- Objectivise and optimise the solutions found by the inclusion of automated reasoning techniques.

As such, the validation of the PACAS process will assess the breakthroughs brought by these innovations, considering that participation is one of the KPAs of SESAR, ensuring, through interaction and consultation between social partners at all levels, better and sustainable support [2].

The baseline for the validation of the PACAS process will thus rely on the gap analysis and requirements elicitation for the decisional processes in ATM, the gamification techniques, and of the multi-objective reasoning mechanisms contained in D2.1, D2.2 and D4.1, respectively, with a special focus on the needs stressed by the results contained thereby.

Note that this part of the validation will also aim at ensuring the generality of the decisional process proposed by PACAS to foster high integration with existing engineering processes of SESAR. Namely, the participatory change management process delivered by PACAS will have
to be proved valid beyond the concrete modelling language(s), reasoning techniques, and the tools that will be used for the implementation itself.

b) **The PACAS Platform:**

PACAS will provide a decision support tool where game elements are used as psychological and social drivers for collaboration, built on well-consolidated multi-view modelling methods and multi-objective trade-off reasoning techniques. The AB will play an intrinsic part in the development of the PACAS platform by initially laying down their strategic objectives, then help building and validating the models of the complementary perspectives/views (i.e., economic, organisational, security, and safety) and their translation to functional aspects, spanning architectural modules and connectors upon which automated analysis will be built. Usability, utility and good correspondence to reality will be the main focuses of the platform validation. Moreover, the value added by the platform to the decision process will be assessed to measure the usefulness of the features of the platform to propagate and calculate the impact of a given strategic objective (reflecting the decision of a specific stakeholder) over the functional perspective and the rest of strategic objectives.
3 Validation plan

3.1 Strategy

3.1.1 The iterative validation process

One of the pillars of the PACAS project is the end-to-end inclusion of the AB members already during the design and validation phases. This feature of the project was already recognised from the AB members during the preliminary Validation Workshop (also referred to as Workshop #0 or WS0) a key strength point of PACAS with respect to the so called “V shaped” project scheme, that includes the stakeholders only at requirements and final validation stages (see D2.1 [3]).

For dealing with this end-to-end inclusion of the AB members into the project, the implementation and validation of the whole PACAS concept was fractioned into a number of sub-goals, or gates, to be achieved before proceeding with the further steps of the project. These gates became more clear and were written down after scoping the project and the defining the targeted level for the ATM changes to be considered in PACAS.

The project was therefore divided into 3 main phases, comprised of four gates to be achieved:

a) **Phase 1: State of art, gap analysis and needs elicitation** => **Gate 1: Requirements definition**
b) **Phase 2: actual work Activity, design, development and implementation** => **Gate 2: Use Case and Scenario definition, Gate 3: Platform design.**
c) **Phase 3: Validation and collection of AB members’ feedback** => **Gate 4: Final validation**

It is important to notice that each gate, as represented in the external cycle of Figure 3, is the necessary enabler for the following phase.

Such a 3-phase cycle (State of Art/Activity/Validation) is repeated, in a fractal fashion, for each goal, or into the evidence of the necessity to start over the same phase, making a further iteration of the smaller cycle in order to meet the AB members’ comments (see the smaller cycle in Figure 3).
This iterative structure has multiple advantages [4]:

a) Keeping the AB members always in the loop, constantly involved in the requirements, design (possibly re-design) and validation phases (thus enabling a real end-to-end enrolment or the stakeholders into the project).

b) Guiding the AB members to keep them always within the scope of the project (sometimes, as they are major experts of the domain, it is not easy for them to focus on the part of their knowledge that is of major interest for the project, and it might be easier to reason on a pre-constructed track).

c) Helping them shape their needs clearly, which, as highlighted by the AB members during the WSO (see D 2.1 for details), are not always clear from the beginning.

d) Clarifying, stressing and enlightening the potentialities of the PACAS concept.

e) Enabling the possibility to steer the project toward any interesting direction on the run.

f) Remaining free and open to discuss again and implement issues that may arise after Validation Workshops with the AB members before proceeding with the project.
3.1.2 The Advisory Board (AB)

As discussed so far, PACAS will make an extensive use of the external AB of domain stakeholders during the whole project. Their key role will help design and validate both the methodology and platform and will support all the phases of the project.

In order to adapt to the PACAS concept evolution during the preliminary phases of the project (see Section 2.1), the AB composition evolved as well. The possible "stakeholders" and "final users" of the PACAS platform where initially addressed generically as spanning managers, decision makers, and analysts from the ATM domain (i.e., SESAR stakeholders, ANSP managers, safety and security stakeholders, air traffic controllers, etc.). However, the composition of the group and their specific competencies needed to be carefully planned and tailored on the revised PACAS necessities and objectives.

The difficulties experienced in defining the right level of decisions to be targeted by the project where mirrored by the discussions on the composition of the AB group and the distribution of their competencies, especially for what concerns the inclusion (or not) of the representatives of the flying companies. Indeed, a first draft of the composition of the AB group was presented by the Consortium to the Project Officers during the KoM, to get an early feedback. The PO stressed the lack of members from a main role in the ATM panoramic, namely the economical drivers: the flying/airline companies. The composition of the AB was revised accordingly to account for the SJU advice and therefore to include a member from a national flying company and a representative of a low cost airline. However, after a further discussion and the Validation WS0, the partners of the project decided to include the members of the flying companies after the modelling phase of the project, i.e., directly in the decisional process. Moreover, after the WS1 a further domain expert was accepted on board, Jörg Buxbaum, from DFS, which took part at the WS1 as representative of Günter Achatz and proved to be crucial for the scenario building.

As stressed in the deliverable D1.1, all the selected members have an accredited experience, from 15 to 36 years, in different fields of the ATM domain, with some expertise in the use of ATM models and different roles and levels in the decisional chain of the ATM. Moreover, most of them have an active role in European projects, especially in the R&D, thus ensuring a deep understanding of the targeted
TRL level of PACAS. Yet, most of the identified members are/have been part of some stages of the SESAR project, to help keep the alignment between the project achievements and the SESAR framework goals. Finally, in choosing the single members, the different views that PACAS aims to model were taken into account, although all of the members actually showed transversal competencies.

We report here the integrated list of the AB members\(^1\), how it has been modified after the WS1, with a brief description of their main expertise and the research projects they are currently involved in.

**Safety:**

a) AB member #1 as representative of the Italian Service Provider – Ente Nazionale di Assistenza al Volo (ENAV) and its department of R&D (SICTA)
   - **Main expertise:** Architectural aspects of ATM System, validation exercises, standardisation, documentation of the static and dynamic behaviour of modules of the architecture using UML via Rational Rose. **Projects:** SESAR WPB; OATA

b) AB member #2 as representative of the German Service Provider – Deutsche Flugsicherung (DFS)
   - **Main expertise:** humans / operators and system safety, developing approaches to understand system safety in a holistic/systemic view; cognitive systems and human - system interactions. **Projects:** Head of Ergonomics, Innovation and Safety Promotion in the SM of DFS; Project leader of different international projects, e.g. Weak signals approach, resilience engineering, CISM, FRAM

**Security:**

c) AB member #3 as representative of an Intergovernmental Organisation (EUROCONTROL)
   - **Main Expertise:** ATM Security Specialist, Research Development and SESAR / Performance & Methods EUROCONTROL, system specification, design and development, software engineering. **Projects:** PATIN (Protection of Air Transport and Infrastructure) Security Research programme; support to ANSPs, Regulators, State Authorities and Industry with respect to methods, tools, and legal and regulatory requirements; supported the ATM Security Team (SET); EUROCONTROL Security Risk Management Toolkit and the associated training course in ATM Security Management and Risk Assessment; managing project 16.06.02; 3 ATM Security SESAR projects

**ATM Systems Modelling, Enterprise Architecture:**

d) AB member #4 as representative of the English Service Provider (NATS)
   - **Main expertise:** Software Development (Fortran and Macro-11), DP System Management and Administration, Installation Management, System Engineering, Operational System Support Team Management, System Architecture, Enterprise

\(^1\) They cannot be named due to privacy concerns but only indicated as AB member #1, #2 and so on.
Architecture Projects: European ATM Architecture (EATMA); Deputy Project Manager of Project B4.1; Architecture Content Integration cycle for EATMA.

Organisational, Business:

e) AB member #5 as representative of the German Service Provider – Deutsche Flugsicherung (DFS)
   - Main expertise: project management, different roles from project assistance up to program manager, Head of Requirements Engineering including test and acceptance especially for Approach and en-route ATM Systems, Director Planning and Innovation, Requirements engineering on SUR and COM Systems, Enterprise architecture, management, Innovation management, Simulation (fast and real-time). Projects: more than 100 medium-size, and 10 very large projects in ATM; DFS' SESAR program (operational); DFS ATM ANS Masterplan; ATM Data management (esp. SWIM).

f) AB member #6 as representative of the Italian Service Provider – Ente Nazionale di Assistenza al Volo (ENAV) and its department of R&D (SICTA)
   - Main expertise: RPAS integration in ATM, validation of infrastructures and their maintenance against the new concepts, real time simulation, R&D, architectural aspects of ATM System, design (UML – Paradigm Plus) and implementation of CORBA, synthetic and global views over concrete situation, Problem-solving, Prioritisation and Focus. Projects: SESAR WP4 (as Project Manager), FREE Solutions; WPB (B4.1 and B4.3), WP3, WP5 (P5.2). P03.03.01 Project Manager – V&VP Architecture and Specification; SPADE II project (Supporting Platform for Airport Decision-making and Efficiency Analysis); OATA Core Team in EUROCONTROL (logical architecture).

g) AB member #7 as representative of the German Service Provider – Deutsche Flugsicherung (DFS)

Flying companies:

h) AB member #8 as representative of the Italian Service Provider – Ente Nazionale di Assistenza al Volo (ENAV)
   - Main Expertise: Crew Resource Management Facilitator for the Human Factor Department, airbus pilot, Multi Crew Cooperation Instructor and Certified Examiner for the JAA, for bon-technical abilities and Behavioural Markers. Projects: invented the CAQ (Cultural Assessment Questionnaire, an innovative and efficient tool for assessing the riskiest areas and professional profiles) and a 4-point attitudinal evaluation scale named RATE, now used in the IAT (Implicit Association Tests) for pilots.
After receiving the feedback on the deliverable D1.1, it was discussed the possibility to ask (through the SJU) for further external support in order to guarantee an independent validation of possible issues that might arise during the project, as, on some specific problems, the AB members might be too involved to be objective. For example, this could be a possibility for support the development of the Economic view which PACAS aims to build. Whenever this necessity will raise, the relative validation activities will be included in the plan, properly scoping them within the necessity to be addressed.

### 3.2 Overall Criteria

In every project it is very important to identify a set of criteria on which the success or failure of the project itself will be based. Such criteria must be tailored onto the targeted Technological Readiness Level (TRL), which is of key importance to drive the validation activities. PACAS targeted TRL is 2: *Technology concept and/or application formulated: Applied research*. This is still a low level of TRL and, as such, the concepts that originate from the project, still play a major role, maybe even more than the fully-fledged prototypes. For this reason, as we stressed already in the previous Section, the PACAS validation subjects are equally important, although other aspects such as initial requirements, scenarios, and models, will be tested and refined as well during the project workshops by exploiting the expertise of the AB members.

All the validation activities will follow the principles of testing the:

- Correctness: if the method is able to provide correct and useful solutions;
- Applicability: if the tool provided are easy to understand use;
- Cost effectiveness: if the trade-off between the effort for implementing the PACAS concept and the usefulness of its output is convenient;
- Participation: if the platform is able to keep end users’ participation level high during decisional processes;
- Scalability: the possibility for the PACAS process and tool to be generalised to systems of different sizes and complexity.

These criteria will be decomposed into possibly measurable sub-criteria, to be applied during validation exercises and whose results will be analysed during WP5. The criteria, their scope and the method to evaluate them are summarised in Table 1.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Explanation</th>
<th>How to evaluate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generality</td>
<td>Check if the PACAS process can be used for different types of decisions (e.g., unplanned, planned, etc.).</td>
<td>Making the AB members reasoning about all the possible application scenarios will provide a range of possible types of changes the PACAS concept would be useful for.</td>
</tr>
<tr>
<td>Exploitability</td>
<td>Identify a range of possible situations in which the use of the PACAS process will represent a clear enhancement (e.g., the</td>
<td>Making the AB members reasoning about all the possible application scenarios will provide a range of possible levels of changes</td>
</tr>
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</table>
automatic decision tree and the tracing of all the discussions that took place before the decision help demonstrate the maturity level of the change management process).

<table>
<thead>
<tr>
<th>Scalability</th>
<th>Check if the PACAS process can be used for different levels of decisions (e.g., high level and highly complex as the introduction of the free-route in Europe or low level and comprising fewer aspects as the introduction of a new runway into an airport).</th>
<th>Reason with the AB members, after the use of the PACAS project (i.e., with a clear view on the actual application of the method and the platform) of other possible changes the PACAS concept might be useful for.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usability</td>
<td>Check if the PACAS platform is reasonably easy to use and understand.</td>
<td>Practical use in the case studies. The experts will be observed while applying the method (e.g., the AB members might be divided into two groups, asked to reason about a specific change, one using the PACAS tools and concepts and one without). In some cases, this evaluation might be integrated with structured interviews with the experts.</td>
</tr>
<tr>
<td>Correctness</td>
<td>Check if the PACAS platform is able to model the interaction of the different perspectives of the system, and the propagation of the changes in a clear and representative way.</td>
<td>Structured interviews or other classical methods (e.g., observation of the AB members reactions to the models proposed) will check the correspondence of the models proposed, their interactions and the propagation of changes through them with the reality and/or the AB members expectations.</td>
</tr>
<tr>
<td>Cost effectiveness</td>
<td>Check if the application effort required and the other possible costs are acceptable relative to the added value.</td>
<td>Practical use in the case studies (observing the experts while applying the method in comparison with the analysis of the cost of the preparatory work). This evaluation might be integrated with structured interviews with the experts.</td>
</tr>
<tr>
<td>Added value</td>
<td>Check the improvements brought by the introduction of the Gamification, the Reasoning techniques, Participation.</td>
<td>Collect feedback (explicit or implicit) on these main features of the project during their practical use in case studies.</td>
</tr>
</tbody>
</table>

**The main evaluation methodology**

One of the main methodologies we plan to use for the evaluation of the project through the Validation Workshops and the feedback collected therein is based on the Method Evaluation Model
[5]: a theoretical model based on Technology Acceptance Model (TAM) [6] and the Theory of Reasoned Action and the Methodological Pragmatism [7] from the philosophy of science. These methods focus on the two different but related dimensions of the “success” of a project: the actual effectiveness and the adoption in practice. Actual effectiveness is the pragmatic success of the method, i.e., the extent to which it improves the performance of the task in question. Adoption in practice is the extent to which the method is used in practice. These two dimensions are captured by the MEM as summarized in Figure 5.

Despite the usual evaluation criteria that predicts that methods that are more efficient and/or effective in achieving their objectives will be adopted in favour of other methods (i.e., are the most successful), MEM poses the accent on the methods that are perceived as easy to use and useful, and sees these as being the most adopted ones in the future. In this way, the intention to use that method is quantified by the perception of its ease of use and usefulness considering subjective reality is more important than objective reality. This method tailors the measure of a success on the human behaviour which might be influenced by other factors (e.g., prior knowledge, experience with particular methods, normative influences) and was therefore identified as more adapt to the validation through AB members. The key constructs constituting the MEM approach are collected below:

- Actual efficiency: the effort required to apply a method;
- Actual effectiveness: the degree to which a method achieves its objectives;
- Perceived ease of use: the degree to which a person believes that using a particular method would be free of effort;
- Perceived usefulness: the degree to which a person believes that a particular method will be effective in achieving its intended objectives;
- Intention to use: the extent to which a person intends to use a particular method;
- Actual usage: the extent to which a method is used in practice.

![Figure 5: Method Evaluation Model](image)

### 3.3 Validation timeline

In D1.1, the forecasted timeline of the project was presented, which is reported below for completeness. The schedule comprises three Validation Workshops with the AB members, and a
number of other internal Activity meetings (specifically, the magenta and blue targets below the timeline).

The forecasted schedule (see Figure 6) has been, so far, followed closely. However, a further validation meeting, with a subset of the AB members, the WS0, was added to the initial plan and held in May. The necessity of an additional meeting became clear after the preliminary phases of the project, in order to consolidate the requirements and needs as a result of the gap analysis performed as part D2.1 and D3.1 before starting the design and implementation phases.

Figure 7 provides an idea of the research flow so far, representing how the concepts evolved through the phases of Figure 3. Reading Figure 7 from left to right, the work done so far starts from the Requirements Definition Phase, in which the literature review on system design and modelling methods was performed. A parallel discussion about the right Use Case for the validation of PACAS started during this preliminary phase as well. The use case, indeed was, from the very beginning of the project, used as a tangible way to reason about the level of granularity of the decisions targeted by PACAS (i.e., it was used for clarifying the scope of the project), that, as stressed several times during this document, was the main difficulty faced so far.

We hereafter analyse the two flows separately starting from the latter (use case) and passing to the former (literature review).

The discussions about a possible use case, its evolution and the final definition of a suitable scenario are described in detail from Section 4. However, in Figure 7 we aim to provide the wider picture of
the flow of concepts and refinements that lead to the definition of the Scenario (see Section 4.2). From the literature review three main use cases where proposed: (i) the re-organisation of the air traffic due to the temporary closure of the Crimean airspace of 2014, (ii) the future possible introduction of an Iris satellite communication system (datalink), and (iii) the implementation of the free-route, in which users may freely plan a route between a defined entry point and a defined exit point (See Section 4.1 for the full details). The output of internal discussions and the WSO highlighted that each of these draft use cases was not suitable for the validation of the PACAS concept. However, they turned out to be extremely useful to identify three main properties (planned change, widely accepted and well known, concrete and not too articulated) that lead, after the WS1, to the identification of the right Use Case Scenario. Notice that this is the example of the iterative research process described by Figure 3: the literature review identified three possible use cases which were excluded by the AB validation. Yet, these feedbacks were used as input for the second iteration which led to the final definition of the use case and scenario. Moreover, the Iris use case helped building the illustrative example, as stressed in Figure 7.

On the other hand, the literature review on the system design and modelling methods led to the definition of a possible set of needs from the field and highlighted the need for a preliminary Workshop to validate them. A validation Survey and an evaluation methodology was thus defined and applied during WS0. This Validation Workshop led, in turn, to the final definition of the requirements but contributed also to the creation of a card driven methodology for guiding the preliminary modelling phases of the platform, by dividing the change into decision-process Activities, Outcome, and Communication. Finally, as output of the WS0, the composition of the AB group was revised, with the inclusion of a member from the Flight Companies. In the next Sections both the methodologies and results of the Validation WS0 and WS1 will be described in detail.
Figure 7: Research flow
3.4 Assumptions and limitations

A key element of any validation is the clear definition of the limitations and assumptions of the validation. They play the same role of axioms in any mathematical theory: a premise or starting point for reasoning, shaping the space in which the reasoning will be valid. Assumptions and limitations of a validation activity are thus necessary and unavoidable. They are often necessary to provide a frame for the evaluation process, but, they can also have a powerful effect on the conclusions of the analysis that should not be underestimated. There are some general assumptions we have made during our validation activities in PACAS:

- The opinion of the AB is assumed to be always correct, representative of the whole ATM domain, and complete (e.g., the needs identified by the AB members are taken as representative of the real needs of the domain). Moreover, validation will be based on expert opinion of the AB members. In particular, we need to evaluate if decisions taken by using the PACAS process and platform are correct and useful in order to assess the value added to the decision/decision process by PACAS. As far as scalability and applicability are concerned, we use the evaluation of AB members
- The analysis of the system under study can be limited to the portion of the ATM world represented by the use case we will apply. This is essential to limit the extent of the analysis at a manageable size. This assumption has no influence on the validation as long as any comparison is done with models considering the same portion of the ATM world.

3.5 Validation activities so far

3.5.1 Activity #0 and Workshop #0 (WS0)

This section describes the methodology used to create the first set of interviews and the analysis of the results of the interviews. As explained in D2.1 Section 3.3, WS0 was divided into a Pilot Interview (to check the validity of the Questionnaire with a representative of the Italian Service Provider – Ente Nazionale di Assistenza al Volo (ENAV) and its department of R&D (SICTA), external to the AB) and a face-to-face interview with the revised questionnaire, with two members of the AB.

The objective of WS0 was to investigate the main characteristics of a decision process in ATM and its specific element such as the actors’ involvement, the decision making procedures, the actors’ roles, the main types of decisions and their aspects related to ATM management. Finally, it aimed at studying the motivational factors that spur individuals in taking decisions, e.g., reputation, responsibility, and trust (see also D2.1 and D3.1). A second part of the interview aimed at investigating the main modelling techniques used in ATM and their main features.

Semi-structured interviews

The methodology adopted for data collection was a semi-structured interview. A semi-structured interview is a qualitative method of inquiry that combines a pre-determined set of open questions (questions that prompt discussion) with the opportunity for the interviewer to explore particular
themes or responses further. Semi-structured interviewing, according to Bernard [4], is best used with one-shot interviews to collect data. The inclusion of open-ended questions and training of interviewers to follow relevant topics that may stray from the interview guide does, however, still provide the opportunity for identifying new ways of seeing and understanding the topic at hand. The major benefit of this methodology is that questions can be prepared ahead of time [8] allowing the interviewer to be prepared and appear competent during the interview. Moreover, it gives informants the freedom to express their views in their own terms, while helping to keep them scoped and somehow bounded into the track to still providing reliable, comparable qualitative data.

The main characteristics of a semi-structured interviews are:

- The interviewer and respondents engage in a formal interview.
- The interviewer follows an ‘ideal interview guide’: a list of ordered questions and topics to be covered during the interview.
- The interviewer can decide to follow topical trajectories in the conversation that may stray from the guide if appropriate.

The preparation to the interviews is based on various peculiar phases, which lead, among others, to the creation of the guide and the description of the interviewer role during the whole consultation (see for example [9] and [10]).

The main phases are:

- **Structuring** the interview: identification of questions and issues to be addressed. In this initial phase the focus is on identifying the thematic areas to be addressed during the interviews, such as:
  - Who are the actors involved in decision processes?
  - Who are the main decision makers, and what roles do they have?
  - What are the decisions useful for (individual utility/organizational utility)?
  - What is the relevance of the decision with respect to the organization as a whole?

- Is there any obstacle in group decision making? If yes, how decision makers reach a final decision? Defining an optimal order of questions/ issues: it is important to create a questions’/issues’ flow that goes from the most general to the most specific argument and that allows interviewees to feel comfortable and fluently thinking during the interview. As commonly accepted, we decided to proceed from general to specific, thus leaving more technical questions at the end. This was mainly done to put the interviewee at ease, avoiding too complex questions at the beginning and providing a logical path for the issues to be addressed. However, it must be noted that the order of the questions in semi-structured interviews can be revised, not only as a result of the feedback provided by the “pilot interviewee” (see next bullet point), but also during the interview by the needs of the interviewees. Nevertheless, having an ideal trace is essential to tackle all the listed topics. Set up the pilot interview with one or more domain experts in order to review both the questions and issues to be raised during the interviews, and evaluate if they are focused, clear, usefully structured, if the questions/ issues flow is linear, and if there is any relevant argument...
missing. The Pilot interviewee was also asked to identify irrelevant or superfluous questions that could be omitted and to provide feedback on item representativeness, wording and difficulty, or any other useful suggestion. Interviewing the AB members and collecting the data: the interviews with the AB members deepened our understanding of decisional processes in ATM and led to the identification of a first set of project requirements and needs to better analyse modelling techniques, thus building a solid basis for Activity #1 and WS1.

**Preliminary set of questions for validation WS0**

**The Pilot interview**

The main issues that raised during the pilot interview were to invert the order of some questions and to be careful with the question "Do you know or use any model?" Which was not well defined and might have been misleading. To mitigate the risk of misunderstanding it, the suggestion was to contextualise it with the use of a case study, like for example if they knew any way to map all the safety implications of the introduction of the free-route.

This preliminary interview also stressed some key strengths of the PACAS project:

- Gamification to ensure an enthusiastic participation is fundamental.
- The integrated management of all the views is something that nowadays is done by experienced managers at corporate level; however, to have a single man in charged is a risky single point failure feature. So the objectivity of the support to a holistic decision management offered by PACAS is one of the main features.
- The automatic synchronization of the impacts is incredibly helpful when taking a decision.

Finally, as described in detail in Section 4.1, he suggested the free-route as a right level of decision to be targeted for PACAS.

The questionnaire, after the revision of the Pilot interview, was divided in two slots: the former (A) dealing with decision making, the latter (B) with modelling languages. The revised version of the questionnaire is reported in Appendix 1: Interview Questions.

**WS0 Results: ATM decision making process**

The analysis of the interviews was conducted with these objectives in mind:

1. To identify the most important *categories* of an ATM system, such as the decision process, the nature of the decisions in the ATM domain and their mainly impacted perspective, or other aspects of ATM management in general.
2. To identify the most significant features of these categories as highlighted in the interviews.
3. To analyse the extracts of the interviews starting from the identified categories.

The identification of the most important *categories* on an ATM system was guided by the literature review and state of art analysis of Activity #1. For this phase we followed the road-map paper by Ball et al. [11], based on existing studies on collaborative decision making processes. In it the authors made a close connection with the Free Flight concept which redefines the decision-making paradigm from a central planning one to a more decentralized process where decisions are taken
collaboratively by multiple actors. Among the challenges that they outline we focussed on the
creation of models that support the decision-making process, both for short-term, real-time
decisions as well as for longer-term, strategic issues. Furthermore, Vossen [12] supported the
coordination among airline operations control centres and air traffic controllers in the context of
ground delay planning, i.e., the sharing of relevant information in order to conduct a collaborative
decision making process. Finally, it is highlighted that, in addition to the importance of information
sharing, coordination among the stakeholders is crucial to ensure effective decisions. The authors call
for the creation of tools and procedures that allow airspace users to respond to collaborate with
traffic flow managers in the decision-making process. What clearly emerged from Activity#1 is that
various actors, with different competences and roles, interact and make decisions to solve problems.
The resulting decision is based on a repetitive game among which actors interact in various rounds
(in projects, in the same organization, etc.) and the results depend on the individuals’ expertise,
reputations and negotiation ability. Moreover, the most relevant categories to be investigated for
shaping a collaborative ATM management were:

- The main characteristics of a decision process in ATM:
  a. the type of actors involved;
  b. the main activities in it;
  c. the most important information needed;
  d. the way in which the process is improved;
  e. the motivations that guide the actors to act in one way or another;
  f. the type of good (private or public) produced by the decision;
  g. other.
- The type of decisions. These, from the interviews, resulted to be roughly dividable into three
  main levels: operational, managerial, and strategic.
- Other aspects related to ATM management (e.g., safety and security management; change
  management and costs management).

Hereafter we summarise the main findings for the categories above:

Main characteristics of ATM decisions. For explaining the findings about the main characteristics of a
decision process in ATM, excerpts of interviews are directly provided below. It must be noted that
since the interviews were conducted in Italian, the reported extracts have been translated. Finally,
these results will be considered as requirements for D4.1.

- Actors

Different actors and different organizations are involved in the validation activities: some of
them are directly involved in the operation management processes, some others are not
directly involved, but are affected by the decisions (e.g., passengers). Both should be taken
into consideration. In ATM the final decision maker is usually placed at the highest levels of
the organizational hierarchy, which takes advantage of the evidences and the supports provided by technical and operational teams managed by him/her.

**AB member:** “[...] surely the final decision maker is ENAV, which is the general manager, rather than the one in charge of the operational activities. For instance, if the decision refers to the adoption of a new tool, the final decision is taken by the operational manager of ENAV. [...]”

This decisional process is carried on at any level, therefore:

**AB member:** “Of course, for each of the key performance area, ENAV has specific reference persons. For example, there is the head of the safety, the head of security, the head of human factors, the engineering systems manager, the responsible for the technical area ... Each of these, of course, for their responsibility segment should be considered as the final decision maker on investments, safety, security, human factors [...]”

Since there is a responsible actor for each area or level, the final decision results from the mediation among these subjects. In some cases, this may generate some conflicts, and the solution may be either political or strategic. In any case the final decision is taken by the person in charge of implementing the changes at operational level.

The ATM is a “highly interdependent system”; on the one hand, it needs to be highly structured, on the other must be simplified. There is a continuous trade off between growing the structure (which will inevitably decrease the degrees of freedom) and reducing complexity (such as to make the system stable and easy to change).

**External expert:** “[...] It is a highly interdependent system ... [...] to make it stable, reliable and safe, you have to build on top of it, usually you give it a certain degree of complexity to better define the interactions among various modules, [as a consequence] the modules are less autonomous and active. So the decision process, the ideal decision process, should find a good trade off among those authorization levels which prevent risks and enable autonomous actions.”

### Activities

The most significant activities that characterize a decision process are:

- An objective presentation of the problem/issue, "clean from contaminations";
- The identification of available options;
- The contextualization with an impact assessment.

### Information

Every issue on which you have to decide is contaminated by subjective considerations. What you need to do is analyse the issue with as low prejudice as possible, trying to reduce it as close as possible to the reality. Then the set of solutions should be contextualized by an impact assessment performed to figure out what are the effects of the decision on the whole ATM system.
External expert: “[...] first of all the presentation of the problem. It must be presented in a way as much objective as possible, because usually the problem is already contaminated. [...] See what are the real problems, let's say ... once you've seen the real problems, you know ... you have to identify a set of options in front of you, so let's say that must be contextualized ... you have to have some sort of impact assessment, to see what is the solution.”

Usually the most important information needed in decision processes are related to the impact assessment.

External expert: “Having a complete picture of the operational context of the business and in particular have an assessment of the impacts various options may occur in the system, is fundamental”.

▪ Improvements

Improving decision making processes means also improving information sharing. This information should take into account the needs of the actors which are not directly involved in the process but which may be affected by the changes. The decision making process is not linear, is very complex and should take into consideration non deterministic variables.

▪ Motivations

Due to this complexity, reputation matters a lot: it allows individuals to have a major role in the decision processes and allows actors to accept easily the solution and build other changes on top of that.

AB member: “[...] if a decision has positive effects, will be accepted as a right decision, you also build your reputation ... So in my work, there is a reputational aspect: individual, ... experience growth your reputation because it empowers you.”

Trust seems to have both a political and an individual side. From a political point of view, trust means construction of interests and future relationships, from an individual side instead it refers to expertise and experiences.

External expert: “[...] you take a flight because you trust the company, because of its brand, history, technical knowledge and [...] even the pilot ... well, you trust them because you have confidence and trust in the person (role) and in that company.”

Motivational sources were also investigated and examined by the analytical tool [13] described in D2.1 defining a set of incentives

▪ Nature of good

Every decision within the ATM seems to have a double usefulness: organizational and individual. The nature of good produced by the decision can be considered either a private or a public good.
Decisions made within the ATM have an impact on the system which may include economic, organizational, safety and security aspects, however it usually have an impact at the individual level.

### Other

Organizational culture plays an important role in decision making. By organizational culture it is meant the set of values individuals share, dealing with the daily life in companies, making decisions, or any other activities. In particular, the safety manager interviewed, argued that:

**External expert:** “[...] to make a right choice, I need to compare it with the environment, let’s say the organizational culture environment and everything is connected with this. [...] As a safety manager I have to deliver a recommendation which is coherent with the culture, otherwise the others will never adopt it”

The validation activities play a key role in decision processes, because “The evidences are the building blocks of any decision.” In particular:

**AB member:** ”[...], gathering evidence plays an important role in decision making. The validation activities are very important in our domain. For example, in the reorganization of the airspace, SICTA is involved in the scenarios definition and their evolutions, then is also involved in any change the current airspace require, [...] SICTA is involved in the study of those alternatives which increase both the airport performances and the airspace management, thus SICTA looks for evidences that will be provided to ENAV, the one that actually implement the innovative solutions [...]”

### Decision types

**According to the interviews’ results management practices, ATM are characterized by complex interrelations among heterogeneous elements of the tree**
**types of decision:**

1. **The operational level** deals with the real management of any air traffic action, decisions are made in real-time and sometimes on an emergency basis. When an emergency happens, several types of subjective factors related to the individual experiences must be combined with objective evidences. What is needed is not a single subject that decides, but rather a decision support system that allows decision makers to have an objective picture of the situation in real-time. This pushes us to reflect on the importance of **objectivity in emergency conditions**, when the evaluations of the situation must necessarily be based on evidences and/or the experience of the subjects.

**External expert:** “[...] there must be a system which supports and provides the evidences of the actual situation, the objective conditions, but also a support in making a decision”. This metaphor was made to stress that, although not vital, as during real time decision, the **objectivity of the information collected** is a key base for a good and effective decision process. No manager can take a well-balanced decision without real and realistic information.

2. **The managerial level** deals with all the technical changes that may occur during a revision of ATM procedures such as the introduction of new technologies, protocols etc. The changes are usually planned in advance and based on a highly technical and specialized knowledge shared in national and multinational projects. At managerial level, decisions must be
assessed by the responsible for the organizational aspects which evaluates the proposal accepting or rejecting it. Since the theoretical results are unique, the operative solutions that will be adopted, should be adapted to the specific national legacy systems, techniques, practices, cultures, etc.

These decision making processes are organized as in a model in which periodic feedbacks are provided. High level requirements, user requirements, technical specifications and use cases are the key elements of a managerial decision process.

**AB member:** "[...] There were a group of people who were closer to the operational world that, on the basis of a high-level view ... had built a high-level view of what were the goals for ... what were the target to be achieved with the new architecture. On top of that high-level requirements were translated into user requirements. Then [...] we took charge of this information and had to be translated into ... technical specifications and use cases and then modelling them via UML."

3. **The strategic level** deals with the adoption of policies, norms and regulations at national and international levels. Strategic decisions concern the adoption of policies, norms and regulations at national and international levels. Strategic decisions are closely related with internationalization which characterizes the ATM and its constrains in the adoption of these rule at national levels.

**AB member:** "Almost no changes other than standardised, trans-national ones will be implemented in ATM."

As such, he added that it is almost pointless for example, to research to build an airport that works at a very high level of automation, exclusively based on datalink and that, for this reason, asks the aircrafts to add some payload on board to be used only for that specific airport. Indeed, if the device is not standard and required for a relatively wide number of airports, it will not be implemented. Changes in ATM are a very long term process, and therefore they must be widely accepted and possibly trans nationally recognised to have a chance to be implemented.

**Other managerial aspects.** Every decision in ATM seems to have repercussions on both organizational and individual aspects. The nature of the product of people involved in decision process is always public: every actor in ATM work to implement/model/validate products that have an organizational impact. The usefulness of decisions is organizational because it involves a change or resolution of a problem that has an impact on the system or parts of it. But the usefulness of decisions is also individual because it has important repercussions in terms of reputation and credibility. When the tasks and individual goals are functional with respect to the entire decision process, the reputation and credibility of the individual are revalued positively. This means that in future situations, in decision processes, their point of view will be taken into account. But this could also have a positive impact in terms of professional growth and changing role within the organization. Moreover, any ATM change deals with different and complex relationships among actors, procedures, and technologies, making also very visible the existing ATM socio-technical infrastructure. Therefore, the relationships among these elements must also be analysed considering the relational elements involved in decision processes (e.g., reputation, usefulness of the decision,
and trust) and how these interrelated elements that are continuously negotiated among each other to converge into a decision.

**WS0 Results: ATM modelling techniques**

We report here for completeness the main results of the interviews for what concerns the modelling techniques in ATM already contained in D3.1.

There are different languages and modelling techniques in use for ATM systems.

The ATM industry usually resist to changes in the modelling language. This is due mainly to license costs, time waste for training and increased risk of misunderstandings. The standard language is usually set by high level organisations such as Eurocontrol, or by the end user (depending on the project). On the other hand, the methodologies of representation are constantly kept updated in the ATM enterprises. The main existing models in ATM are usually focused on single perspectives and individual results thus being somehow “closer to reality”. As such, they do not take into account all the ATM levels as a whole.

At present there is no universally recognised model or modelling language, however for some specific perspectives there seems to be some languages that are quite widespread. The security field is probably the most mature from a modelling point of view as it has been developed for IT issues. Known languages in this field are STS, UML, rational rose, SESAR System Wide Information Management (SWIM). For what concerns safety several languages exist, which seems to be equally spread and are chosen time by time by the scope of the project. Among them for example some adaptations of UML or DiMAG: "But they should be definitely improved by help prioritising the modelled items". Moreover, it was said: "to analyse structures of data and traffic conflicts, which we could call Capacity view, the model is usually realised in MatLab or other fast time simulators, model based, mainly making some Monte Carlo simulations". Validations are usually modelled with such simulation tools as well. And finally, it was said that: "Human Resources are usually the ones that deal with the organisational view and they don’t really use a model to what is my knowledge. [...] The Economical aspects of an issue, as well, have no usual interface".

From the interviews it was clear that: "The advantage of using a universal language is to learn it once, instead of reinventing it every time". As such, choosing or creating a specific modelling techniques suitable for ATM systems very complex.

While modelling languages used in ATM industry vary in appearance, it is however possible to define the ideal life cycle of a model, starting from the reflections of one of the respondents: “It starts with an abstraction and is constructed, piece by piece [...] then it is validated and shared with the community to make it acceptable as a reference system. Then you use the model as a decision support system”. It is remarked, however, that this cycle may have a duration of decades.

Models usually arise on the base of specific enterprise needs, but might also be proposed by research and European projects. “The process of developing a model, starts collecting the user requirements, then these requirements are specialized and fitted into the model, which is developed, and, at the end, you go back with the same people who decided the requirements to test it. This is a classic kind of implementation. Depending on specific needs you will develop different models.
Some features a good model for ATM should have are:

- Immediacy of the message you want to send;
- Standardized language to avoid misunderstandings between, for example technicians and higher role people with no specific knowledge of the software: “The idea is to speak a common language, to be clear and define exactly what do you want. So you need to connect users with who has to develop”.

The need for sharing between community members seems to be the common focus of these recommendations, as such it is possibly one of the goals to target when creating a model. Immediacy and general awareness, indeed, allow subject involved in decision process to reach a common vision and share the objectives.

**WS0 Conclusions**

Generally speaking, what emerged from WS0 is the necessity for a holistic view of the ATM system; a relevant assessment centre which is able to measure the impacts of changes provided in the new model; a multilayer perspective and view of the different sources of information; a model through which evaluate pros and consequences of each decision; a review of the decision processes taking into account actors indirectly involved in the decision. The decision process in the design of an ATM model may occur in two distinct stages: during the model creation and/or customisation, or during the model adoption. It is key to make a distinction between these stages mainly as the individuals acting on these two stages have different roles, needs and set of incentives. During the model creation and/or customisation of a model the teamwork is focused on the requirement analysis and the definition of the model meant to overcome a given operational problem. The goal is to find the most suitable model, the task is very specific and depends on the abilities of individuals, the result will be analysed and probably adopted by other actors who play a different role in the ATM system. The model adoption stage, instead, is carried on by actors representing the national or international economic environment, institutions and other supranational actors. In this case, decisions are more related to the policy that the national or international sector should adopt. The decision processes in ATM are usually “multilevel, multi-dimensional”, as they involve several levels at once, like for example the organizational, economic, safety and security levels. The decisions within ATM systems are usually group decisions. There are two ways to participate in decision processes, depending on the role the actor plays in the organization and the relation to the issue/problem to decide upon. These two ways are related to two different points of view, the managerial and operational. The managerial point of view refers to the policy making and the adoption of the models; the operational point of view refers to the model creation and/or innovation.

These hints can be summarized as follows:

- **Holistic view**: try to reach the widest possible view of the levels involved;
- **Impact assessment**: it is key to understand as deep as possible all the consequences of your decision;
- **Information sources**: try to get as much information sources as you can;
- **Trade-offs**: carefully weight and evaluate pros and cons and possible cascade effects;
- **Review process**: give importance to the review process.

Modelling languages could be improved as well. For example, from a safety point of view, it could be useful to have a decision support system for the management of priorities of intervention at the system level. “As a function of failures, difficulties or weather conditions, should give suggestions for decisions to be taken at different levels (e.g. corporate and operational)”. Another important tool discussed would be an automated way to select the objective data, i.e. the information that is not contaminated, described to potentially be an incredibly useful support for information processing.

Through the interviews it was further possible to identify several different ways to improve the ATM modelling techniques, each of which are explicated below to understand their roles in modelling: multiple roles, multiple views, inclusion and integration, measurable indicators, tracking and translating. These critical aspects seem to emphasize the need to have a “complete model”, which takes into account several views (e.g. organizational and safety, but also services and systems). As such, from WS0 it was possible to gather the following feedback on ATM models:

- Can be adapted to the multiple roles one might cover in ATM systems;
- Being suitable for describing the multiple views one should consider (see D2.1);
- Include and integrate different elements;
- Use measurable indicators;
- Requirements can be traceable in the model.

These features were used as an input for the first proposal and development (mock-up) of the process and platform, including the modelling concepts as described in D2.2.

### 3.5.2 Activity #1 and Workshop #1 (WS1)

The two main aims of the WS1 were: (i) to gather information from the AB members to devise the reference scenario for the PACAS project and (ii) to obtain preliminary feedback on the concept of the PACAS platform.

**Scenario building**

In order to collect information for the PACAS scenario, we organized an interactive scenario-building session (see Appendix 2: Scenario building protocol for more details) that consisted of the following steps:

1. An introduction of the objectives of the session was given to the AB members by the session moderator. The presentation also introduced the basic terminology used in PACAS, such as the term *change issue* that refers to “a topic or problem upon which a decision should be taken that leads to a change in the ATM architecture”;
2. Each AB member was provided with sticky notes and was asked to write down two change issues based on their experience in the domain. The collected notes were then positioned by their proposers on a flip-board, with the aid of the moderator. The positioning of the notes was left up to the proposers, who should find the right location based on the similarity with other notes. The output of this activity consisted of two selected change issues;
3. The selected change issues were discussed in groups. Every group consisted of at least two AB members as well as two or three members of the PACAS project. The AB members were leading the discussion, while the project members were assisting trying to keep the AB members focused. The aim of this activity was to construct a scenario for each change issue; a scenario was physically built on a table by filling in and placing cards that were provided to the AB members. Three types of cards were available:

- **Activity**, to describe a task that is conducted by a stakeholder during the decision-making process. Besides explaining what the activity consists of and who conducts it, this card type asked how the activity was executed (face-to-face, via skype, …) and the purpose of the activity (the why);
- **Outcome**, to denote the output of an activity. This card type presented a number of alternative outcomes to help the groups think of different outputs that may originate from an activity. Pros and cons could be associated with each alternative;
- **Communication**, to represent the interaction between different stakeholders in the decision-making process. Besides the identity of the interacting actors and a description of the communication, the group members could also express the type of communication (proposing a change, informing about something, asking for clarifications, …) and the utilized communication means.

The cards could not only be placed sequentially (to indicate a simple flow), but it was also possible to create forks to express alternative flows.

4. At the end of the scenario building session, a member of each group presented the created scenario to the whole audience.
Wireframe demonstration

Concerning the preliminary feedback on the PACAS platform, a demonstration of a wireframe was conducted. The wireframe was created using the Microsoft Axure tool. The tool included no actual functionality, but was showing a hypothetical scenario of interaction among several ATM stakeholders in the decision-making process concerning a change issue. The demonstrator tool was showing the multiple modelling perspectives (one per stakeholder), the capability of the automated reasoning techniques of analysing the models and identifying problematic aspects therein, the use of gamification to highlight important elements in the model and to foster collaboration, and the use of a platform-integrated communication channel to exchange messages among the stakeholders. The goal of this demonstration was to obtain early feedback on the concept of the PACAS platform that will be developed in the remainder of the project.

Evaluation Session

Finally, a session with the representative of NATS was conducted loosely based on the insights coming from the Validation WS0 to obtain further knowledge concerning the organizational aspects of decision-making processes in the ATM domain, the interactions among the stakeholders, and the possible factors that either inhibit or promote effective collaboration.

WS1 Results: Evaluation Session

As preliminarily identified during WS0 (see D2.1 for full details), WS1 insights confirmed that the most significant activities that characterize decision making during change management are at the tactical and strategic levels. The analysis of this interview has been summarised in Table 2.

<table>
<thead>
<tr>
<th>Key elements in decision making within the ATM system</th>
<th>Challenge</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activities and information in decision processes</td>
<td>Information management is a key issue especially for operative decisions. Improvement of this element might bring to system’s changes</td>
<td>SWIM Project has been proposed to create a more agile and efficient information management system</td>
</tr>
<tr>
<td>Actors in decision process</td>
<td>Change management processes are usually tactical and strategic decisions. They involve many actors. Usually this process needs to be pushed by one actor to achieve its goal. Coherently with insights of WS0, the decision maker is the head of each hierarchical level. Other actors (e.g. airlines) might be involved in such processes to give their view and actively participate</td>
<td>Within organizations, the final decision is mediated by the person who is responsible of the involved organizational function. Such processes are based on mutual trust and reputation among actors (e.g. between different NSPs)</td>
</tr>
<tr>
<td>Solving conflicts during decision processes</td>
<td>Change management might imply local challenges, which are driven by different plausible scenarios</td>
<td>Plausible Scenario: “There is a new communication platform to be</td>
</tr>
</tbody>
</table>

Table 2: WS1 results key points
perspectives (e.g. economic, organizational). For instance, a new technology might imply the change of a specific technologic asset implement in the firm. My firm still uses Windows 7. Should I upgrade to Windows 10 considering that security updates of Windows 7 will be discontinued in the near future?

**Improving decision processes**
Models might be useful to improve decision processes. Modelling techniques are diverse: Technical view (process modelling) service modelling, economic modelling, etc.

**Tools for decision making**
Integrated models should be used to think about and integrate different perspectives. Due to the fact that ATM is a very complex and not deterministic system, models might be used to: a) reduce complexity and focus attention on specific challenges/characteristics, and b) validate the decision making process. Validation can indeed be done via simulations to identify critical factors (e.g. identification of costs dynamics, efficiency level of processes, security and safety).

**SESAR2020 program puts infrastructure and modelling at the centre of program. It is a model centric approach. KPAs might be used to represent an organizational/economic perspective of a specific change.**

**WS1 Results: PACAS use-case and scenario**
As the PACAS validation scenario is one of the three main aims of this deliverable, we preferred to move the results of WS1, dealing with them, to a dedicated Section. As such the description of the PACAS validation scenario is contained in Section 4, together with the evolution of the scenario definition before WS1, that actually highlighted the necessity of a dedicated Workshop for the scenario building and to the definition of some useful requirements ("properties") for the scenario itself.

**WS1 Results: Wireframe Demonstration**
As said, to collect an early feedback on the PACAS platform that will be developed in the remainder of the project, the demonstration of a wireframe was conducted. The wireframe is described in full detail in D2.2: First release of the platform and guidelines. AB members’ reaction and feedbacks collected in D2.2 as well, however, for completeness, they are summarised hereafter.
1) It is unrealistic to force a strictly linear communication protocol on to the stakeholders. The PACAS platform should accommodate more complex communication schemas where the stakeholders may follow multiple branches in parallel and propagate changes on several perspectives.

2) The platform should provide a dictionary support for significant concepts and relations relevant to each perspective.

3) The platform should provide an organizational scheme of the stakeholders.

4) The platform should provide a global timeline of the change issue that is under discussion.

5) The platform should enable sharing models with other stakeholders.

6) The platform should add social incentives to increase the level of participation and engagement to the decision process.

7) The user interface should be enhanced to highlight changes, alternatives, and possible impacts in the perspective screens.

8) Many decisions in ATM are taken through the conduction of face to face meetings so the platform cannot support digital interaction only.

9) The avatar should not annoy the user; the platform should enable the user to turn it off.

Feedback 8 was probably the most important comment we received during WS1, and will be taken in particular consideration during the next steps of the project. However, all these feedbacks, described in full details in D2.2, will be considered as requirements for the platform building phase.

**WS1 Conclusions**

The main focus of WS1 was the scenario building described in the next session. As such the majority of the time of the workshop was dedicated to the discussions about the use case, decision points, and in general to the flow of the decisional negotiation all along the built scenario.

The scenario selected was an ideal European research call for the implementation of a Sectorless, flight-centred ATC, a novel way to tackle air traffic management in upper airspace without conventional sectors that has already been proven feasible.

The main feedbacks collected during the WS1 where about the wireframe and decision making process while little feedback was collected about the other dimensions of PACAS (e.g., modelling).

The results on the decision making process mainly confirmed the results of WS0, while the wireframe demonstration allowed the construction of a list of requirements for the platform building phase.
4 Use case and scenario

As stressed at the beginning of this document, one of the main difficulties of the initial phases of the project was the definition of the level of the decisions targeted by PACAS. The number of proposed use cases helped shaping the right scenario for the validation of the PACAS concept, and this is the reason why we briefly describe the evolution of the scenario within the initial phases of the project.

4.1 The scenario evolution

During the preliminary phases of the project several possible Use Cases were identified and discussed. Although none of them proved suitable for the validation of PACAS, from the reasons to exclude them some 3 features that the "right" scenario should have as requirements were identified, which guided the use case and scenario definition of WS1.

Feature 1: The Use Case should deal with a planned change.

The first possible use case for the validation of the PACAS concept was proposed during the Kick off Meeting: the closure of the Crimean airspace after Russian transports and newspaper reported that at least five Ilyushin-76 Russian transport planes landed at a Russian naval airstrip near Simferopol. In mid-February 2014, Ukrainian air traffic control services closed the airports in Simferopol and Sevastopol as well as lower airspace over Crimea "until further notice". This was followed by the closure of much of eastern Ukraine as a result of the tragic loss of MH17. This has not only had a major impact on the traffic over the whole of Ukraine, it has also affected the traffic flows in the entire region which needed to be reorganised. Indeed, as a result, Eurocontrol (European Organization for the Safety of Air Navigation) banned European airlines from flying to any airports in Crimea or passing through the region [14]. It was thus proposed in the PACAS KoM, to try to figure out whether the PACAS concept could be used to shape the proactive changes to the issue of flights over conflict zones by promoting and facilitating the sharing of information and risk assessments, and the impacts on the various aspects of the ATM.

***

However, the discussion that followed established that PACAS mainly aimed at the discussion of design time changes or planned changes to be implemented in ATM. As such, the closure of the Crimean airspace, showing the sole cascade effects of an event at run time without providing the planning of rearranging the traffic was out of the interest of PACAS. It must be noted here that this does not imply that the PACAS concept might not reveal its validity for this type of changes in ATM.
management, but only that the validation activities will be focused on planned changes in ATM architecture.

**Feature 2: The change should be the implementation of a widely accepted and well-known solution**

The IRIS project communication link was then proposed as a possible use case to be examined.

The European Union is moving towards the implementation of the Single European Sky ATM Research (SESAR) project that will introduce a new Air Traffic Management administrative, operational and technical concept. Satellite communications for Air/Ground communications (i.e., voice and data exchange between aircraft and flight control centres) have an important role to play in the future ATM infrastructure, both in Europe and in the rest of the world. In coordination with the EC, EUROCONTROL, ATSPs and the SESAR consortium, the European Space Agency (ESA) ARTES 10 Programme (“Iris”) intends to define and develop the use of Satcom for ATM communications in the future ATM system defined by SESAR. The ARTES Satellite Communication for Air Traffic Management element, or Iris, is the European Space Agency programme to support the development of a satellite-based communication system for European air traffic management (ATM). The Iris Programme is a new type of initiative for ESA, where the space component is one of the component in a much larger system, tuned to the needs of external partners and end-users who are not always familiar with satellite technology. Because of this, a long-term, incremental approach is necessary.

![Figure 9: System Wide Information Management enables sharing of digital information on the ground and in the air](image-url)
Iris, aims to make aviation safer by developing a new satellite-based air–ground communication system for Air Traffic Management (ATM). Currently, aircraft are tracked by radar when over land and in coastal areas, and flight paths are negotiated by radio. However, once an aircraft heads out over the ocean, ATM is no longer possible until it re-enters continental airspace. This means that flight paths are difficult to adjust in response to adverse weather and other factors, and wide buffers must be maintained between aircraft flying in a given oceanic corridor. Iris will provide the satcoms technology for this programme. Iris will provide air–ground communications for initial ‘4D’ flight path control, pinpointing an aircraft in four dimensions: latitude, longitude, altitude and time. This will enable precise tracking of flights and more efficient management of traffic. High-capacity digital data links via satellite carrying this information to cockpit crews in continental and oceanic airspace are expected to become the norm, with voice communications used only for specific operations. By 2028, Iris will enable full 4D trajectory management over airspaces across the globe and the data link will be the primary means of communications between controllers and cockpit crews. Table 3 contains IRIS project communication link key features.

Table 3: IRIS project communication link key features

<table>
<thead>
<tr>
<th>Current situation</th>
<th>Future</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>There are many Flight Information Regions (FIRs) in Europe</strong> (see left part of Figure 10). These FIRs manage their local airspace, and there is a flight handover when aircrafts cross from one to another.</td>
<td>Fewer FIRs (see right part of Figure 10) will result in fewer handovers and less fragmented route planning.</td>
</tr>
<tr>
<td><strong>Current flight paths follow non-flexible “highways” across Europe</strong> (see Figure 11 left part). Flight levels and landing slot given over voice radio.</td>
<td>4D trajectory route information shared between air and ground (see Figure 11 right part). Enables free-routing, and more flight path crossing. Less controller intervention.</td>
</tr>
<tr>
<td><strong>Route updates exchanged over voice radio to local FIR.</strong></td>
<td>Route information shared and updated over digital communication channel, all parties get access to information through System Wide Information Management (SWIM) (see Figure 9).</td>
</tr>
<tr>
<td><strong>Communication between cockpit and ground (ATM and Flight Ops) is shared using VHF band.</strong></td>
<td>VHF offload using satellite communication. Increases capacity, range (especially over for oceanic flight) and data rate.</td>
</tr>
<tr>
<td><strong>Communication between cockpit and ground is shared using insecure voice channel. Possibilities of misunderstandings (language and poor sound quality), VHF capacity over European HUBs is a serious problem.</strong></td>
<td>Security mechanisms to ensure authentication of aircrafts and ground, message integrity and possibly confidential communication (encryption).</td>
</tr>
</tbody>
</table>
Figure 10: Reduction of Flight Information Regions in Europe

Figure 11: 4D trajectory route planning will enable smarter exploitation of the air space over Europe
In order to use the implementation of the IRIS satellite communication system as the change to test the PACAS methodology and platform, a list of decision points was also identified for this use case:

- Free-route Operations Airspace sectors.
- The role, format and applicability of the Route Availability Document (RAD).
- Security requirements for data exchange (signature enough for all data, encryption need for some?).
- What information (e.g., activity of all pertinent airspace reservations areas) should be broadcast vs direct link?
- Should Electronic Flight Bag (EFB) be updated directly by the system in-flight, or must the pilots authorize data updates.
- Frequency, range and method of updates to flight plan distribution (data has a cost for the airlines).

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Again the problem of finding the right level of the decision(s) to be implemented came out in the IRIS Use Case. The decisions (e.g. the format of the RAD, the frequencies of the communications) seemed to be too specific and hard to explain to the domain experts in a workshop time.

Moreover, as the solution was highly technical, the AB experts might not know its details deeply enough to be able to forecast impacts and possible cascade effects on the different views. This was discussed as being a major problem of the Iris use case, as the WS50 confirmed. In order to comprehend the utility of the PACAS process and the added value brought by process and platform, the scenario has to be already highly shared and well known, since only if the Use Case is already "mature" in the knowledge of a member of the AB he will be able to argument and reason about all its possible aspects, drawbacks, improvements and impacts.

**The Illustrative Example**

Yet, the discussions about the level of the implementation of the Iris solution as the possible change to be discussed for the validation of PACAS, brought to a generalisation of the Iris scenario, which played a key role in the building of the illustrative example scenario described in D2.2: First release of the platform and guidelines. The illustrative example scenario allowed the initial presentation and explanation of the process and the platform, which will enable the further validation activities in WP5 in order to collect feedback for refining both process and platform.

The illustrative example scenario is an illustrative example of the creation and resolution of a fictional change issue in the Air Traffic Management (ATM) domain. As written in a more detailed fashion in D2.2, in our example, the European Aviation Safety Agency (EASA) initiates a new discussion by propagating a new change issue on the communication between aircrafts and air traffic control operators (ATCOs) in order to further secure the communication channels. EASA asks security and safety divisions of German Air Traffic Control (Deutsche Flugsicherung, DFS), as well as Jepessen as the single-point representative of airlines to discuss the issue and devise a solution. EASA adds a
Feature 3: The Use Case should have clear decision points.

During the pilot and face to face validation activities the so called free-route emerged as a possible use case for the validation of the PACAS concept.

By definition, free-route Airspace (FRA) is a specified airspace within which users may freely plan a route between a defined entry point and a defined exit point. Subject to airspace availability, the route can be planned directly from one to the other or via intermediate (published or unpublished) way points, without reference to the ATS route network. Within this airspace, flights remain subject to air traffic control.

It is a concept of providing air traffic services in which an operator can choose their route subject to only a few limitations (e.g. fixed entry and exit points and the need to avoid danger areas, TRAs or TSAs) as opposed to the situation where standard airways should be used. In most cases the straight line between an entry point and an exit point will be chosen. If for some reason this is not appropriate (e.g. a danger area needs to be avoided) additional turning points can be specified. These can be navigational aids, published navigational points or points with specified coordinates.

The following diagram gives an overview of the main FRA rules:
In the example FIR depicted, INTRO and ENTER are entry points, ALTAV and EXITO are exit points, SNA is a VOR and REKRA is an RNAV point. When FRA is implemented, the green routes would be accepted and the red routes would be rejected by the ATC flight plan processing system. The reasons for rejection include the crossing of a danger area (INTRO-ALTAV) and the requested route not remaining within the FRA (ENTER-ALTAV). The approved routes can be either direct from an entry to an exit point (e.g. ENTER-EXITO) or with intermediate points (navigational aids (SNA), published points (REKRA) or randomly selected points (42°39'26" N, 23°22'42" E)).

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As said, the free-route Use Case was proposed by an ATM expert during the so called pilot interview of WS0. The preliminary investigation of the possible impacts on the various perspectives of relevance for PACAS lead immediately to a set of "non-linear" consequences, namely the aspects where changing each other reciprocally in a complicate cascade effect. From the economical point of view there where both high and very low level aspects: the companies were gaining by the introduction of direct routes, the geodetic routes needed thus to be somehow commercialised to prioritise the aircrafts. Moreover, a direct route would mean a different distribution of en-route taxes to the various nations with major organisational and political consequences. Finally, an adequate datalink system must be implemented to support and ensure the right level of security to the ATM, but datalink comprises a wide range of security issues as well.

To summarize, the main problem of the free-route use case was that it did not map a single need or problem of the ATM world, with one solution to be implemented to solve it: free-route comprises a wide range of sub-problems which will be solved by a range of solutions that, coordinated together will enable the implementation of the FRA. As such this use case introduces too many non-linear effects into the system and therefore we couldn't understand changes nor derive from them clear decision points from the level of details that were provided.

### 4.2 The resulting scenario

After the whole discussion about the Use Cases, and the properties derived from their exclusions, the necessity to have a full workshop on the Use case and scenario definition was clear. The AB members were explained the targeted level of the planned change we wanted them to identify, and we asked them to propose changes of which they knew pros and cons, in order to be able to forecast their consequences. Moreover, we asked them to try to keep it focussed in order to be able to properly use it to test the PACAS concept. The procedure followed is described in detail in Appendix 2: Scenario building protocol, while in this Section we will briefly explain the ideas and discussions of the WS1 that yielded to the identification final Use Case and Scenario described in the next Section.

As described in Section 4.1 the AB members were provided with some sticky notes to write down the possible changes in the ATM domain as possible candidates for the Use Case.
The AB members proposed different levels for the targeted change, some resembling more to a general recommendation for the ATM then a proper change, as for example more protection from malware, noise reduction, performance improvement and simplification. As expected, the AB members experienced the same difficulty of the preliminary phases of the project to find the right level for the decisions targeted. Among others, the most relevant proposed scenarios were:

- Minimisation of delays in arrivals to major hub airports through airspace design optimisation, extended arrival management (Extended AMAN) and runway optimisation;
- Transition to the SWIM implementation deployment;
- Sharing delays/time gains with arrival management across states;
- Single sector operations: with the controller playing both as a planner and executive with the aid of tools such as advanced separation management or conflict detection;
- Optimisation of en-route airspace through dynamical management of conditional airspace;
- Pan-European airspace redesign;
- Collaborative Decision Making (CDM) deploy.
Keeping in mind the 3 Properties identified by the PACAS partners in the preliminary phases of the project, all the proposed use cases were discussed. The two initially selected were the CDM deploy and the Optimisation of en-route airspace through a multi sector coordination. In the second part of the Workshop the latter proved to be of too high level. The discussion on the possible options for its implementation got stuck and guiding it through the three Properties, mainly to reduce it at a lower level, it converged toward the resulting use case and scenario.

**Use case**

The use case selected after the Activities and WS1 was the so-called implementation of the Collaborative Decision Making (CDM), one of SESAR’s R&D frontiers. A variety of possible scenarios emerged inside this context, with a particular focus on the concept of sector-less ATM.

**Collaborative Decision Making (CDM): “best planned– best served”**

![Figure 14: The CDM use case as proposed by the AB members at the WS1](image)

SESAR is driving the creation of a European Air Traffic Management Network to handle the forecasted traffic increase in aviation, targeting some high level goals such as:

- Triple capacity;
- Reduce ATM costs by 50% per flight;
- Increase safety by factor 10;
- Reduce environmental impact by 10% per flight.

Airport capacity, in particular, was found to be one of the major bottlenecks for future growth and the implementation of an airport ATM network has been identified as a major solution for this challenge. The implementation of Airport Collaborative Decision Making (CDM) is the enabler for the creation of an ATM integrated network and the further developments toward a Single European Sky. Airport CDM is part of the SWP6.6. It is composed of two projects [15]:

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**Founding Members**

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• 6.6.1–Operations in adverse weather and/or exceptional operating conditions / recovery management;
• 6.6.2 – Integration of airport – airline/ground handlers – ATC processes (incl. turnaround) in ATM.

This second part aims at the:
• Integration of landside information (external actors) in an enhanced CDM;
• Integration / combination of processes and information of for example AMAN;
• User Driven Prioritisation Process into / with CDM processes;
• Development of enhanced information exchange in a SWIM environment.

Many complex processes, such as the ones related to Arrivals Management, Departure Management and Turn Around Management, etc. in air traffic management must work together to ensure that the large number of flights are handled orderly and safely. Indeed, CDM will apply across these as it facilitates the sharing of information between Airspace Users, Airport Operators and Air Traffic Service Providers. These processes must accurately interlock to ensure overall efficiency. Airport CDM process will help to optimally use available capacities and operational resources, reduce costs, improve punctuality, reduce emissions and strengthen partnerships that are, for example, strategic partnerships between Airlines and Airport Operators (e.g., British Airways and LHR Airports); strategic alliances between Airlines (e.g., One World, Star Alliance, etc.); ATS Operator and Airport Operators (AENA does both functions at many Spanish Airports; NATS and LHR Airports have a partnership at Heathrow). Airport CDM aims at optimizing processes at an airport. Its objective is a comprehensive exchange of information between all parties concerned and, thus, an efficient coordination of all work processes in connection with the turn-round process of aircraft. This coherent process comprises flight planning, landing and even the turn-round process on the ground before the next departure. The connection of the different system infrastructure elements ensures that the required data are available to all parties concerned at the same time. To accelerate change, it is crucial to work on feasible solutions that are acceptable to operational staff and to workers’ unions. To help them support the change, things must be simplified. Increasing complexity in the tasks of air navigation services shall no longer be accompanied by a more complex working environment (equipment, airspace, procedures, HMI). One of the possible simplification identified into the CDM frame was the unification of sectors for some flight levels and types of airspace. The beneficiaries of these change will range from air navigation service providers, to airports, airlines and ground service providers.

Sectorless, flight-centred ATC

Sectorless ATM is a novel way to tackle air traffic management in upper airspace without conventional sectors that has already been proven feasible. It envisions that each controller will be assigned several aircraft regardless of their location guiding them during the entire flight in upper airspace. This aircraft-centred approach provides more flexibility, fewer handovers and enables user-preferred routes together with a significant increase in capacity and controller efficiency. Already today there exist undividable sectors in which transit times will decrease, while the need for controller coordination will increase considerably. Flight-centred ATC addresses these problems by looking at airspace as one piece without conventional sectors.
So far, this concept has been validated assigning up to six aircraft to one controller, regardless of the aircraft’s geographic position. The controllers are responsible for these flights from the entry into airspace to the exit. A controller may only give instructions to the pilots of assigned aircraft. There are no more handovers between controllers as one controller guides the flight all the way through the airspace. There are no handover points, which decreases the need for controller coordination and enables pilots to follow user-preferred routes. A two-week feasibility analysis with eight controllers at the DLR facilities in Braunschweig has shown that flight-centred ATC could increase controller efficiency by more than 100%.

An even workload distribution and greatly reduced need for coordination allows controllers to work more efficiently and concentrate on their main task: conflict resolution. Additionally, controllers can work more flexibly and are no longer restricted by sector based licensing which is also known as validation. Indeed, in current operations a controller will be validated/licensed to work on particular sectors. To gain that validation they will have to have proved that they are competent to work on that sector. In the future environment this will be less important as the competence required will be related to the system and systemised method of operation. This opens up new possibilities for contingency solutions. Since there are no handover points between sectors anymore, pilots can follow user-preferred routes and have the advantage of only one contact person during their entire flight. Moreover, this concept allows for easy integration of new vehicle types with different flight performances, such as remotely piloted aircraft systems (RPAS) [16].

**Figure 15:** The Sectorless ATM concept with aircraft-centred ATC (left) in comparison with conventional sectoring (right). Credits [14]

**Scenario**

The scenario for the validation of the PACAS concept was thus created using the concepts illustrated so far. The main change issue was identified as the introduction of a sectorless ATC. An accurate trade-off between the economical, organisational and safety aspects would possibly lead to the
identification and analysis of alternative solutions for its implementation, each having a different impact on these perspectives.

In the scenario, SESAR makes a call for projects about the so-called ATM optimisation with the performance ambition (key performance area) to increase the operational capacity of an airport, which is usually defined as the maximum possible number of aircraft landings and take-offs.

![Figure 16: The SESAR performance ambition levels for 2035](image)

Indeed, these ambition levels are subject to the optimal development and deployment of the Operational Changes, made possible through SESAR Solutions, which are enabled through improvements to technical systems, procedures, human factors, and institutional changes supported by standardisation and regulation. The Master Plan [17] includes roadmaps of the identified changes, ensuring their deployment is planned in a performance-driven and synchronised way (e.g., between ground and air deployments) to maximise the benefits gained in four key features (illustrated in Figure 17).
In particular, the scenario focuses on “Optimised ATM network services” and “Advanced air traffic services”, which are foreseen as part of the FRA Operational Change, a dynamic management of the airspace (as described in the previous subsection).

According to a perceived need to change driven by a performance deficit, a consortium of universities, companies and other research institutes, with, say, the main interest in Germany, decides to apply to the proposal to propose a flight centred approach to ATM, no longer divided into sectors, where each controller guides the flight all the way through the airspace. As it is a novel approach, a feasibility study of the concept (low TRL) is proposed at this stage, where different possible ways to implement it are taken into account, discussed and evaluated in order to shape the main features and guidelines for the design phase. These differences in implementation will be driven by environment requirements, existing technology capability and capability of human actors. The solutions will be initially generalised and then specialised in later maturity states. Broadly speaking, those will be typically behavioural changes by the human actors with no technology change, purely technological change and a hybrid of both changes.

In the scoping phases of the project, the concept feasibility limitations and assumptions are defined, shaping the scale where the concept will be proved (e.g., unification of a few sectors, nation-wide or Europe-wide unification) and in what phases of the flight (departure, cruise and targeted flight level, approach, landing or a combination of them). Furthermore, economical, safety and organisational aspects will need to be balanced to identify the right number of flights which can be assigned to each controller in order to keep safety levels acceptable, which can be assessed by simulations and validation activities. The possibility to include external inputs from other research projects in SESAR, is thus tested by including into the decisional tree the impact (i.e., revised or new operational standards, infrastructures, procedures and operators’ training) of the final implementation of the System Wide Information Management (SWIM) by SESAR. It consists of standards, infrastructure and
governance enabling the management of ATM information and its exchange between qualified parties via interoperable services.

The introduction of this external factor (i.e., SWIM or any other ATM concept which is deployed jointly with this), which might be done automatically by the PACAS platform through a selection of possible affinities between the decisional issue selected and the other on-going SESAR project (i.e., all the ones dealing with the introduction of new or higher levels of automation such as STRESS aiming at addressing, analysing and mitigating their impact on the Human Performance aspects associated to the future role of ATCOs) and National research projects (i.e., TeFiS covering sectorless working principles), will propagate through the models of the economical, organisational and security perspectives, however, at this stage security issues (i.e., cyber-attack, which may impact availability (jamming), integrity (spoofing, corruption), and confidentiality) will arise as well, which, in turn, will have nonlinear effects on the other perspectives.

Below we describe the scenario in detail.

**Step 1:** SESAR makes a call for projects about ATM optimisation with the main KPA of increasing operational capacity of air traffic in Europe. The objective of SESAR is to find feasible solutions for Airport CDM to optimise flight operations and increase efficiency of the procedures. An accepted project within the call is conducting a feasibility study of a novel concept: sector-less ATM.

The first stage of the project was aimed at scoping the project, namely at defining the main limitations and assumptions of the work to be accomplished. Among them, the geographical area to apply the sector-less ATM must be defined: whether to limit it to the unification of a few sectors, or maybe to all the sectors in a national airspace, or to the whole European aerospace sectors. Such a decision has mainly Economical and Organisational aspects and impacts to be modelled and discussed through the PACAS platform. Moreover, the partners should decide what phases of the flight to consider, e.g., take-off, en-route, descent to the airport or a combination of them. At this initial stage, the PACAS platform mainly supports communication between the consortium partners and guides a creation/integration of the models and a high-level analysis of them.

Balancing the organisational, economical and safety impacts of the choices, the partners converge to the first two decisions: the flight centred ATM will be proved on a national base for the cruise phase, i.e., unifying all the sectors of a nation, and considering only the en-route phase.

**Step 2a:** The en-route phase comprises multiple flight levels. The unification of the sectors on each one of them corresponds to a different safety level that can be guaranteed. One of the partners of the project (e.g., the Deutsche Flugsicherung, or DFS) sets up real time simulations concerning safety in order to assess what flight level the project should focus on to guarantee an acceptable safety level. Possible options studied are: flight level 380 and above (cruise, only transiting Germany), flight level from 360 to 380 (at which many bypass and separation manoeuvre take place) and flight level below 360 (in which the huge variety of vertical manoeuvers make the airspace very complex to predict). The safety experts share the result of the simulations held through the PACAS platform, modelling the possible options and adding the hurt/help relations.

The platform avatar then helps the consortium reasoning about the results received and analyse the economic benefits that would arise from the unification of the sectors at all flight levels against the increase likelihood of safety issues of such a complex environment at one of the lower flight levels.
The consortium decides to go for the flight level 380 and above.

**Step 2b:** The organisation experts of the consortium raise a concern about the new procedures for the controller in a unified airspace, and in particular about the redefinition of the workload for each controller and possible relocation of the exceeding controllers. The consortium asks a human factor/organisational expert (HF) company (e.g., Deep Blue – DEM from UNITN) to study the possible options. The company finds two reasonable, acceptable options which, from a workload and HF and safety point of view, seem to be almost equivalent (the pros/cons of each pretty much balance the ones of the other). In the first one, ATC is responsible up to seven aircrafts while for the second option a team of two ATC is in charge of up to fourteen flights. Redundancy guarantees, coordination threats, workload distribution and other aspects of the two options are included in the model to detail the two options, however, no tangible difference can be assessed from a HF point of view, i.e. the PACAS platform can also deal with situations in which an actor does not converge to a preferred decision.

The consortium analyses the results of the analysis through the platform, but this time from an economical perspective, and concludes that the 1-controller-7-aircraft option is cheaper not only in terms of salary but also training, available hours per time period, pension and so on. In the case of 7, or multiple of 7, the former option would force you to keep a team of 2 controllers anyway.

**Step 3a:** An external factor is now introduced to force and stress the PACAS methodology: it is assumed that at a certain point of the project/discussion process, the SESAR solutions found to implement the System Wide Information Management (SWIM) become operational. The implementation of SWIM, among others major changes, would mean a significant change in the paradigm of information management across the whole European ATM network. Roughly speaking, this means the introduction of datalink as major/sole way of handling all aircraft information. It must be noted that we forecast here the (reasonable) possibility for the PACAS platform, to be able to automatically detect new SESAR solutions (from the EATMA repository through some keywords) that may have an impact on the issue discussed and to alert the stakeholders of the possibility to introduce them into the decision options.

The traditional focus of Communications Navigation Surveillance (CNS) security has been protecting against physical attacks and Radio Frequency Interference (RFI). It is currently not possible to prevent some of these attacks, such as jamming of RF signals (including air/ground data link and voice communications) and spoofing of voice communications. This is well understood, with standard procedures to manage a loss of service. In many cases (partly for Communication and Surveillance) the service will not be impacted because of the distributed architecture of the ground systems.

Furthermore, the systems are also vulnerable to cyber-attacks, which may impact availability (jamming), integrity (spoofing, corruption), and confidentiality. It may be assumed that for digital communications (including datalink) security best practices are being implemented across the networks (e.g. SWIM technical infrastructure). However, the likelihood remains that a successful attack could potentially impact datalink, either via the supporting ground systems and network, or via RF jamming. The use of datalink as the “major/sole way of handling all aircraft information” might result in a more vulnerable system. This is also true for all the new services/developed for the
“Management of Common Network Resources Service” as part of the security infrastructure of the ATM systems (i.e., European IPS Repository (CNR/EIPR) - Security Certificate Service (CNR/SCS) and so on). Indeed, there was also a stronger focus on security with the upgrade of the information security management system and the preparation for a new security managed service, including the Security Information and Event Management/Security Operations Centre to be deployed in 2016 [18].

According to the scenario, different security aspects could be investigated such as:

- the potential impact of loss of datalink on safety, capacity, service level, etc., resulting from possible attack scenarios (including potential geographical extent and duration)
- Systematic analysis of the risks
- Selection of controls (technical, procedural, ...)
- To support the prevention of an attack
- To facilitate recovery to normal operations after a successful attack

The above activities, forming part of a standard risk assessment, will be discussed with the AB members and detailed in dedicated deliverables². As such, DFS is asked to perform a security cost/benefit assessment based on real time simulation to analyse the pros/cons of the possible use of 1 or 2/3 frequencies for radio communications, however they are not able to perform any simulation for the datalink option which will be performed by other security experts (refer to step 3b).

Their analysis shows clearly in the PACAS platform that the multiple frequencies options do not add any valid benefit and that the single frequency option is actually secure enough but they give no feedback on the datalink option.

**Step 3b:** The Consortium asks a security expert (e.g., SINTEF), which has already performed studies on datalink communication, to report the major results of the analysis performed on the PACAS platform, filling the models with the most reasonable options for the datalink implementation and their help/hurt relations to help them reasoning about the decision. SINTEF compares three different options (which are very close to the Iris options, see Section 4.1): encrypted data, signed data or a hybrid approach with some data partially signed and some other data partially encrypted.

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² N.B.: The main objective of PACAS is NOT to provide any final conclusions on the sector-less ATM concept itself or provide an exhaustive security risk assessment report, but rather to use this as a test-scenario to validate the method and the platform, which are intended to improve multi-stakeholder decision making through gamification and automated reasoning techniques. Consequently, the listed security aspects are only intended to matter for reflection during the workshop or offer hints for the modelling activities.
The PACAS avatar encourages the stakeholders to analyse the options through the different perspectives using automated algorithms and intuitive explanation of the results of the analysis performed by SINTEF. The consortium concludes that the hybrid datalink is the preferable option.

**Step 4:** The consortium, with the aid of the platform, easily gathers all the analysis performed and collects them into a decision tree which will constitute the main body of the final report.

The SJU, who is in charge of assessing the maturity level of the project, has a clear picture of the rationale and the empirical evidence behind all decisions and trade-offs that have been performed, proving the improvement brought by the PACAS platform and methodology to demonstrate maturity level of a change implementation by helping and keeping track of the entire process.

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3 This is one of the envisioned possible form
5 Conclusions

This deliverable makes three main contributions. First, it states the PACAS concept, dividing it into the PACAS process and the PACAS platform, both to be validated during the course of the project. Second, it illustrates the plan for the validation of the project, by illustrating the iterative strategy we plan to apply, the overall criteria that will be used, the assumptions and limitations for the project and its validation and the time schedule for the validation. Moreover, as the Advisory Board plays a key role in the project, a detailed description of the members and their skills is provided. As such, a detailed description and the results of the validation Activities conducted so far are shown in this document. Third, the validation scenario, and the process that lead to it, are shown in this document. This is of main relevance as it was built by the AB members as the result of the first validation activity of the project, i.e., WS1, and will be used during all the future Validation Workshops of the PACAS project. As a matter of fact, the case study provides an example (it is only a means) of how the PACAS gamified platform should work (please refer to [19]. The main objective of PACAS is NOT to provide any final conclusions on the sector-less ATM concept itself, but rather to use this as a test-scenario to validate the method and the platform, which are intended to improve multi-stakeholder decision making through gamification and automated reasoning techniques.
References


Appendix 1: Interview Questions

A - General questions on decision making

QUESTION 1. May you provide us with examples of ATM related decision making in which you were involved? What are the most important steps?

QUESTION 2. Who/what was the decision-making intended for? (For the organization, for yourself, etc.)

- ISSUE 1. How critical was the decision with respect to the overall objective of the ATM?
- ISSUE 2. What is the most important kind of information you need to take decisions?
- ISSUE 3. Is this kind of information represented in one or more ATM chart pattern you use?
- ISSUE 4. To fully understand an ATM chart pattern, up to what point you need an explanatory text?

QUESTION 3. What are the most significant activities in the decision-making process and how important is your role in the process as a whole and why?

QUESTION 4. Who are the parties involved in the decision-making process and what are the main obstacles for effective cooperation during the decision-making process?

- ISSUE 1. How do you resolve these obstacles?
- ISSUE 2. Can you give examples of scenarios where it is difficult to reconcile different points of view of different stakeholders?
- ISSUE 3. What are the organizations involved in the decision-making process?

QUESTION 5. Is the decision process always made collectively? If so, can you give an example? If not, can you explain why and give an example?

QUESTION 6. Who is responsible for the final decision? Do several types of decisions involve several managers? Can you give some examples?

QUESTION 7. How would you improve the process?

QUESTION 8. How important is the reputation compared to the formal relationships (e.g. hierarchy)?
QUESTION 9. How much is trust important in your relationships (for example, personal trust and mutual understanding)?

QUESTION 10. Are there other important elements in decision making?

B - Domain analysis on modelling languages

QUESTION 11. Do you use any modelling language to represent ATM scenarios? For what stage are more useful (e.g. design and modelling)?

QUESTION 12. What type of information allow representing the modelling languages that you are using? (Data Structures, processes / activities, physical infrastructure, component software, interface ...)

QUESTION 13. What is the ATM model lifecycle? Who creates the first version of an ATM model? Who reads, comments, updates and approves it?

QUESTION 14. How would you improve the current modelling language of ATM systems?

- ISSUE 1. What information would you represent?
- ISSUE 2. What do these modelling languages not support?

QUESTION 15. Do you know of any other modelling languages used for the design of ATM systems? How is evolution of ATM systems managed?

QUESTION 16. What kind of software do you use to create models? (Visio, PowerPoint, UML, TOGAF ...) What are the pros and cons of these instruments?

QUESTION 17. What are the main activities for which they are created (planning, analysis, decision making, documentation, etc.)?

- ISSUE 1. What kind of use do you do of the model? Create, update, comments or approve?
- ISSUE 2. What are the most useful features of the models that you use?
- ISSUE 3. What are the characteristics of these models less useful?

QUESTION 18. The ATM systems are constantly changing. Are you keeping track of the different versions?
Appendix 2: Scenario building protocol

Interactive scenario building session objectives

- Collect a set of realistic change issues regarding the ATM domain
- Identify actors involved in decision making process for the selected changes
- Create a story flow for two selected change issues
- Identify the dynamics of actors’ interactions

Steps

1) Identifying change issues
   a) Time: 50’ + 10’ buffer
   b) Objective: To identify two design time change issues to be used for scenarios
   c) Specific tasks for roles:
      - Facilitator: Initiates the discussion. Checks that the activities are completed in a timely manner. Steers the discussion if it halts.
      - Critic: Deepens the discussion on the presented ideas by stating the possible shortcomings through the use of positive reinforcement.
      - Enabler: Provides guidance and support in the identification process, while taking a neutral stance.
      - Observer: takes notes, try to identify concepts and relationships mentioned in the proposals.
   d) Flow of interaction:
      1. The facilitator explains the objective, process, and the basic terminology to be used to the participants. [10 mins]
      2. Divergence stage for the change issues: [10 mins]
         o The facilitator asks the participants to write down on post-it notes two possible design level change issues per participant.
         o After sufficient time the facilitator ends the writing session.
      3. Refinement stage: [20 mins]
         o Each participant shares its ideas by sticking the notes to the white board and by briefly explaining them.
         o The participants discuss ideas, they merge, link, and explore the initial change issue proposals
The participants also eliminate proposals that are not relevant to PACAS project, such as run-time changes.

4. Verification stage: The facilitator directs the participants to select two proposals to focus on to build the scenarios. [10 mins]

Note: it is possible that step 1 takes less time. If that is the case, more time will be devoted to the following steps, especially step 3.

2) Scenario building
   a) Time: 60 mins
   b) Objective: To identify decision points, state alternative decisions and their impacts, describe main activities, discover stakeholders involved in the decision making process and capture the main interactions between stakeholders.
   c) Specific tasks for roles:
      • Facilitator: starts the scenario building by asking generic questions: Who? What? When? How? Divides the participants into two groups and assign critics and enablers. Makes sure that the discussion goes on during the session. Encourages participants to relate their past experiences with the change issue in discussion.
      • Critic: Questions an actor’s involvement in the process. E.g., does XXX really contribute to the decision making? Encourages participants to relate their past experiences with the change issue in discussion: E.g., is this how you/your institution contribute? Asks details about activities. But what is the objective of XXX? Asks details about alternatives and impacts? Does XXX have an impact on security? how? But this may create problems in YYY.
      • Enabler: Encourages identifying new actors/interactions by asking who talks to this (existing actor)? Who says/sends/requests what? Encourages adding new activities by asking what else do they do? Encourages identifying decision points. E.g., have you ever witnessed a change issue about this point? Encourage describing alternative decisions and their impacts by asking what could be another solution? Does XXX get affected by this?
      • Observer: takes notes, try to identify concepts and relationships mentioned in the proposals.
   d) Flow of interaction:
      1. Joint session:
         • The facilitator explains the three types of cards that will be used: analysis, outcome, communication.
         • The participants are divided into groups by the facilitator based on their interest in / relevance for the scenarios.
      2. Split session
         • Enablers initiate the discussion and ask participants to identify the actors involved in the decision making process—starting from those that come up during the previous discussions—, their activities, communications, and outcomes.
• Critics questions whether the identified entities are really involved, their relevance, require more details
• Enabler suggests new entities if the discussion is stuck, ask specific questions. They also help building the flow among the identifies entities.
• The facilitator makes sure that significant progress has been made within the allocated time frame.

3) **Scenario walk-through**

a) Time: 10 mins (but can be considerably longer if we have sufficient time)
b) Objective: validate the input of the participants
c) Specific tasks for roles:
   • Facilitator: Wraps up the session.
   • Participant: Goes over the collected input and sketches.
   • Moderator: Reflects the changes into sketches (if any).
   • Observer: takes notes, try to identify concepts and relationships mentioned in the proposals.
d) Flow of interaction:
   1. For each scenario, a representative participant repeats the story flow generated by the group
   2. All the participants validate the generated scenario, suggests changes if there is a misunderstanding
   3. All other members support constructively the session, but try to not interfere with the content of the scenarios
   4. The facilitator ends the session.

4) **Supplies needed**

a) Pen
b) Paper
c) Post it notes
d) White boards
e) White board markers
f) Screens
g) Cards: Analysis (see Figure 18), Outcome (see Figure 19), Communication (see Figure 20)
### Analysis

<table>
<thead>
<tr>
<th>Why?</th>
<th>What is the purpose?</th>
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<table>
<thead>
<tr>
<th>What?</th>
<th>The matter or issue that is being discussed</th>
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<td></td>
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<table>
<thead>
<tr>
<th>How?</th>
<th>Face-to-face, Skype, MSI? Any supporting tool or model?</th>
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### Outcome

<table>
<thead>
<tr>
<th>Originating analysis:</th>
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<td></td>
</tr>
</tbody>
</table>

### Alternatives

What are the identified alternatives? Use only one row if only one option was identified.

<table>
<thead>
<tr>
<th>Alt ID</th>
<th>Description</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
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<td></td>
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</tbody>
</table>

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**Figure 18: Elicitation Card – Analysis**

**Figure 19: Elicitation Card – Outcome**
### Figure 20: Elicitation Card – Communication

<table>
<thead>
<tr>
<th>Communication type</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Examples are</td>
<td>What actor sends the message?</td>
<td>What actors receive the message?</td>
</tr>
<tr>
<td>- propose/accept/reject a change or solution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- inform about something</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- ask for clarifications</td>
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</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Communication means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mail, oral communication, telephone, ...</td>
</tr>
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</table>