European Commission

2050AP Report Summary

Project reference: 284529
Funded under: FP7-TRANSPORT

Final Report Summary - 2050AP (The 2050+ Airport)

Executive Summary:
The 2050+ Airport project has been commissioned by the EU-Commission, DG Research, to explore radical and novel solutions to prepare airports for the year 2050 and beyond. Key to the project is the assumption that the airport of the future must address a wide variety of different, sometimes contradictory objectives. To this end, the project has developed three different concepts to support development of the airport of 2050 and beyond:
• The time-efficient airport concept to maximize the value of time through efficient and effective air transport operations,
• The cost-effective airport concept to create an airport with extremely low operating costs and optimal revenues, and
• The ultra-green airport concept to make the airport self-sufficient regarding its energy needs and to support climate neutral operations with limited noise exposure to municipalities surrounding the airport.

These concepts aim to provide insight into the time-efficient, cost-effective and ultra-green airport of the future including the level of performance that can be expected. The concepts have been developed by analysing a baseline reference airport and identifying all processes, operations and infrastructural bottlenecks that could be improved. The resulting concepts are composed of several solution elements yielding added value compared to the reference situation. Airports and related stakeholders may choose from these different concept solutions those that fit best their airport in preparation for the year 2050 and beyond.

By developing these three concepts, the 2050+ Airport aims to provide the seeds to feed the long-term development of airports in Europe. The project's main activities focus not only on concept development, but also on building a methodology for concept development, providing partial concept validation and disseminate results to stakeholders.

These main project activities comprised:
• Building a Methodology for airport concept development:
A concept development methodology has been defined based on the well-known Value Operations Methodology (VOM). Central to VOM is the idea to express the value of a concept by its performance difference compared to a reference concept. VOM further provides a high-level set of objectives and attributes based on a thorough assessment of the different airport stakeholders and their interests.
• Development and delivery of three airport concepts:
Using the above concept development methodology, diverse ideas/solutions have been captured through workshops, expert judgement and brainstorming sessions. This in turn lead to the creation of an initial version of the concepts according to the methodology, which has been further refined by a number of validation activities in the course of the project. The concept documents have been updated accordingly following a spiral life cycle until the concepts were considered sufficiently mature.
• Partial validation of these concepts:
Validation activities have been performed to increase the maturity level of the concepts from V0 to "late" V1 (according to the E-OCVM) and to enable their performance assessment. During a first cycle, validation activities were aimed to achieve V0 by initially assessing the value of concept ideas with respect to stakeholder needs and key performance indicators formulated. The second cycle applied analytical methods to further refine and quantitatively assess the concept ideas solutions. This task aimed to ensure coherence of the maturity levels achieved by each concept.
• Dissemination and assessment of feasibility:
Three workshops have been organised during the project to ensure alignment with airports and other stakeholders as the potential "customers" of the operational concepts, to allow for timely feedback and to capture new innovative ideas. The objectives of the three workshops have been:
• 1st Workshop: To ensure commitment on innovative ideas by feedback on the assessment methodology and by capturing innovative ideas for airport concepts directly from stakeholders. This workshop has been organised and took place in March 2012 in Budapest.

• 2nd Workshop: The focus of the 2nd Workshop has been to achieve consistent results for the first cycle of the validation, feeding the second cycle of validation and the second part of detailing the airport concepts. Inputs to the workshop have been the gaming sessions, the validation plan, and the methodology and initial concepts developed earlier in the project. Simulations and modelling tasks started just after the workshop is held. This workshop has been organised and took place in June 2013 in Madrid.
• 3rd Workshop: The final workshop allowed the project consortium to disseminate final results with relevant stakeholders to share experience and evaluate the final outcomes. A common understanding of the three concepts developed, together with the results of the corresponding validation activities, provided the opportunity to collect attendances' feedback in order to identify future research possibilities in the area of interest.

The reader is referred to attached Figures 1 - 3 visualizing the Time-Efficient, Cost-Effective and Ultra-Green airport concept, respectively.
Project Context and Objectives:
Project context

Europe and its surrounding world is changing rapidly and towards 2050 a strong increase of air traffic demand is expected due to an increase in population and consumption rates world-wide, as well as strongly growing economies in the BRIC (Brazil, Russia, India, and China) countries and other emerging markets. In Europe, air traffic demand is expected to grow as well, although at a more moderate pace and under heavily constraining conditions of scarcity of resources, increased prices of fossil fuels and the need to limit environmental pollution, in particular CO2 emissions.

The increase in European air travel demand is a result of the growing desire and ability of people within and outside of Europe to travel. This increased demand can only be accommodated if the European air transport industry is able to meet its targets to significantly enhance mobility, cost-efficiency and sustainability for door-to-door travelling. This is no easy task, but fortunately a number of Time-Efficient, Cost-Effective and Ultra-Green improvements have already been initiated within the European SESAR and CLEANSKY research programmes and can be expected to be in place by 2025 – 2030. For 2050 and beyond, however, a much more radical set of solutions may be required. It is here that the AP2050+ project steps in, developing airport concepts for the far future.

The Flightpath 2050 report sets the objective to allow 90% of European travellers to be able to complete their intra-European door-to-door journey within four hours. Europe will only meet this objective if the European Transport Network improves significantly, meaning that:
• The connectivity between the critical nodes (hubs) of the Air Transport network has to improve
• The connectivity between the Air Transport Network and other modes of transportation has to improve
• The network of nodes has to expand to offer full coverage
• A seamless service provision has to improve door-to-door travel time and meet the requirements for user-friendliness, sustainability and undisturbed service provision

Airports are the major nodes of this European Transport Network and, even though parts of the network are functioning well already today, the network itself is far from complete and far away from providing full network connectivity and door-to-door transport services against the most competitive prices, centred towards the passenger, and in the most environmentally friendly way.

This justifies the development of advanced airport concepts, reflecting the need to improve the airport's performance as the critical nodes in the European Transport Network. In a competitive world, constrained by several limitations, European airports have to develop to enhance their operations, strengthening their role in the network:
• Airports have to improve their connectivity with other airports and their catchment area by offering seamless service provision to their passengers. This justifies the development of a Time-Efficient airport concept for 2050, improving seamless operations and removing delays and other hurdles in travelling whenever possible.
• Airports have to reduce their costs and increase revenues to cope with an increased competition from other modes of transport (e.g. high speed rail, autonomous vehicles) and increased resource costs (including fossil fuels, land costs etc.). This justifies the development of a Cost-Effective airport concept for 2050, reducing costs and improving efficiency and revenues whenever possible.
• Airports – and Air Transport in general - have to reduce their impact on the environment by reducing not only emissions and noise, but also its overall consumption of resources and its production of waste. This justifies an Ultra-Green airport concept for 2050, reducing the burden on the environment as much as possible.

In the 2050+ Airport project, the European Transport Network of 2050 is assumed to consist mainly of already existing, yet upgraded airports, with limited possibilities for the construction of brand new airports. Existing airports shall have to expand and modernise their operations to cover full 4-hour door-to-door services throughout Europe, even though some airports already provide at present an elaborate network of transport services within their catchment areas. The focus of the 2050+

Airport project is on civil commercial air transport operations, excluding military air transport or general aviation but including, to a limited extent, other modes of transportation linking airports to their catchment areas. Very specific and dedicated service provision such as airships and/or cargo drones operating from dedicated airfields, and/or dedicated cargo rail transport lines are considered less relevant for the network of interest.

Project objectives

The main objective of the 2050+ Airport project has been to explore radical and novel solutions to prepare airports for the year 2050 and beyond. This objective was achieved by performing the following tasks to achieve the underlying sub-level objectives per work package:

• WP1: Overall management
The objective of WP1 has been to ensure satisfactory project progress towards its goals by implementing the management processes detailed in the project management plan. This entailed – amongst other things- organising the kick-off and all subsequent project progress meetings as well as inviting external participants to the three workshops held in the course of the project. In addition, WP1 work included reporting on project progress and attending review meetings with the EC.

• WP2: Building a methodology for airport concept development:
The objective of WP2 was to define a concept development methodology to guide the development of the three airport concepts in WP4. This objective entailed developing an elaborate methodology to develop high-level airport concepts (at a V0 – V1 maturity level according to the E-OCVM) consisting of the following documents as part of deliverable D2.1, the Concept Development Methodology:
• D2-1-1: Vision 2050, giving an outline of the 2050+ future (based on existing literature) to envisage boundary conditions for concept development.
• D2-1-2: The methodology framework and outline of the Value Operations Methodology, providing the means for quantification of potential benefits.
• D2-1-3: The Concept Context and Architecture Description Method (CAD), describing the method to analyse current airport operations and identifying bottlenecks to be solved by creative solution finding.
• D2-1-4: The Change Impact Method (C-I) to categorise the different changes to airport operations proposed by the solutions, and to perform initial quantification of their impacts on stakeholder value.
• D2-1-5: The Methodology manual, providing a short overview of the entire D2.1 development framework.

In addition, after developing a draft of the methodology a WP2 workshop (task 2.2) was organised to get feedback on the methodology and capture initial ideas for the WP4 airport concepts

• WP3: Partial validation of these concepts:
The objective of WP3 was to develop a validation plan and to implement this plan by organizing several validation activities to increase the maturity level of the WP4 airport concepts from V0 to “late” V1 (according to the E-OCVM) and to enable their performance assessment. This objective was achieved by implementing three phases: a 1st validation cycle, a 2nd validation cycle and validation integration. The first cycle aimed to validate the WP2 methodology and WP4 airport concepts at a V0 maturity level. The second validation cycle focused on achieving a V1 maturity level of the airport concepts – this by employing analytical validation methods to quantify the performance with respect to the baseline. The validation integration phase, finally, focused on identifying ideas from different airport concepts that could be combined to improve the overall efficiency of an airport.

• WP4: Development and delivery of three airport concepts:
The objective of WP4 was to incrementally develop the three airport concepts central to the 2050+ Airport concept. By applying the WP2 concept development methodology, initial concept ideas were captured through workshops, expert judgement and brainstorming sessions. This lead to the creation of three initial concepts: the time-efficient airport, the cost-effective airport, and the ultra-green airport concept. Subsequently, the concept documents were incrementally updated and improved based on elaborate feedback/input from the WP3 validation activities and workshops.

• WP5: Conclusions
The objective of WP5 was to collect the conclusions of the work performed in the project and integrate them in a final report and provide recommendations to airport stakeholders, the EC and the research community. This objective entailed:
• D5.1 Final Report: summarizing all work performed in the project, drawing conclusions from it and providing an integrated ‘Mixed’ airport concept combining the best ideas (according to the WP3 validation activities) of all three airport concepts
• D5.2 Recommendations: formulating detailed recommendations based on the conclusions drawn from the project for all stakeholders. This entailed recommendations for (1) direct stakeholders, such as airport managers, ANSPs, industry, airlines, passengers and greenfield airport developers; and for (2) the research community including the EC.

• WP6: Dissemination and assessment of feasibility:
The objective of WP6 was to develop the project's dissemination strategy and to implement this strategy. This entailed setting-up and maintaining the project website, developing brochures, a project movie and other dissemination material and organizing, in close cooperation with WP2 and WP3, three workshops to ensure the project's alignment with and timely feedback from stakeholders.

Project Results:
Below, an extensive description of all science & technology results obtained in the 2050+ Airport project per work package (excluding WP1 – management). For each WP the (1) methodology employed, the (2) main results, and the (3) conclusions are listed.

WP2: Concept Development Methodology

Methodology
In WP2, a Concept Development Methodology (CDM) has been iteratively developed throughout the project to support the development of the three WP4 airport concepts by means of an adequate methodology framework. The CDM is described in five documents, al contained in deliverable D2.1 (Development Framework):
1. Vision 2050 (D2.1.1)
2. Methodology framework and introduction to the Value Operations Methodology (D2.1.2)
3. Concept Architecture Description (CAD) (D2.1.3)
4. Change-Impact method (D2.1.4)
5. Manual, providing a high-level summary to guide WP4 (D2.1.5)

Each part relates to a different step in the concept development (linked to WP4) and validation and performance assessment (linked to WP3). This is shown schematically in Figure 4.

The CDM consists of three main steps: (1) concept background determination, (2) context analysis and solution generation, and (3) concept impact analysis. Solution generation and analysis of the impact of the solutions has been an iterative process during concept development in the project, allowing both consortium members and stakeholders to continuously re-evaluate any new or improved solutions within the three airport concepts.

Main Results
Main result of WP2 has been the development of a Concept Development Methodology (CDM). This methodology is laid down in five documents (listed above) which provide the following content: see Table 1.

Within the 2050+ Airport project, WP2 played a crucial role by (1) providing a clear and common view on the world of 2050+ (the vision document), by (2) advocating a concept development process focusing on added value compared to a baseline airport concept, by (3) proposing different views to elicit different types of solutions, by (4) describing different tools to capture and further develop high-level concepts, and by (5) proposing an elaborate change-impact method to both qualitatively and quantitatively measure the impact of new concept ideas on (relevant KPIs related to) the sustainability, cost-effectiveness and time-efficiency of the airport.

Apart from D2.1, the Methodology Framework, the work performed in WP2 also resulted in the organization of a workshop and subsequent delivery of D2.2, the Framework Workshop Results. This workshop was organized in March 2012 with a twofold purpose. First, the workshop aimed to gather feedback and ideas from the aerospace industry and academia with respect to the goals, challenges and solution directions applicable to each of the three concept airports. To that end, three brainstorm sessions were held resulting in extensive feedback (27 A0 sheets of notes) providing a valuable starting for the WP4 concept development work. Second, the concept development methodology itself was reviewed. The overall response to the methodology was positive and attendants expressed confidence in the preliminary value structure and methods forming part of it.

Below a more elaborate description of the 5 documents describing the concept development methodology.

Vision 2050
In order to develop solutions that meet the needs of future airports, a good and as precise as possible knowledge on the different factors that might affect in a relevant way the air transport sector during the next decades is required.
From the research developed in this direction, in which several sources were reviewed (UN, EC, ACARE research programmes, etc.), four main big changes and trends were spotted. These will be the origin of the main challenges that future airports will have to face (and solve):

- Airports will be full. Air travel growth will have congested large airports even further, forcing them to expand where possible, but with some reaching the absolute limits. This will have created growth of other, middle-size airport and small airports.
- Airports will be scrutinized more than ever in terms of time-efficiency, cost and, environmental sustainability. Passengers and public will expect the industry to be completely mature, and to offer them the best and punctual service possible, at lowest cost and in such a way that is perceived as sustainable.
- Airports will have better technology. The implementation of the Single European Sky ATM Research (SESAR) and near-complete data connections in most of the world will allow unprecedented data-exchange, information sharing, planning capabilities and efficient performance.
- Airports will be integrated. As travellers will look upon their mobility as an end-to-end event, focus will be on the overall level of time, efficiency, cost and sustainability. They will expect seamless connections to road, rail and air transport and as such, integration and cooperation between these modes will become abundant.

Additionally, a stakeholder analysis was performed and the main agents participating in and influencing airport operations by 2050 were determined.

Finally, with the knowledge acquired on future context and future stakeholders around the airport, the characteristics of the background present around 2050 airports were determined. This was an essential step towards determining the needs and objectives that they will have to fulfil by then.

Methodology Framework and introduction to Value Operations Methodology
In this part of the Concept Development Methodology a framework was proposed for the concepts development, describing what herein the place and role are of the selected value theories and tools that consortium members would use to develop their airport concepts. Also, the main philosophy that would drive the concepts development was introduced: the value-focused thinking. The main advantage of value-focused thinking is that the consortium was able to first determine the values or objectives for the different airport concepts, which could then be used to drive the solutions for the 2050 airport. This is opposed to traditional approaches in which the concepts would have been developed before a stakeholder and objectives analyses were performed.

The framework proposed sees a top-to-bottom approach for developing the airport concepts, using the Value Operations Methodology (VOM) to determine key value drivers for the 2050 airport and to evaluate these by measuring how much the main objectives of the airports are achieved. This methodology is developed following the value-thinking philosophy. Subsequently, the consortium partners took this VOM a level deeper to determine, for each concept, a highly specific focus on value drivers and metrics, stressing this way what are the most important objectives for each airport concept.

The framework also set a scope for the project: it was proposed that the main focus lies on the airport itself (its operations, economics, technologies etc.) and to consider the outside air traffic and Air Traffic Management (ATM)-system as much as possible as a ‘black box’ from which traffic and passenger are supplied.

Concept Context and Architecture Description
Here the Context and Architecture Description (CAD) method was introduced, which essentially consisted of two steps:
1. Context analysis: This step delivered a clear analysis of the processes, cost/revenue structure and environmental features a general airport nowadays has and how these will change up to 2050. This, together with the objectives or key value drivers determined through VOM, provided all partners with a clear understanding of their areas of interest for the 3 concepts. Initial methods to facilitate this are e.g. IDEF (Integration DEFinition) or sequence diagrams for process analysis.
2. Determining solutions for future airport concepts: Based on the information gathered from step 1, partners were challenged to think in a structured but creative way about the detailed aspects of their context (costs, processes, environmental activities) to determine where changes are needed for 2050 and along which lines these are possible. The activities performed to develop this step were mostly brainstorming sessions and gathering input from industry experts during the Validation Workshop in WP3, though other tools or methods for this step were provided to all consortium partners to use them whenever they deemed most opportune (e.g. the theory of constraints and morphological grids).

These two steps helped all consortium members in establishing a framework for the context analysis and the solution development during the concept development process, allowing them, departing from the Vision 2050 and the Value-focused thinking approach, to create the future airport concepts that would answer future air transportation needs.

Change-Impact Method
The Change-Impact Method was used by industry experts in the Validation Workshop performed in WP3 to evaluate the solutions generated in each airport concept, with the final objective of quantifying the impacts of these solutions in future airport performance indicators.
The solutions developed in the three airport concepts were described to experts, so that they could understand their operational impacts in the airport concepts and then they used a simple qualitative scale, which later on would be translated to

a quantitative one, to calculate the overall value that each solution would add, comparing the impacts to the current state of operations at airports.

Methodology Manual
This manual served as a guide that included the most key agreements with respect to things such as concept definitions, abbreviations to be used and tools or methods that can be employed when applying the Concept Development Methodology. Consortium members could use it as reference to check how the various sub-methods are related and what their functions are in the development of WP4.

Conclusions
In the first place, a draft of the Concept Development Methodology was distributed amongst all consortium members to provide the framework and common view on the development of airport concepts early in the time-span of the project. Additionally, a workshop was organised with industry experts. They gave feedback on this methodology, so that it could be improved by taking into account their perspective on development of future airport concepts. In this sense, the main objectives of the WP were realised successfully.

To summarize, the concept development methodology (CDM) proposed proved successful in guiding the concept development process in the Airport 2050+ project from its initial V0 to its final, V1 stages of maturity. The CDM supported consortium members by means of a guide to develop the airport concepts in a structured manner, proposing a value-focused thinking approach and several tools and methods suitable for this project. In addition, the rather elaborate CDM developed in this project could very well be re-used for other projects focusing on the development of high-level, futuristic, low TRL concepts. This re-use may not be limited to the air transport domain, nor even to the transport domain. The vision, but specifically the framework itself including the detailed concept architecture, tools and methods may proof beneficial for a range of other long-term research applications.

WP3: Validation Framework

Methodology
WP3 provided the validation framework in order to increase the maturity level of the WP4 airport concepts from V0 to “late” V1 (according to the E-OCVM) and to enable a preliminary performance assessment. This validation framework consisted of several methods, techniques, and tools. The scope and resources required varied depending on the level of maturity and type of concept validated. The highly innovative character of this project called for a new validation approach tailored to the needs of high-level airport concept development.
In the early Operational Concept Validation stages (V0), knowledge on the concept itself and its operational environment is typically immature and needs to be complemented by assumptions. Yet, the process of ‘validating’ a concept requires producing cases/ideas that are detailed enough to support some form of testing. To satisfy the Operational Concept Validation objectives, the underlying assumptions therefore need to be clearly stated.

As E-OCVM is a methodology widely tested and accepted, it has been chosen to be used as a basis for the 2050+ Airport Validation Strategy to reach results close toV1 maturity level. See Figure 5 illustrating the relevant maturity levels of the E-OCVM.

Another pillar to the Validation Strategy formed the Best-For-Purpose Validation Techniques, providing support for the implementation of the validation exercises through the following phases:
• First Validation Cycle: focused on validating at V0 maturity level the innovative concepts and ideas developed by WP4, by means of adequate validation techniques based on the methodology developed by WP2, which was also validated.
• Second Validation Cycle: linked to the first cycle, the focus has been to increase the maturity level of the WP4 concepts to (close to) V1. At this stage, the concepts were more mature, and analytical methodologies were used to achieve consistent results and assess whether a solution should be rejected or to continue with the development of specific ideas. In this case, each concept chose the methodology that best suited their needs, as the main variables affected had a different nature in each one of them:
o Time Efficient concept decided to use an Extended Queue Model simulation based in Matlab, lead by UPM;
o Cost Effective concept decided to proceed with an Evaluation Matrix process based on the impact of the different solutions on the Airports cost structures, lead by SMART CONTINENT;
o Ultra Green concept chose an Analytic Hierarchy Process (AHP) based on the comparison and prioritisation made by experts on the resulting ideas, lead by INECO.
• Validation Integration phase was carried out in parallel to the previous two validation phases, by identifying ideas that could be combined to improve the overall efficiency of an airport.

Main Results
The First Validation Cycle aimed at validating at V0 maturity level the innovative concepts and ideas developed by WP04, by means of adequate validation techniques (a combination of brainstorming, expert judgement and paper gaming was found as the most suitable technique) based on the methodology developed by WP02, which was also validated by using this validation methodology.
The focus of the First Validation Cycle was the execution of the validation exercise during the 2nd Workshop, held in June 2013 in Madrid, as well as the analysis of the results, in order to feed the development of the concepts and the Second Validation Cycle.

The validation exercise performed during this 2nd workshop consisted of four gaming sessions running in parallel, each one of them corresponding to four different scenarios: Time Efficient (TE), Ultra-Green (UG), Cost Effective (CE) and Mixed (MIX) (where experts decided on the most probable scenario for 2050).
The target of the game was to score as many points as possible, and the way to achieve high scores was by:
• Providing good/successful ideas
• Improving the ideas provided by other participants
In each game there were 5 different roles that the participants had to assume depending on the phase of the game. These roles were: Airport, Airline, ANSP, Industry and Passenger.Afterwards, the invariant processes table was introduced, representing the common part of the scenario for the four sessions and the tool used to organise the ideas.

The invariant process´ table (see Figure 6) represents the processes that are present in today´s airports and will definitely be present in the future airports of 2050 and beyond. These processes may change its order or location, but will never disappear because they are inherent to the airport´s activity.

The game was divided in five parts that are hereafter summarised:
1. Idea Selection and Brainstorm: assume different roles by the players and choose, invent, propose improvements and assess the ideas that the project had previously developed.
2. Value Function definition: agree on the weights of the parameters of the value function to be used for the ideas assessment.
3. Strategy Game: assess the priorities of the stakeholders and identify the most popular ides among different players.
4. Ideas assessment: assess the ideas using the results of the previous parts of the game and the methodology developed by the project.
5. Concept building and conclusions: select three ideas that could work together so as to improve the overall efficiency of the airport; and estimate the rearrangement of the future airport processes layout.
The first validation cycle, which was concluded after completing the game and analysing the results, lead to the following results (formulated as answers to the following four questions):
• Where are the main areas of improvement of the airport located?
o Security and Passport Control
o Landing/Take Off
o Taxi in/out
o Turnaround
o Intermodality.
• What are the most promising ideas to cover the needs of the future airport?
o Electric Ground Movement
o Walk Through Security Check Corridor
o Automation Of The Turnaround Processes
o High Speed Aircraft Taxi System
o Electric Taxi For Door-to-door Airport Transport
o Remote Tower
o Door-to- Door Transportation Of Baggage
o Microwave And THz Metrology For Homeland Security
o Automated People Movers (APMs)
o Electric Guided Taxi System
• Why? Priorities of the future airport in terms of KPAs & KPIs.
o Regarding the KPAs, the airport of the future will be driven by a balanced compromise between cost, time and green variables.
o The KPIs related to economics show that the focus will be reducing “Aeronautical Costs” and increasing “Non-aeronautical” revenues.
o The KPIs related to mobility that were assigned a higher priority were reducing the “Average Connecting Time” and reducing the “Delay Level”.
o The KPIs related to sustainability with a higher priority were reducing “Noise” and “Energy Consumption”.
• How will the future airport evolve?

o The future airport layout will probably change, tending to externalize those processes that provide a lower ratio in terms of benefits and time, such as the “Check-In”, “Processing Baggage” or “Security and Passport Control”.
The Second Validation Cycle’s main goal was to achieve “close to V1” maturity levels for the evolved concepts provided by WP4, taking as a reference quantitative measures of each proposed solution (from the First Validation Cycle), and also indicating areas where further research would be required.

The second validation cycle was performed using the conclusions of the first validation cycle of WP3, the results achieved in WP4, and the methodology of WP2. The purpose of this validation cycle was twofold:
1) To propose clear, usable and reliable methodologies to be used within the second validation cycle for each one of the three concepts.
2) To apply these methodologies, analyse the data required and provide the second validation cycle with its results.
For the Time Efficient airport concept, the validation technique used was a simulation tool, specifically the Matlab® Discrete Event simulation. This tool is most suitable for simulation based on timely processes. Simulation exercises for the TE concept were conducted using an airport scenario as baseline and simulating the proposed solutions applying modifications to the baseline. See Figure 7: the Airport Baseline model for simulation with MatLab.

The simulation is focused on the airport processes, which were taken from the Invariant Processes Table.
Based on the results of the 1st Validation Cycle for the TE concept, as well as on criteria that identified those ideas that could be mathematically modelled, the following ideas achieved the best results based on “saved time per passenger”:
1. Automatic Displaceable seats
2. Door-to-door transportation of baggage
3. Electric Taxi for Door-to-Door Airport Transport
4. Automatic People Movers
5. Electric Guided Taxi System
The Ultra-Green airport concept rewarded those concepts that would improve environmental sustainability of the airport in the future. The methodology used for the Second Validation Cycle of the Ultra Green concept was based on Analytic Hierarchy Processes (AHP) and Expert analysis of benefit and limitations.
The AHP methodology consisted of five step methodology aimed to achieve a hierarchical list of ideas by prioritising KPIs, variables and specific ideas. The model used was structured as shown in Figure 8.

After following the aforementioned steps, the results showed that the most promising ideas from an UG concept were:
1. Magnetic Levitation for Take-off and Landing
2. Electric Engine Accelerators
3. Cleaning and De-Icing Robots
4. Electric Ground Movement
5. Weather Protected Turnaround

The Cost Effective Concept was based on the assessment, by means of expert judgement, of the impact of the most promising ideas after the First Validation Cycle on an estimated cost & revenue structure, calculated after researching the economic structures of several airports. Figure 9 shows the estimated cost structure.

The final outcome showed that the ideas with a more positive impact on the cost structure were:
1. City and single central terminal
2. Door-to-door transportation of baggage
3. On-board self-boarding gate
4. Walk through security check corridor
5. Remote Tower

Conclusions
The conclusions derived from the WP3 validation activities can be summarised as follows:
• The overall, main areas of improvement for airports are: Security and Passport Control, Landing/Take Off, Taxi in/out, Turnaround and Intermodality.
• The airport of the future will be driven by a balanced compromise between cost, time and green variables.
• The future airport layout will probably change, tending to externalise those processes that provide a lower ratio in terms of benefits and time.
• The possibility for integration of solutions determines their potential benefit; therefore, when further improving maturity, research should focus on the performance of integrated solutions.
The validation that has been carried out in the AP2050+ project can be considered a success for a number of reasons. First, the main goals of this work package were attained, producing a feasible validation framework to increase the maturity level of the concepts studied. Secondly, all the validation objectives that were described in the Validation Plan have been fulfilled, meaning

that the validation strategy has been successful. Third, the validation methodology developed by WP02 was proved to be adequate for the First Validation Cycle; and for the Second Validation Cycle different techniques were tailored for each concept in order to achieve appropriate results. Finally, the outcomes of the project have been validated by a consortium of leading organisations and the collaboration of authorised experts, representing a valuable picture of feasible scenarios for 2050 and beyond for both airport stakeholders, the research community and the European Commission.

WP4: Concept Development

Methodology

WP4 followed the Concept Development Methodology developed in WP2 to develop the three airport concepts central to this work package and the entire Airport 2050+ project: the Time-Efficient, Cost-Effective and Ultra-Green airport concepts. To further raise the maturity level of these initial concepts, the WP3 Validation Methodology was employed.

Main Results

The main results of this work package will be detailed below related to the Time-Efficient, Cost-Effective and Ultra-Green airport concepts.

Time-Efficient (TE) airport concept

The “Time-Efficient airport” is the airport that has been designed and is operated and managed in such a way that the mobility value is maximized for both passenger and aircraft, through efficient and effective air transport operations. Based on new forthcoming technology it aims to make sure that the passenger’s and the aircraft’s throughput time through the airport is minimized and that seamless intermodality is guaranteed. To do this the airport applies intelligent, collaborative, dynamic, and automated systems capable of reacting to the daily needs of its stakeholders.

Objective of the TE airport concept is to maximise value through efficient and effective air transport operations. This means that the air transportation enabler (airline operator) needs to provide the required services to the passenger and that they all need to come together at the airport and receive support in managing the traffic flows seamless through the air transport system, of which the airport is the pivotal part. Thus, the whole process must allow the passengers to depart from their point of origin, be transported to the airport, and board the aircraft without any disruption. To achieve time efficiency, the following objectives must be satisfied:

• Minimise throughput time for airlines
• Minimise throughput time for passengers
• Ensure seamless intermodality

The TE airport concept, detailed in deliverable D4.1, proposes several solutions that contribute to a TE airport concept for 2050+, such as a walk through security check corridor, electric taxis for door-to-airport transport, an integrated (intermodal) guidance system, Automated People Movers (APMs), and underground piers. For details on all CE solutions the reader is referred to D4.1. These solutions affect one or more invariant processes – i.e. the processes that are assumed to be present in air travel of 2050+. For each solution the possible benefits for a 2050+ airport concept have been given by analysing their impact on the Time-Efficient Key Performance Indicators (KPIs):
• Minimise taxi times
• Minimise turnaround time
• Minimise delays
• Minimise travel time through airport
• Minimise waiting time between processes
• Minimise processing time
• Minimise connecting times between modes

An further, elaborate assessment of the elements in the TE airport concept has been made by industry experts during the interactive validation workshop held in June 2013 in Madrid. This workshop resulted in an initial validation of the expected benefits to time-efficiency of the ideas developed in the 2050+ Airport project. The most promising ideas from the TE airport concept in terms of time-efficiency turned out to be:

• Walk through security check corridor

• Electric taxi for door-to-airport transport
• Automatic displaceable seats
• Electric guided taxi system
• Automatic People Movers (APMs)
• Automatic de-icing
• High-speed aircraft taxi system

Apart from that, several ideas from the two other airport concepts (UG and CE) are also expected to be beneficial for the TE airport concept, which includes: microwave and THz for homeland security; biometric identification of passengers; configurable platform runways and taxiways; and dual split thresholds. Figure 10 yields an overview of the best TE ideas coming out of the WP3 validation exercise based on value analysis (left side) and expert judgement (right side). Half of the ideas following from the analyses are considered to be most promising from both analyses, which are displayed in the centre of the figure.

Cost-Effective (CE) airport concept

The cost-effective airport is the airport that has been designed, operated and managed in a way that:
– The direct and indirect operating costs are minimized.
– The revenues are kept as high as possible.
– While the investment costs for new infrastructure (either for expansion or for newly developed airports) are minimized as well.
In terms of layout/structure it is foreseen that by 2050 surface transport to and from the airport will be much quicker, more efficient and more predictable. In addition, security processes will probably consume less time than nowadays. As a result, the future airport terminal might change a lot. Given the fact that airport terminals are one of the biggest cost centres for airports today, an important reduction of overall costs can be achieved by moving the landside part of the terminal towards city centres/railway stations. The required infrastructure and service centres can be shared with other transport modes, increasing the revenue/cost ratio. In addition, automation of processes at airports will also have a strong impact on the costs and revenues of airports.

The CE airport concept, detailed in deliverable D4.3, proposes several solutions that contribute to a CE airport concept for 2050+, such as on-board selfboarding, remote towers, self-cleaning materials, THz based passenger screening, and active building technology. For details on all CE solutions the reader is referred to D4.3. These solutions affect one or more invariant processes – i.e. the processes that are assumed to be present in air travel of 2050+. For each solution the possible benefits for a 2050+ airport concept have been given by analysing their impact on the 4 CE Key Performance Indicators (KPIs) (aeronautical costs, aeronautical revenues, non-aeronautical costs, non-aeronautical revenues) of the three extreme airport concepts considered. An elaborate assessment of the elements in the CE airport concept has been made by industry experts during the interactive validation workshop held in June 2013 in Madrid. This workshop resulted in an initial validation of the expected benefits to cost-effectiveness. Figure 11 yields an overview of the best CE ideas coming out of this workshop and consecutive analysis based on value analysis (left side) and expert judgement (right side). Half of the ideas following from the analyses are considered to be most promising from both analyses, which are displayed in the centre of the figure.

Ultra-Green (UG) airport concept

The Ultra-Green airport concept aims to make the airport self-sufficient regarding its energy needs, to operate in a climate-neutral way and to limit noise exposure to municipalities surrounding the airport. Three major principles underlie the specific Ultra-Green solutions that form part of the airport concept:
– Aircraft engines emissions are reduced as far as possible within the circle of influence of the airport.
– Airport resources are used as effectively as possible to reduce vehicle and infrastructure emissions and waste production.
– The airport facilitates a seamless connection to the encompassing, multi-modal transport system to support an efficient and sustainable trip door-to-door.

The concept solutions proposed aim to replace fossil fuels by electric energy for many processes at the airport. In addition, solutions aim to automate processes to improve efficiency and thereby reduce their resource consumption. Finally, solutions aim to make the airport infrastructure more compact to reduce the overall land use and environmental footprint.

The UG airport concept, detailed in deliverable D4.2, proposes several solutions that contribute to an UG airport concept for 2050+. . Solutions are described for four areas: (1) airside airport services, (2) landside airport services, (3) intermodal transport services, and (4) infrastructure.in D4.2, each solution is elaborated and the expected contribution to the UG airport concept’s objectives and KPIs (noise, water use, energy use, emissions, and waste) is given. For airside airport solutions, the following solutions are given:
• Electric engine accelerators for take-off

• Electric ground movement
• Cleaning & de-icing robot
• Parafoil landing
For Landside services: city & single central terminal. For Intermodal services, Automated Seats. And for Infrastructure, finally:
• Dual threshold runway
• Magnetic levitation (MAGLEV) for take-off and landing (M-TOL).
• Automated apron services
• Weather protected turnaround
• Shielding landing and take-off operation by landscape design

An elaborate assessment of the elements in the UG airport concept has been made by industry experts during the interactive validation workshop held in June 2013 in Madrid. This workshop resulted in an initial validation of the expected benefits of the Ultra-Green solutions. Figure 12 yields an overview of the best UG ideas coming out of this workshop and consecutive analysis based on value analysis (left side) and expert judgement (right side). Half of the ideas following from the analyses are considered to be most promising from both analyses, which are displayed in the centre of the figure.

Conclusions

Below each of the three airport concepts is summarized by means of an encompassing description of the time-efficient, cost-effective and ultra-green airport.

The Time-Efficient airport

The TE airport concept proposes several operational changes to the airport's invariant processes. These processes, which would otherwise have remained unaltered (invariant) over time, will need to be modified to implement the concept ideas part of the TE concept. These modifications can be summarised as follows for each invariant process:

• Airside process: The TE airport concept proposes both the use of electric engine taxiing and (electric) guided taxi systems. The first solution requires modifications on the aircraft, while guided a guided taxi process at least requires modification to the airside and makes the taxi process dependent on the airport's infrastructure. However, both solutions are expected to quicken the taxi process, especially in combination with an optimal taxi planning and control using the systems (e.g. A-SMGCS) available in 2050.
• Turnaround process: Several ideas are proposed to improve the turnaround process. In general, these solutions include the automation of several turnaround processes. For unloading and loading baggage and other goods, underground loading devices are proposed that deploy from underground if necessary. This requires an infrastructure change, but also reduces the amount of apron vehicles necessary and allows for faster unloading and loading of the aircraft. Another innovative idea is to use automatic seat loading (including hand luggage) instead of the current boarding process, which has heavy impact on the aircraft layout and airport operation.
• Passenger transport: For door-to-airport transport electric taxis are foreseen. In order to benefit in terms of time-efficiency, the concept proposes to have a centralised, airport operated, system of electric taxis driving from and to the airport. This would allow for an optimised planning and operation of the taxis. Also inside the terminal an increased use of Automated People Movers (APMs) is foreseen, as these have the benefit of transporting passengers quickly to the gate, thereby also eliminating way finding and long walking distances. Several pre-boarding processes could be integrated in these APMs. To optimise the boarding process, passengers are called on-time using their mobile information devices. Security checks are comprised in a walk through security corridor, in which the passengers and luggage are checked for dangerous goods without stopping. The latter solution is a severe change compared to today's operations.
• Baggage transport: Fast baggage sorting is required to enable time-efficiency for the passenger. The TE airport concept also proposes the automatic loading of baggage in containers, e.g. by the use of robot arms. This will enable a quick loading process of the baggage into the aircraft.
• Infrastructure: The TE airport concept proposes some radical infrastructural changes in order to achieve time-efficiency. Moving the terminal pier and the loading devices underground has the benefit of a clean apron area, which allows for a straight taxi-out (i.e. no pushback necessary). However, it also involves large infrastructural investments in underground facilities. The circular terminal concept allows for more aircraft stands in areas with spatial limitations. This also concentrates aircraft stands and thereby reduces distances between terminal and aircraft and connecting flights. The high-pier concept moves the terminal and loading facilities upwards, such that the aircraft taxis 'under' the terminal while the passenger and baggage movements are above the aircraft. This has similar advantages as the underground pier, but also requires severe infrastructural changes.
• Intermodality: The concept proposes better information sharing and guidance for the passenger in the intermodal process, both for the home-to-airport journey as well as at the curbside and in the intermodal area of the airport. Automatic Electric Taxis (AETs) are proposed for an optimal home-to-airport journey, though different forms of public transportation are

suggested to be improved by using dedicated infrastructure.

The Cost-Effective airport

The CE airport concept proposes several operational changes to the airport which can best be illustrated by presenting an integrated story of a Cost-Effective door-to-door journey. To this end, let us imagine that we are in 2050 and that we would like to travel from Budapest to Frankfurt. Using our tablet we visit an internet travel site and enter the origin and destination location and the date when we would like to travel. The application offers different opportunities including door-to-door travel times, e.g.:

• We can go by airplane: taking 1,5 hour
• We may travel by train: taking 3 hours
• It is possible to go by bus: taking 8 hours

The application also introduces the travel fees, taking into account the travel time and cost. Assume we then choose the airplane as a means to travel. We could then subsequently choose two different options for baggage drop off:

• For an extra fee we can choose door-to-door delivery, where a van picks up our baggage at home and we receive it upon arrival at the destination place, weather is it the airport, a hotel, or a baggage pick-up point in the city centre.
• Alternatively, we can drop off the baggage at the airport terminal using a self-boarding service.

Assume we choose door-to-door delivery and we buy a ticket for the whole journey, including train (to and from the airport) and airplane with exact seat position. We receive a confirmatory message, which contains also information on train and flight departure, travel time for the sequences, seating numbers and baggage pick-up.

On the day of the flight the baggage pick-up van comes to get our baggage in the morning and later on we get on the train to go to the airport. The train station is also secured, as part of a secured transportation chain. No ticket is needed for travelling as we receive a QR code for our mobile which replaces it.

The airport terminal is part of a complex transportation centre point, where different public and private transportation possibilities are available, such as private car, private airplane, train, bus or taxi. We arrive well in time to the transportation centre, e.g. 25 minutes before the departure of the airplane, so we have enough time to eat a sandwich and drink a coffee and to download a book or magazine to the tablet for our journey. As the transportation centre is part of a bigger commercial terminal, to find a good restaurant or coffee bar doesn't mean a problem. While sitting in the coffee bar we receive a warning from our mobile device that the boarding will start in 10 minutes, so we need to proceed to the terminal.

The airport terminal is a separate part of the transportation centre. When we enter the terminal the following processes start automatically:

• Biometric identification
o If the biometric identification fails (no information in the system about the particular passenger), the system automatically directs me to the 'Identification Check point', where our ID will be established and uploaded to the system
• Our mobile device automatically links to the terminal's IT system
o Communication with the system will establish that we have a ticket for a particular flight,
o The system will provide information regarding the number of the boarding gate and the map of the airport terminal,
o A smart application on the tablet or smart phone can localize our position and using the received map can navigate us to the required boarding gate calculating also the required time to reach it.
• The THz based security system of the terminal will check if we have any dangerous materials or weapon on us.

The most important goal for the short-haul flight aircraft is to accomplish as many flights a day as possible. Therefore they are equipped with many built-in systems, such as boarding stairs, automated water replenishment, etc. to speed up the turnaround. In this case there is no catering at the aircraft, because a flight will not take more than 2 hours.

In case of the long-haul flights it is the opposite: the focus is on the comfort of passengers. The airplanes are much bigger, therefore requiring different handling equipment, for example special equipment to reach high level decks for boarding.

As our flight flies within Europe (short-haul), we go on the stairs of the aircraft and enter the deck. Upon entering the aircraft, the automated boarding process takes place, as the plane checks our identity using biometric identification system and the validity of ticket by connecting to our mobile device. We proceed to our pre-selected seat and in some minutes start the journey.

Upon arrival to Frankfurt airport, we leave the terminal and proceed straight to the train. There is no problem to find it, as our mobile device is in connection with the local IT system of the terminal and therefore receives personalized information regarding our further route.

We take the train and soon arrive to the hotel where we receive our baggage at the reception desk.

The Ultra-Green airport

The UG airport concept aims to meet the expected increase in demand in a sustainable manner and fulfil its role in the Transport Network within Europe. It will be servicing a broad range of destinations, by being the European wide binding factor for other modes of transport such as the rail and high speed rail network, as well as for road transport. The large hub airports in

Europe have the lead in this development. To improve the effectiveness of such an intermodal hub a central terminal concept can be used. This intermodal hub can also be situated remote within a metropolitan city with a high speed connection to the actual airport.

Looking at operations around the airport and at the airport, the more challenging improvements aiming at greening the airport are those improvements that reduce aircraft emissions. Leaving aside the improvements that fall prominently in the ATM (Air Traffic Management) domain, all operations based on aircraft or combustion engines on the ground will be reduced or transferred to electrified movement in order to reduce or even eliminate emissions. An extension beyond the take-off roll is added through electric engine accelerators. The usage of split runways will further reduce taxi distances. The ideas of electric engine accelerators, split runways and other concept ideas are elaborated further on in this chapter.

Stemming mainly from enhanced logistics, turnaround flight support services, passenger and baggage transfer services and processes will be automated with robots. This in turn, will deliver time savings, seamless processing, increases in efficiency and thus an overall reduction in needed resources.

Regarding the infrastructure, the challenge is to make efficient use of resources, minimize waste production, improve waste management and decrease emissions, whilst being energy efficient and sustainable in constructions. In the future strict construction standards aimed at sustainability will be applied to airport infrastructures in general. The sustainability is further enhanced through innovative airport constructions like weather protected apron operations.

Smart information technologies on personal devices will further improve up to 2050 and beyond providing passengers with an individualized experience at the airport resulting in a significant reduction in equipment and resources for general information services.

Possibly more radical solutions were subjectively rejected given the scope of interest of this project. It was assumed that aircraft frames would not be radically different from today, given the lead times needed for the design and building of radical new constructions in a large, established transport system due to long amortization times, legacy and transition problems, in addition to the requirement to fulfil cost, efficiency and environmental constraints. New developments that are aimed at pilotless aircraft are not foreseen for passenger transport within the mentioned timeframe. Also resource intensive concepts, like having the pier underground or having a circular banked runway, are kept outside the scope of the project.

WP5: Conclusions

Methodology
The work of the WP5 was divided following the structure of two deliverables:
- Task 5.1: Final report (led by UPM), which presented a guide through the path followed by the project providing the final conclusions of the research activities developed. Special emphasis was given to user needs and barriers detected. The document also includes lessons learned during the process and evaluation of methodology as well as validation techniques used. The document included summaries of the work performed in previous WPs, and which were provided by each WP leader: TUD provided WP2 methodology summary; CRIDA provided WP3 Validation summary and; WP4 concepts summary were provided by TUD (Time-Efficient), INECO (Ultra-Green) and SLOT (Cost Effective).
- Task 5.2: Recommendations (led by UPM), which included the recommendations to prepare the industry to focus their research effort and activities on those areas considered more promising to prepare airports for 2050 and beyond. The work performed in this task was performed by all partners of the consortium.

The recommendations were obtained form different sources following the methodology showed in Figure 13.

The methodology unfolds according to these premises:
• Each recommendation was reasoned and based upon the experience gathered and the work carried out within the Airport 2050+ project.
• Recommendations aim at enabling the research community to focus the future effort on those areas that are considered more promising, and/or preparing airports and related stakeholders (i.e., ANSPs, industry, passengers, airlines, greenfield airport developers) for the second half of the century.
• The following were considered valid sources of recommendations:
- Project results and deliverables.
- Partners experience during the project.
- Expert’s contributions during the workshops.
• The set of recommendations obtained were addressed to two target audiences:
1) Airport and related stakeholders

2) Research community including the EC

Main Results
The results of WP5 are presented following the deliverable structure:
The final report (D5.1) summarizes the work performed during the project following a spiral life cycle focusing on the following achievements:
– To provide a vision and methodology for airport concept development for defining and evaluating a value function allowing determining the best options for the 2050+ airport. First, a vision has been developed to describe the context of the airport of 2050+ by considering a number of future trends in the area of demography, society, politics, economics, environment, mobility, and technology. This vision, based on a variety of sources specified the boundary conditions / constraints that will be relevant for airports of 2050 and beyond. The vision formed part of an encompassing methodology established to develop the three different airport concepts. The methodology was based on value theory. It assessed the different stakeholder relations and interests by providing a high-level set of objectives and attributes for each concept. This value driven methodology made it possible to rate the concepts' designs and make trade-offs between different proposed solutions.
– Providing the three airport concepts themselves: For each airport concept, several ideas have been captured mainly through workshops and brainstorming sessions. This in turn created an initial version of the concepts and underlying concept ideas/solutions in accordance with the methodology. The overall concepts and their specific concept solutions have been refined by different validation activities to select, based on the value driven methodology, the most promising solutions for each concept. The concepts have subsequently been updated accordingly and the process continued to follow a spiral life cycle until all concepts were considered sufficiently developed (i.e. at phase V0/V1 in the Concept Life Cycle model of the European Operational Concept Validation Methodology (E-OCVM)). -
– Providing a methodology for partial validation of these concepts: A validation methodology has been developed to validate as much as possible the three concepts, to increase their maturity level, and to assess their performance against a relevant set of KPIs. During the first validation cycle, the validation activities identified the stakeholder needs and corresponding potential solutions. Based on this validation cycle a first selection of most promising solutions was performed. During a second validation cycle any problems related to e.g. the implementation of performance of specific solutions were identified to support further concept refinement and specification. This second cycle ensured the coherence of the maturity level achieved by each concept offering a walkthrough of the steps followed by the project.

The deliverable D5.1 is divided in several chapters: the airport concept development methodology is presented in chapter 2, the validation methodology corresponds to chapter 3 and the three concepts themselves are described in chapter 4. These three concepts address time-efficiency, cost effectiveness, and sustainability, with each airport concept strongly focusing on its own objectives. This entails, amongst other things, a reduction of the aircraft turnaround time, a reduction in the passenger throughput time, a decrease airport's cost, an increase in airport revenues, and a minimization of the airport's environmental impact. Even if these aims can be considered over-ambitious, they represent aspects of the present-day airport concept that seem most in need of change in light of expected future requirements.
The three concepts studied allowed to cluster the proposed ideas and solutions aiming at each one of the high level objectives and to evaluate their value within the concept. The process of validation allowed establishing a value classification of the solutions within each concept.

Additionally, an overarching description of the airport of 2050+ is given in chapter 5 combining several elements of the time-efficient, cost-effective and sustainable airport of the far future. The three concepts presented shown what the future airport could look like and which level of performance can be expected. The Mixed or overarching concept presented in this chapter depicted a concept which provided a balanced weight to the three high level objectives. All four concepts described the interface between aircraft and ground, passenger/baggage related processes, new airport operations management principles and how the application of new principles of airport layout can better integrate future intermodal connections.

The use of the validation for the mixed concept allowed obtaining a balanced weight to the three objectives. The best ideas for the overarching concept coming out of the value analysis (left side) and expert judgement (right side) were studied and are shown in Figure 14. Half of the ideas following from the analyses are considered to be most promising from both analyses, and they are displayed in the centre of the figure.

Finally, in chapter 6, a number of conclusions are drawn based on all research activities conducted in the course of the Airport 2050+ project. This chapter also includes a summary of the lessons learned during the process, including and evaluation of the methodology and the validation techniques used, as well as the results and solutions chosen according to the presented bottlenecks.

The Recommendation document (D5.2) provides all recommendations that were gathered during and after the research activities of project Airport 2050+. In the course of this project, several ideas were captured to support the airport of the far future. Initially, a set of recommendations from stakeholders, external experts and consortium partners was gathered to create

– following the concept development methodology employed - an initial version of the three concepts central to the Airport 2050+ project: the time-efficient, cost-effective and ultra-green airport.

The set of reasoned recommendations presented in this document aim to show both airport stakeholders and the research community those areas that are considered most promising for focusing future research efforts and preparing airports for the second half of the century. Recommendations for stakeholders are further subdivided into recommendations for airport managers, for Air Navigation Service Providers, for the industry, for airliners, for passengers, and for greenfield airport developers. Recommendations for the research community focus more on the methodological lessons learnt from the Airport 2050+ project: the difficult task to capture and partially validate very high-level concepts and concept ideas suited for the uncertain world of 2050+.

A wide variety of sources have been used to draw up the recommendations given in this document: recommendations were inferred from project results/deliverables, were given by external experts consulted during the project, were formulated by consortium partners during e.g. brainstorm sessions, or were suggested by the many external participants (airport CEOs and operational experts, industry, ANSPs, amongst others) of the three workshops organized in the course of the project. Figure 15 represents the template used for the harvest of project recommendations.

As part of the recommendations are highly correlated with the innovative solutions studies into the Airport concepts proposed by the project. The solutions can be regarded as building blocks for the airport of 2050+. This modular approach taken implies that not all ideas recommended should be regarded as mandatory for a sustainable, cost effective or time efficient airport. Instead, interested airport managers and stakeholders are given the choice to combine only those ideas that fit their specific airport, business plans, target groups and local community. Nevertheless these solutions may offer the benefits to enable small, medium and large airports in Europe to become seamlessly integrated as nodes in the European Transport Network.

From the recommendations, it can be seen that the general focus to improve airports of the future should be made on improving passenger experience, allowing him/her to take decisions about the journey based on updated and reliable information, as well as intermodality (improving the connectivity with other means of transport). It is also recommended aiming at those solutions reducing processing times and considering environmental sustainability and economic viability. Also, it can be seen that the solutions are strongly influenced by the need to reduce the time spent by the aircraft on the ground, reducing the time spent in the turnaround and servicing.

With the development of these solutions and overarching concepts, the AP2050+ project hopes to contribute to the long-term development of European airports meeting the challenges of the far future.

As a conclusion, it can be said that the major achievements of this project summarized in this WP5 have been:
• Integration of different methodologies and tools to support the generation of innovative airport concepts in a spiral life cycle process
• Integration of conclusions of all R&D activities performed within the project
• Deliverance of an extensive set of recommendations for different stakeholder groups:
– Airport managers, ANSPs, industry, airlines, passengers, greenfield airport developers
– The research community including the EC
• The solutions are described at an acceptable level of detail for V1 that includes the identification and description of the operational elements and impacted invariant processes, the possible applicable technical elements and the benefit mechanisms.

Conclusions

As a final conclusion, based on the AP2050 activities and achievements previously described, it can be said that the project has succeeded in its overall objectives since it has:
• Managed to define a Concept Development Methodology (CDM) appropriate for developing high-level and far-future airport concepts. This methodology may also been used to define future operational concepts for other modes of transport.
• This CDM can also be used to identify improvement areas and needs in the airport of the future at a V0 maturity level. The project provided an adequate scope for the three concepts of operations (TE, UG and CE) for identifying and classifying quantitatively the technical and operational solutions that can solve identified bottlenecks.
• Validation procedures have been successfully custom-designed for this R&D project with a starting point at V0: at the very beginning of the development of an Operational Concept.
• Developed solutions and ideas which fulfil the objectives set out by the three Airport Concepts were able to satisfy the expectations, requirements and objectives of future airports in the areas of sustainability, costs and mobility for the year 2050 and beyond, and considering that every Airport has the option to focus on one or more of these objectives using the value function to fulfil its future needs.

• Identified the major R&D needs that will be required by such concepts in terms of modifications to the operation, management and infrastructure needs for the future airport.

WP6: Dissemination and Exploitation

Methodology
The methodology followed for the dissemination of the foreground of the 2050+Airport project is the one set at the Dissemination Strategy and Plan drafted with the agreement of all partners about what to disseminate, to whom, when to disseminate and in which effective ways. The workshops were carried out according to the workshop strategy, included in the Dissemination Strategy and plan.

Main Results
Main achievements/results:
– Delivery of the dissemination strategy and plan. The D6.1 Dissemination Strategy and Plan was submitted in April 2012 and included the lesson learnt from the first workshop carried out in March 2012 in Amsterdam.
– Project website: The first 2050+ Airport website was launched in March 2012. A reviewed website was launched on September 2013. Since this date the website contents have increased considerably as all WP were finishing their deliverables and the 2050+ Airport project was gaining maturity.
– Delivery of the project flyers and video animation: The final project brochure was drafted and finished by January 2014. Copies were handed out during the Final dissemination workshop, on 4th February 2014. The 2050+ Airport project video animation was finished by January 2014 and filmed also during the final dissemination workshop
– Dissemination of the findings of the project among the aviation community. A number of dissemination activities have been carried out during this period. The most important dissemination activity was the Final dissemination workshop held in Frankfurt on the 4th of February 2014. The results of the project were presented to the aviation community. Sixteen external participants attended this workshop. The D6-5 Dissemination Report gathered all the information about this dissemination event, as well as the other dissemination activities carried out by all the consortium partners.
– Organization of the workshops. Three workshops were carried out:
• WP2, the Concept Development Methodology Workshop (Amsterdam, March 2012)
• WP3, Validation Methodology Workshop (Madrid, June 2013), and
• WP6 Final Dissemination Workshop (Frankfurt, February 2014)
– List exploitation opportunities per partner after finishing the project. The Exploitation Plan (D6-6 Exploitation Plan) was elaborated by all the consortium partners and submitted at the end of February 2014.
Conclusions

The WP6 objectives were:
• Develop the dissemination strategy and plan
• Prepare and maintain the project website
• Disseminate the findings of the project among the aviation community
• Provide exploitation opportunities that allows further research of the findings (after finishing the project)

All the objectives set for WP06 have been achieved. All partners have been involved in the dissemination activities, which have been understandably more intense during the last part of the project.

All partners have drafted their own exploitation objectives and future research activities roadmap and the exploitable foreground detected. Also, they have identified consultancy services and future research activities.
Furthermore, the dissemination activities for the Airport 2050+ project will continue after the finalization of the project, as papers have been accepted for two events:
• CIT June 2014, Santander (UPM)
• PANAM June 2014, Santander (UPM)

Besides, the 7th FP Project, “Promo-Air” aiming at undertaking actions to raise the interest of young Europeans towards scientific and technical studies in the field of Aeronautics and Air Transport has chosen the 2050+ Project for its dissemination.

After 2.5 years, the dissemination and exploitation activities performed during the Airport 2050+ project have enabled the achievement of the objectives defined in the Dissemination Plan. The three workshops organized have been crucial in supporting the work done in WP2, the Concept Development Methodology, WP3, Validation, and WP6, Dissemination,

respectively.
Potential Impact:
Below first the main dissemination activities, then the potential impact and finally the exploitation results of the 2050+ Airport project are summarized.

Main dissemination activities
All dissemination activities are described in D6.5, the Dissemination report. Table 2 summarises all the Dissemination activities carried out by the 2050+ Airport Project.

Potential Impact
The 2050+ Airport project has focused on engaging large groups of stakeholders from the start. The potential impact of the project – notoriously difficult to assess - can therefore probably best be estimated by focusing on the three main workshops organized by the consortium. These workshops, together with the many other dissemination events listed above (and the promotional material: website, brochures and project movie), had an impact on a rather large share of airport stakeholders. Below a summary of the workshop organized and the external stakeholders involved.

First Workshop – Concept development (TUD) and Validation

Purpose
This workshop, held on the 5th of March 2012 at the NLR premises in Amsterdam, was part of the WP2 (Methodology development) work package and aimed to capture feedback from industry representatives on the concept development methodology as well as a first approach to the 3 airport concepts (time-efficient, ultra-green, cost-effective airports) and their possible solutions. In the methodology development a top-to-bottom approach to work on the airport concepts was proposed. This approach used the Value Operations Methodology (VOM) to determine key value drivers for the 2050 airport, where new airport concepts with radical and novel solutions are explored to support the development of airports for 2050 and beyond. Concretely, the workshop's goals were the following:
1. Capture, via brainstorming sessions, the ideas of the industry participants on each of the 3 concepts' specific
a. Goals for 2050 operations,
b. current and expected challenges to achieve these goals, and
c. initial ideas on creative solution(s) (directions) to overcome these challenges and achieve the concept's goals
2. Allow the committed airport partners to present their airport's specific views on 2050 challenges and development trends.
3. Capture feedback from the participants on the Concept Development Methodology as it was currently developed in WP2.

Impact: targeted audience
In order to ensure a good start on the Concept Development Methodology (WP2), this workshop aimed to obtain feedback from airport industry experts on the path followed to establish a common development framework for all three airport concepts. Using the networks of the consortium, participants were invited from the scientific community, R&D and end users like airports. This resulted in participation of representatives of the following organisations:
• Frankfurt Airport (D)
• Amsterdam Airport Schiphol (NL)
• Kaunas Airport (LT)
• Madrid Barajas Airport (ES)
• Zurich Airport (SW)
• NACO (NL, Dutch Industry)
• Milan Malpensa Airport (IT)

Second Workshop – Validation (CRIDA)
Purpose
The purpose of the Second Workshop of AP2050+ was to validate, through a variety of gaming techniques (i.e. brainstorming, role play, expert judgement and strategy game), the three concept descriptions that had been developed since the First Workshop: the time-efficient, cost-effective and ultra-green airport concepts.
The workshop took place as the last milestone of the First Validation Cycle, aiming at validating the concepts at V0 maturity level . Besides, it led to the Second Validation Cycle, which used the results obtained during the workshop to study in more depth those concept ideas which had achieved the most successful outcomes.
Impact: targeted audience
The workshop took place on 19th June 2013 at the School of Aeronautical Engineering in Madrid with the participation of a wide variety of experts, representing the following organisations:
• Frankfurt airport (D)
• Schiphol airport (NL)
• Kaunas Airport (LT)

• Targu-Mures Airport (RO)
• Barajas airport (ES)
• Vilnius Airport (LT)
• Vienna Airport (AS)
• AESA (ES)
• ISA (FR)
• AENA (ES)
• ISDEFE (ES)
• Boeing RT (ES)
• Eurocontrol (EU)
• Imperial College (UK)
• DLR (D)

Final dissemination workshop
Purpose
On the 4th February 2014 the final dissemination workshop of the Airport 2050+ Project was held at the Steigenberger Airport Hotel near Frankfurt Airport. The main objectives were the dissemination of the achievements of the Airport 2050+ Project and to obtain feedback from the participants (stakeholders and other interested parties) about the concepts developed feasibility of implementing them and new ideas / opportunities for future work.

Impact: targeted audience
The workshop took place with the participation of a wide variety of experts, representing different stakeholders, such as Airport and ATM experts, Academia and Researchers. The affiliations attending were:
• Frankfurt Airport (D)
• Schiphol Airport (NL)
• Kaunas Airport (LT)
• Targu-Mures Airport (RO)
• Barajas Airport (ES)
• Vilnius Airport (LT)
• Vienna Airport (AS)
• Riga airport (LV)
• Max-Planck Institute for Biological Cybernetics (D)
• ISDEFE (ES)
• Airbus (D)
• Eurocontrol (EU)
• Imperial College (UK)
• DLR (D)

A total of sixteen external participants attended the final Workshop in Frankfurt. All consortium members participated in the event.

To summarize, apart from the other dissemination events, the three workshops organized involved a large number of different organisations (airports, industry, ANSPs, governmental organizations, academia, research institutes) and therefore had a potentially large impact on this subset of potential stakeholders. The extensive feedback received during the workshops, including the plenary discussion at the dissemination workshop, proved that many of the ideas proposed by the 2050+ Airport consortium at least evoked stimulating discussions and exchanges of ideas. It seems reasonable to assume that the wide range of concepts and ideas presented as well as the large variety of brainstorms/validation games/discussions (to which all actively participated) held will have had an impact on the ideas stakeholders have for long-term development of their own airport or airport related activities.

Exploitation results
The main exploitation opportunities identified by all consortium partners have been summarised in the D.6.6 Exploitation Plan. Figure 16 depicts these foreseen exploitation activities.

The depicted future activities in Figure 16 are further explained below:
• Development / Improvement of VOM: Further research will focus on the development and improvement of the Value Operations Methodology to overcome the research challenges that have arised during the project.
• Evolve the successful concept ideas from the Airport 2050+ project: further development of ideas with outstanding results in the validation processes.
• Refine Airport 2050+ Project Validation procedures to overcome the issues that have arised specially during the first

validation cycle.
• Investigation of the results of an integrated concept solution: Investigate the hypothetical results that could be achieved from the interaction and integration of groups of related and compatible ideas.
• Engage stakeholders: Further efforts should be made to bring together all stakeholders involved in the airport activities.
• Development of new methodologies for performance assessment.
• Cost-revenue modelling investigation: Further investigation into cost-revenue modelling.
• Policy making and strategic planning: Project results are seen as guidelines for policy making and strategic planning due to the fact that the objectives are set in the far future.
• Re-think airport concept: Re-evaluate the airport concept from scratch, bringing the infrastructure to a minimum and shifting the “finger-based” boarding concept to an APM based one.
• Further development of SimEvents (TE validation): The Matlab® SimEvents tool has been used for validation purposes. This tool can be further developed to focus on specific processes or elements of the airport system.
• Further participation to vital R&D programmes.

List of Websites:
The address of the project website is: www.2050airport.ineco.eu. The web-site has been launched on 31st of March 2012 and contains amongst others the following information:
• General and public information on the project activities and organizational structure
• More detailed and regularly updated information based on project progress
• Finally, reference material and results produced within the project itself, including public deliverables as well as a calendar of important events.

Related information

Result In Brief	• Travel of the future
Documents and Publications	• final1-ap2050-final-publishable-summary-report-v1-0.pdf

Contact

Van Leeuwen, Pim (R&D engineer)
Tel.: +31205113144
Fax: +31205113210
E-mail

STICHTING NATIONAAL LUCHT- EN RUIMTEVAARTLABORATORIUM
Netherlands

Subjects

Transport

Last updated on 2014-12-17
Retrieved on 2015-03-31

Permalink: http://cordis.europa.eu/result/rcn/153694_en.html