AN ASSET FOR IMPROVED EFFICIENCY AND PUNCTUALITY IN AIR TRANSPORT

Axel B. Classen*, Tim Alers*, Kerstin Bueker, Sebastian Kellner****
***DLR, German Aerospace Center, **RWTH AachenUniversity**
axel.classen@dlr.de

Keywords: punctuality, airport process optimization, simulation, assessment

Abstract

This paper is to present the European FP7 project ASSET. The project focuses on methods of airport operations optimisation and aims at finding improvements in the airport operations process chain in order to increase punctuality and predictability in these processes, thus also improving overall efficiency of air transport.

1 Introduction

It has been shown that compared to the ACARE[1] goal of 99% punctuality in European air transport within 15 minutes, the average actual value in Europe is only around 82% (as of 2009) [1]. Studies from Eurocontrol Performance Review Commission (e.g. Punctuality of Airports Study and Performance Review Report 2010 [1]) reveal that a main contribution to insufficient punctuality results from a variance in off-block times. Therefore punctuality is strongly affected by the predictability and duration of landside processes at the airport. Poor predictability within flight planning and the necessity for costly time buffers in airline schedules are therefore major hazards for reaching envisaged goals. A reduction of 5 minutes of buffer in 50% of all European flight-plans would save a magnitude of one billion Euros per year [2].

These issues were the impetus for the project ASSET (Aeronautical Study on Seamless Transport) [3] funded by the European Commission in FP7[2]. The project combines skills of fourteen partners in research and industry from five countries for a three-year period. The project focuses on methods of airport operations optimization and aims at finding improvements in the various modules of the airport process chain within the terminal and at the gate in order to improve punctuality and predictability regarding these processes, thus also improving overall efficiency of air transport.

2 Methodology

Time efficiency at airports – measurable as duration and variance of process times and in on-time predictability of the process chains – is mainly determined by the performance of four processes:

a) timeliness of passenger inbound and transfer flows at airports including boarding and de-boarding of aircraft
b) associated processes for baggage / freight handling at aircraft and within the airport
c) aircraft service processes at stand or gate (fuelling, cleaning, catering, maintenance etc.)
d) network effects generate late arrivals due to previous delays at prior departure airport (again mainly dominated by pre-departure primary delay causes as described in point 1 - 3) and to a minor part by ground-holding measures from the CFMU (Central Flow Management Unit of Eurocontrol)

[1] ACARE - Advisory Council for Aeronautics Research in Europe
[2] see http://ec.europa.eu/research/fp7/index_en.cfm

Enhancing off-block punctuality can therefore only be obtained if all those processes are improved in an integrated manner. To reach this goal the ASSET project was structured in four work packages focusing on

1. identifying bottlenecks and requirements of airports landside operations
2. status quo analysis, model definition and fixing the baseline
3. development of single solutions and their assessment
4. development of integrated solutions and their assessment.

To find solutions having a substantial effect on increasing time efficiency of turnaround processes, the requirements are analysed first from the passenger's perspective. Concurrently the requirements of stakeholders involved in airport processes are also analysed.

2 Stakeholder's Requirements

The stakeholders' view on the processes chain or on parts of the process chain as well as their opinion on (their own) requirements, anticipated trends and bottlenecks is regarded as a means to implement a bottom-up and real-life orientated focus on an otherwise technical approach. The project aimed to assess the requirements of the various stakeholders (a/c manufacturers, airlines, airport authorities, security system providers, ground handlers, national authorities etc.) also with regards to regulatory constraints and IT automation in order to optimize processes and aircraft turnaround times. The airport process chain is broken down in points of activity (POA), managed under the responsibility of a stakeholder's category. The assessment has been conducted by addressing current situation, regulatory framework (ICAO, EC, national) and expectations for future improvements.
From the information gathered critical elements regarding the airport ground processes could be derived. Concerning airport ground processes the various stakeholders regard different (or sometimes similar) elements as critical. These events can be infrastructural like certain points within the airport operation process chain (passengers, baggage, turnaround) but can also be immaterial like regulations. These elements constitute potential bottlenecks of operation and inefficiencies. Major challenges have been identified as potential bottlenecks:

- wayfinding
- check-in
- security check
- boarder control
- implementation of new technology/automation, delay thereof
- information system/data interfaces
- transfer baggage handling system
- general turnaround time
- security regulations and necessity/ban of new equipment thereof

3 Process Analysis

Building on these first requirements and bottleneck analysis the focus then lay deeper on the actual process chain. A comprehensive analysis of all relevant airport processes is an inevitable prerequisite for the development of both the generic models and ultimately any process optimizations. Building especially on empirical data that has been collected by means of stakeholder interviews during a requirements analysis in the project as well as on the experience of the project consortium the airport landside processes have been thoroughly examined and described. A system of points of activity (POAs) and corresponding processes and bottlenecks that describe the airport landside process chain and apply to passengers, baggage and turnaround activities have been identified. The identified and analysed points of activity in question are:

- Arrival
- Security
- Border control
- Transfer
- Baggage
- Boarding landside
- Boarding airside
- A/C turnaround

A detailed analysis for each point of activity describes the main process steps as well as detailed actions and bottlenecks referring to that element in the process chain. Thus, to illustrate the approach exemplarily, the following process steps have been identified concerning the border control POA:

Fig. 1: Example – main process steps at border control

On a next level, single activity, bottlenecks and possible motives for bottleneck occurrence are identified.

Activity	#	Bottlenecks	Reasons
passenger welcome, travel document identification			
passenger face authentification			
travel document control	1	queue	number of counters
			missing documents
			expired passport (-->Airline?)
			lettering, language writing (exotic passport)
			language barriers
			children need own passport
			old/not matching photo
fraud and passenger biometric capture and control, watchlist checks	2	automatic border control	non readable documents
			old/not matching photo
			rejection rate/false rejection rate
	3	access to watchlist database	
passport stamping	4	VISA overstay/lack of visa	
inbound flight and return ticket	5	queue	wrong filled formulas (US)
			interview (US)

Fig. 2: Example – activities and bottlenecks at border control

4 Generic Models

One main goal of the project was to render two generic airport models as a representative testbed for assessing the solutions to be found in this project. The models shall also be publicly available to serve as a comparable and easy to use testbed for other projects in airport research.

To cover the specific needs of medium-sized and hub airports, two different sets of models were built. One to represent a medium-sized airport and one representing a hub airport. The airport models are built to be generic as to maintain a universal validity as well as to enable future re-use outside ASSET. The models are used to simulate the behaviour of the various "agents" throughout the airport and to measure the potential impact of proposed solutions. To obtain thoroughly relevant results scenarios representing both peak-day traffic and average day traffic are produced for both airport type models. The corresponding parameters are evaluated and inserted into the models. The reference models deliver reference simulation output against which all alterations induced by potential optimisations are compared to.
The models comprise details including passenger attribute (see chap. 5) dependent distributions of process times that correspond to normal operations and peak traffic.

The term generic airport model underlines the representative characteristic of the models. To achieve this demanding goal, an approach of a modular airport was established, based on the analyses of relevant airport processes. Modular in this context means, that the model is able to adapt to different configurations of process stations in the airport. For example one module has a line of check-in counters associated to specific airlines whereas another module has check-in islands with desks available for different airlines including self-service kiosks.

The reference airport, which can be seen as one representative realization of the modular airport model, had to be defined. To keep a high relevance and close relation to real airports, a statistical approach was used to find two representative airports, one representing the medium-sized airport and the other one representing the hub airport. To accomplish this approach two lists of airports had to be built from which the reference airport could then be selected. Besides being a European airport, the airports on the lists had to comply with the following definition:

- A medium-sized airport serves less than 25 million but more than 5 million passengers. It has less than 30% of transfer passengers.
- A hub airport serves more than 25 million passengers and has a share of 30% or more of transfer passengers.

Following the criteria above European airports have been categorised and used to form the long list for the selection of a reference airport meeting the characteristic of being generic. The IATA airport data [4] served as a basis. After this step, a list of 48 medium-sized airports and 8 hub airports was available. A statistical approach has been used to find the medium-sized and hub airport, which is close to the averages of numerical parameters. In short the statistical approach compares the combined deviation of 16 airport parameters like terminal size, number of check-in desks and passenger screening facilities from the median of these parameters. As a result the medium-sized reference airport model is based on Hamburg (HAM) airport and the hub reference airport model is based on Paris Charles-de-Gaulle (CDG) airport. Both airports fit well, are representative and data availability was comparably high – at least for the ASSET consortium. It is important to mention that the simulation models are not 1-to-1 implementations of the two airports. To ensure the generic characteristic both models are streamlined of certain peculiarities. The two abstract models based on these two airports could then be transferred into the simulation environment thus defining the infrastructure and location of points of activity (POA) in the terminal building.

The following chart (see Fig. 3) visualises this approach. The horizontal axis depicts passenger processes in chronological order from left to right starting with the arrival at the airport. The vertical axis depicts different scenarios for each process station. The black arrow shows the selection process for the reference airport. Scenario 1 denotes the scenario representing the configuration of the

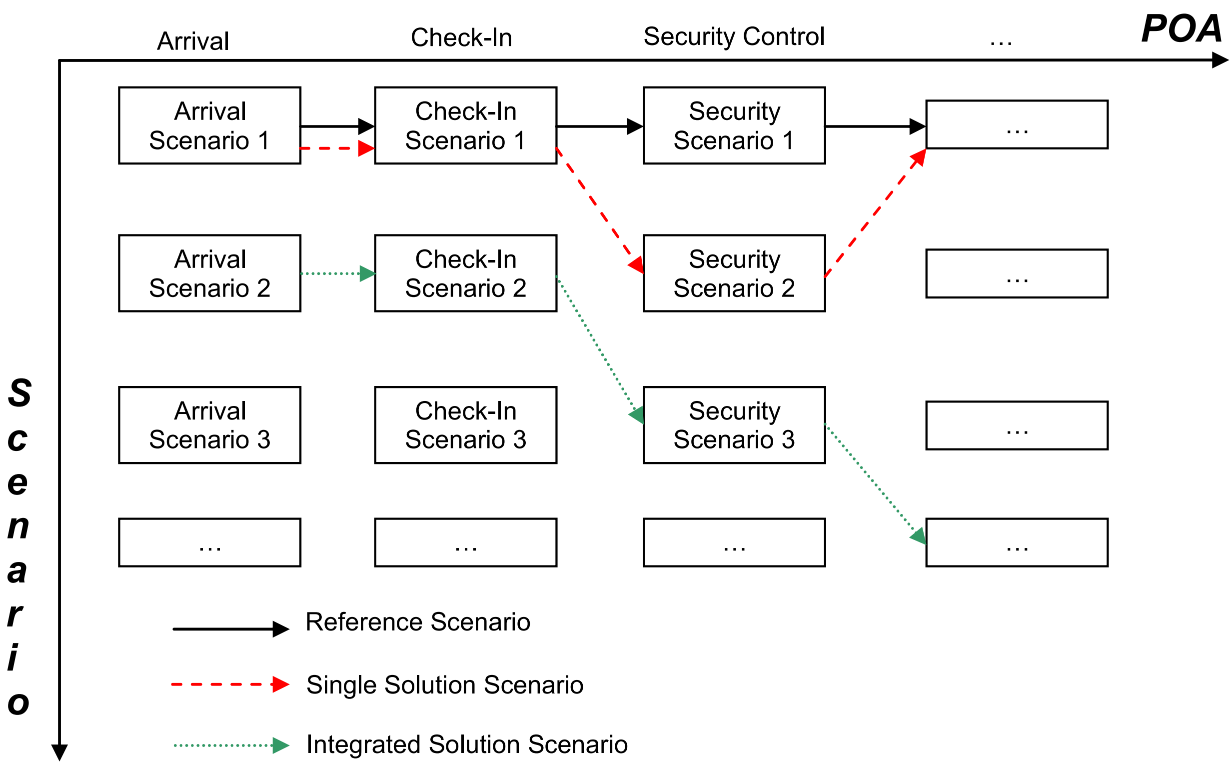

Fig. 3: Structure of the generic airport models

reference airport. In the case of the medium-sized airport model, the box “Arrival Scenario 1” describes the arrival configuration of Hamburg airport.

The red arrow demonstrates the implementation of single solutions developed in the project (see chap. 6). One process station switches to a different scenario, here “Security Scenario 2”. Finally the green arrow demonstrates an integrated solution, which allows multiple process stations to deviate from the reference airport scenario 1.

5 Passenger typologies

The second pillar of the generic airport model is the detailed allocation of process times. The simulation is done with TOMICS (Traffic Oriented MICroscopic Simulator), a simulation software that enables to model and simulate microscopically the behaviour of individual passengers at airports. The microscopic approach allows for incorporation of different characteristics like walking speed and direction, group membership, or process status (e.g. checked in…). TOMICS is specifically developed by DLR for capacity and bottleneck analysis aiming at the optimization of airport processes. Therefore each passenger is modelled individually in the simulation. Consequently a list of passengers including their attributes and derived process times is required. In order to compile this list, a combination of destination groups and passenger types was used, based on the assumption that the distribution of passenger attributes is mainly determined by the passenger’s destination.

Destination groups classify the flight destination based on process requirements (Schengen, High Risk or Other) and dominating type (business or leisure). The combination of both criteria leads to six destination groups. Each destination of the reference flight plan is then assigned to one destination group.

Passenger types define the distribution of passenger attributes. In ASSET two passenger types are differentiated: business travellers and tourists. There are 15 attributes with specific values available. For example it is assumed that 85% of business travellers have a high travel experience whereas only 50% of tourists do so.

Based on expert assessments, literature and partners data, the influence of the attribute values on process times were set. For example, high travel experience reduces the basic value of self-service check-in process time by 20%. These influences were combined for all 15 attributes.

The required number of passengers is taken from the reference flight schedule and is then calculated from the aircraft type and the load factor. The destination group defines the split between business travellers and tourists. There are four flight plans used in ASSET: each a normal and a peak day scenario for the medium-sized and for the hub airport model. The arrival flow of passengers is used to derive the schedules for gates and counters.

6 Single Solutions

Key elements of the project’s objective to improve airport and aircraft turnaround processes are Single Solutions (SiSo) and their effect in combination (see chapter 9) on how the status quo can be changed with a view to airport operations optimisation and time efficiency. In a first step the project aimed at the development of single solutions which can be associated to one relevant airport process or point of activity. Single solutions have a broad scope and can be of technical or operational nature as well as related to business strategies. They can be associated to one relevant airport process or point of activity.

An external expert moderator has been brought in to support the development of the single solutions during a two-day workshop i.a. with help of creativity techniques. The consortium has been invited to bring in additional colleagues having specific experience in airport operation to the workshop. This two day workshop was exceptionally productive in a way that well implemented creativity techniques produced manifold ideas as a basis for the development of a list of SiSos. The workshop also included the analysis of the processes and the investigation of bottlenecks again as a means to find creative solutions. The approach of the development of solutions in the workshop was based on brainstorming sessions that took place in small groups consisting of a mixture of process experts and consortium members, discussing each process chain and collecting first bottlenecks and subsequently possible solutions.

As a result of this workshop a first long list of **89 single solutions** was developed. In order to have a solid ranking, a detailed description of each SiSo was developed, allowing the assessment by every partner of the consortium.

The detailed descriptions of single solutions were collected on structured sheets. To crystallize the most promising single solutions a survey was performed where all solutions were evaluated according to two main parameters:

- Expected benefit for the process duration and variance
- Probability that the solution could become reality ("reality check")

Using the survey results and a final discussion within the consortium the solutions were then selected for further use in the project or for rejection. After this selection process a **short list of 56 single solutions** was left, serving as base for the further work of the project.

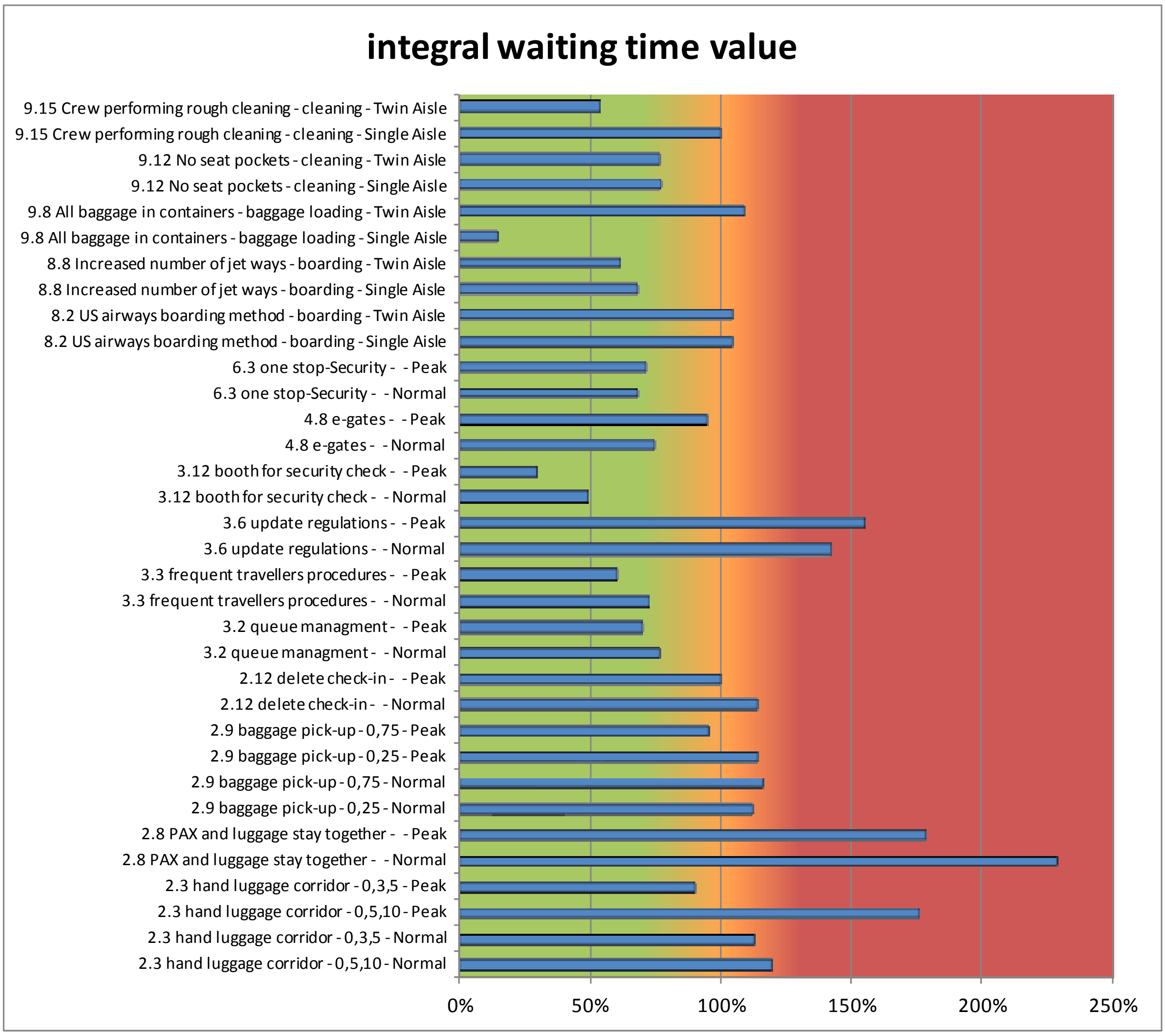

Fig. 4: Integral waiting time value – integrated solutions

7 Simulation of Solutions

Prerequisite of the simulation are the models (see chap. 4), the passenger typologies as well as the flight scenarios (see chap. 5). In order to facilitate the assessment of the solutions described above, the solutions need to be translated into the simulation model. On the one hand, the abstract nature of the models limits the capabilities of the simulation models. On the other hand, the solutions range from minor changes in process steps to overall replacements of existing equipment. Obviously there is a gap between the ideas collected in single solutions and the simulation models. Consequently, not every single solution can be simulated. In fact, only 15 of the 59 SiSos could be simulated.

In order to compare the simulation results an indicator capturing the overall positive or negative effects of a simulation run is required. To address this issue the integral value of the average waiting time curve is selected. The comparison is made between the value in the reference scenario and the value in the single solution scenario. It measures the area below the two curves and produces a percentage indicator answering the question: “What is the value of the single solution in percent of the reference scenario?” This means that a value below 100% indicates a single solution with lower overall waiting times. It may still be that there are timeframes where waiting times are lower in the reference scenario. A value of 100% indicates that the overall waiting times are equal, although the distribution does not have to be the same. A value above 100% indicates a solution which leads to worse results than the reference scenario.

Figure 4 presents the integral value comparison for all single solutions. The value is calculated for the most important source of delay, security control except for SiSo 4.8 “e-gates” which shows the results for the border control instead. The latter SiSo does not affect the security process which is why “border control” has been chosen. The boarding airside solutions show the values for boarding airside and the aircraft turnaround solutions depict the values for the addressed sub process of aircraft turnaround.

8 Assessment

As a further step to assess the single solutions, a survey has been conducted, rounding off the process of single solution evaluation, as the final ratings are based on the results of a broad basis for decision-making. The survey consists of two parts – the evaluation of the parameters and their weighting itself. The whole consortium as well as other experts within the companies of the consortium were asked to participate in the survey. Each solution was evaluated against a set of assessment parameters specifically designed in this project. The parameters are based on the projects requirements analysis as well as on the overall project goal of increasing process punctuality. Thus the paramount factors to measure the degree of target achievement are time and financials. These global parameters have been broken down into the following 14 process specific assessment parameters:

- Service time
- PAX benefit
- Implementation costs
- Time for Implementation
- Employees
- Infrastructure / space consumption
- Compatibility
- Privacy constraints
- Security level
- Safety level
- Waiting time
- Walking time and transportation time
- Level of service
- Robustness

To this, a scale between 0 and 100 was elaborated for each parameter. While ‘100’ represents ‘highest benefit’ regarding the individual parameter, ‘0’ stands for ‘highest disadvantage’ considering the status quo. Consequently, ‘50’ signifies that the single solution has no or negligible influence on the parameter. For statistical reasons the mean

Ranking	1		2		3	
	Name	*[%]*	*Name*	*[%]*	*Name*	*[%]*
Consortium weighting	Reduction of Security Checks Through Common Rules	64,7	Skip Check-In	62,7	Award Self-Service	61,8
Advisory Group weighting	Reduction of Security Checks Through Common Rules	63,4	Skip Check-In	62,2	Information exchange (stakeholder) and Coordinated Operations	61,2
Security	ID-Card as Boarding Pass	69,3	Security Corridor + ID-Check	64,3	E-Gates / Manual (On the Fly)	61,3
PAX Benefit	Reduction of Security Checks Through Common Rules	80,4	Baggage - Pick Up	79	Queue Management	78,2
Service Time	Reduction of Security Checks Through Common Rules	76,1	Skip Check-In	75,6	Information exchange (stakeholder) and Coordinated Operations AND Increased Number of Jet Ways/Doors	75,4
Waiting Time	Skip Check-In	81,7	Queue Management (Boarder Control)	79,2	Queue Management (Check-In)	78,7
Implementation Costs	Reduction of Security Checks Through Common Rules	55,4	No Seat Pockets	53,5	Crew Performing Rough Cleaning	52,9
Service Time and Waiting Time	Skip Check-In	78,5	Increased Number of Jet Ways / Doors	74,2	Reduction of Security Checks Through Common Rules	74,1
Level of Service and PAX Benefit	Counting System	74,6	Baggage - Pick Up	71,7	Queue Management	71,1
Implementation Costs, Infrastructure/Space Consumption and Employees	Skip Check-In	67,4	Reduction of Security Checks Through Common Rules	62,7	Award Self-Service	59,5

Table 1: Single solutions ranking

value, standard deviation and the number of given answers are provided as well.

Furthermore, the experts were asked to weight each of the 14 assessment parameters. This weighting is needed in order to derive a final ranking list of solutions incorporating also the importance of the different parameters. It could be chosen between a single, double or triple weighting. This weighting is used to influence the ranking of single solutions according to different stakeholder requirements. A parameter with a triple weighting is considered most important while the importance of a single weighting is comparatively low. The results of the parameter weighting are shown in the table below. In addition to the consortium members the Advisory Group (AG, for details see [3]) members contributed with their own parameter weighting.

In order to rank the single solutions a multi-criteria analysis method was used. It is a modified version of the "Technique for Order Preference by Similarity to Ideal Solution" (TOPSIS) [5] which measures the distance of each sample to an ideal solution and an anti-ideal solution. TOPSIS is used, as the majority of the assessed single solutions are on an early level of development, their benefit and costs cannot be quantified exactly.

Based on the survey results and weighting of the consortium and the Advisory Group, different ranking lists referring to different preferences and weightings were developed. As can be expected the results of the ranking differ depending on the weighting applied. Some results are shown in Table 1. The same assessment approach has also been applied to the integrated solutions as described in the next section.

9 Integrated Solutions

The process of developing integrated solutions started early at an individual stage in the project by looking at possible combinations. First ideas came naturally while closely examining and assessing the single solutions. To focus and control this activity a structured workshop was conducted. In a first step combinations within each point of activity were identified. On the other hand combinations that are mutually exclusive, i.e. solutions that would obstruct one another or would just be illogical, needed to be separated out. A second step thereafter then dealt with the combination of all single solutions in a 56x56 matrix thus looking at combinations of solutions throughout the whole process chain. The workshop produced a list of integrated solutions and excluding solutions.

To discuss, confirm and complete the results produced during this workshop, another workshop was conducted where solutions have been presented again and were assessed in a structured discussion focussing on possibilities of creating integrated solutions covering the whole process chain. In this regard focus was consecutively set on different aspects such as highest savings of waiting time, queue management, overall best ranked solutions, etc. However, an exhaustive accomplishment of this approach could not be fulfilled, because neither a simulation nor a qualitative assessment of these integrated solutions was possible at this stage. The number of single solutions that has been prepared for simulation earlier was not sufficient for this endeavour and a qualitative assessment cannot address highly complex interdependencies in a 56x56 matrix. Finally discussions based on the focal points described above resulted in a list of 24 integrated solutions.

The methodology for the assessment and ranking of the 24 integrated solutions is similar to that of the single solutions described in chap. 8. An assessment against defined criteria was carried out by the consortium. Integrated

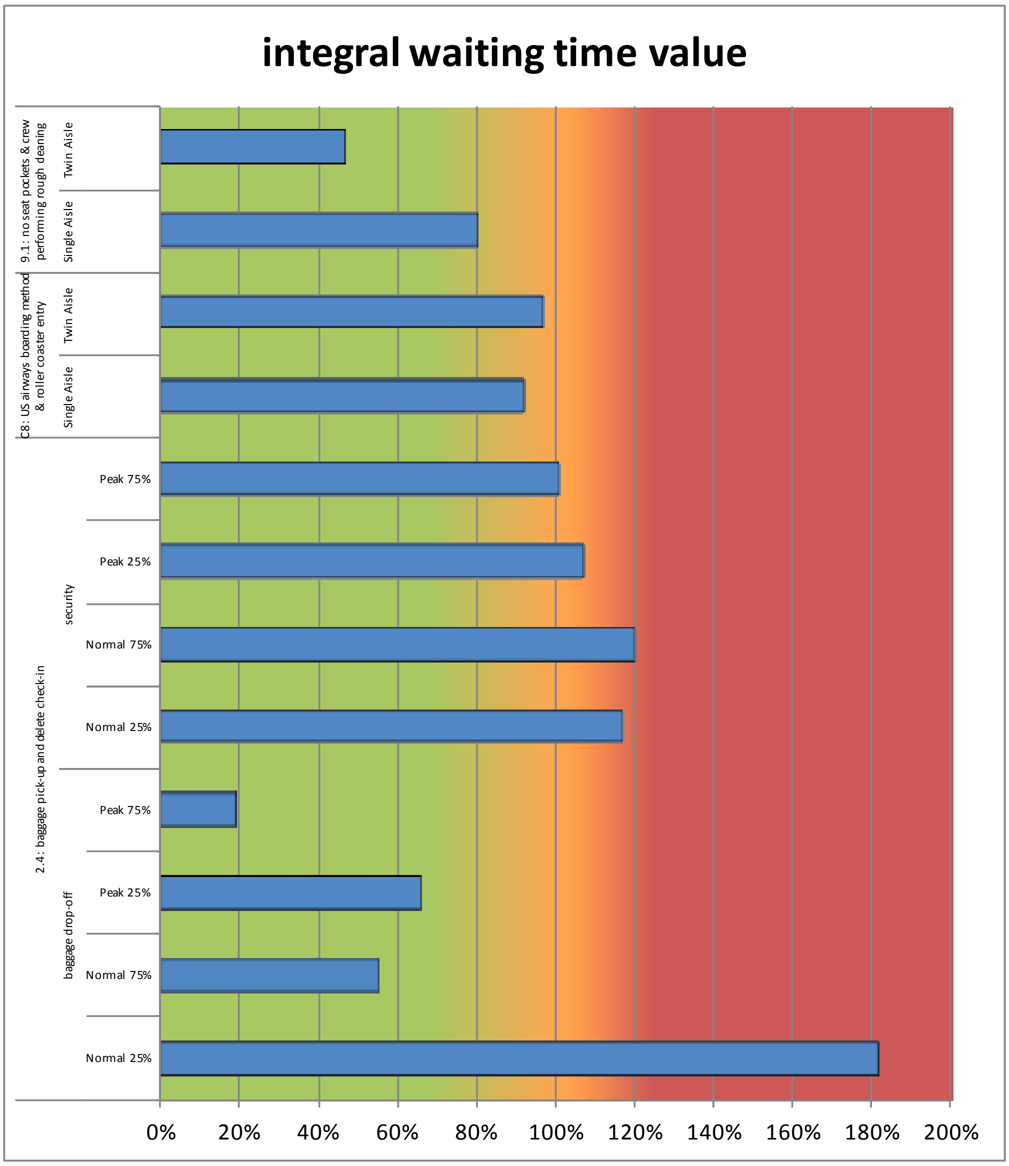

Fig. 5: Integral waiting time value – integrated solutions

Ranking	1		2		3	
	Name	[%]	*Name*	[%]	*Name*	[%]
Consortium weighting	Delete Check-in POA + ID-card as boarding pass	68.4	Delete Check-in POA + RFID Baggage Tags +standardized baggage and self-service luggage drop-off	64.6	Queue management + e-gates/manual (on the fly)	63.4
Service- and Waiting Time	Delete Check-in POA + ID-card as boarding pass	81.4	Delete Check-in POA + RFID Baggage Tags +standardized baggage and self-service luggage drop-off	80.1	Queue management + e-gates/manual (on the fly)	77.1
Level of Service and PAX Benefit	Delete Check-in PO + baggage pick-up	72.7	mobile apps for orientation incl. time to gate + ID-card as boarding pass	69.3	Dynamic/personal information + Gate allocation	69.2
Costs, Infrastructure/Space Consumption, Employees	Delete Check-in POA + ID-card as boarding pass	74.8	Delete Check-in POA + RFID Baggage Tags +standardized baggage and self-service luggage drop-off	67.2	standard kiosk + ID-card as boarding pass	60.0

Table 2: Integrated solutions ranking

solutions that are translatable into simulation are further analysed by the simulation as described chap. 7. Only those integrated solutions which are made of already simulated single solutions could be translated into the simulation environment. Fig. 5 reflects the simulation results of the integrated solutions related to waiting time.

Table 2 shows the top three ranked integrated solutions for each weighting including the percentage based on the weighted parameters' assessment analogue to the approach described above (see chap. 8). According to the percentage value, the ranking is set up, meaning the closer to 100 % the better the alternative.

10 Conclusion

The European co-funded FP7 project ASSET successfully developed two generic models including reference scenarios and passenger typology. These models have the capacity to be modified and to facilitate further research.

A thorough process analysis with regard to airport stakeholders' requirements has been conducted and according KPIs have been developed to ensure an assessment against relevant parameters.

On bases of analysis and stakeholders' expertise a comprehensive set of single and integrated solutions has been developed. This bunch of solutions has been assessed against a set of practice-oriented assessment parameters. The assessment and ranking method applied in ASSET also allows for different focuses depending on stakeholders' preferences.

Beneficial next steps would be the incorporation of curbside and airside process chains as well as issues of cargo handling in order to broaden the scope to the full airport process spectrum.

Discussions with experts also showed that an overall better information exchange of the air transport actors would also benefit the performance of the whole process chain.

References

[1] Performance Review Commission. Performance Review Report 2010

[2] Performance Review Commission. Performance Review Report 2005

[3] www.asset-project.eu

[4] IATA, ACI and ATAG. Airport Capacity/Demand Profiles, Montreal 2003

[5] Marcović, Z. "Modification of TOPSIS Method for Solving of Multicriteria Tasks", Yugoslav Journal of Operations Research, Volume 20 (2010), Number 1, 117-143, 10.2298/YJOR1001117M, Belgrade 2010

Copyright Statement