AIRPORT OPTIMIZATION ANALYSIS –

POSSIBLE ENHANCEMENTS OF AIRPORT SYSTEM PROCESSES

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Abstract

The increasing number of passengers and freight represents a huge challenge for airports, airlines and other stakeholders at the airport. Despite expansions of the infrastructure, a more efficient usage of existing systems is needed. The optimization of according processes requires the availability of more process information at the right place and at the right time.

This paper presents an overview of modern airports main elements: processes, infrastructural elements, actors and their interrelationships. Based on these results, potentials for optimizations were identified for both the landside and the airside infrastructure.

To provide an extended overview of the airport landscape with its highly complex organizational structure, the airport was divided into the three areas, namely 'terminal', 'baggage handling system' and 'apron'.
Within these areas 90 processes, 82 actors and their main tasks, and 149 infrastructural elements have been identified. Four process chains, namely 'passenger departure', 'passenger arrival', 'baggage handling', and 'apron' could be identified, as well as five main control centers and 34 separate IT-systems. According information flows are presented, showing the involved actors and systems, the content of the exchanged information and the physical realization of the communication.
Based upon the as-is analysis, potentials for optimizations have been studied jointly with the Frankfurt airport operator FRAPORT and Lufthansa.

Two main topics for optimization have been identified.

- Location based services can support all kinds of navigation of vehicles, airport personnel, and passengers. Combination of these services and airport status data allows for example to guide passengers dynamically to a security check with shorter waiting queue.

- Harmonization of communication technologies can improve the operation of broadcast services. In air traffic for example, collaboration is of special importance because each flight is worked on by several companies. Efficient communication and interfaces between these companies (e.g. airport operator, airline, caterer, security) will contribute to safe and more punctual air traffic.

Based on that, proposals for the resolution of the identified gaps were developed as the basis for process optimization with regards to operating costs, productivity, quality of service and investment intensity.

The conclusion of this study is that new technology and wider collaboration between the stakeholders at the airport is a key requirement to handle the projected increase in air traffic.

1. INTRODUCTION

1.1. Purpose

Airports are the nodes of the international air traffic networks, they are the interfaces between air and land transport. The rising quality and requirements for economy represent an increasing challenge for airports, airlines and ground handling service providers. Processes have to be examined and further developed continuously. Additionally the political and administrative conditions change constantly, for example the liberalization of the market and the intensified requirements of air security. The airport is requested to fulfill the requirements of its customers such as shorter transfer times, additional services as well as more security, reliability and productivity of the systems. The availability of information at the right place and the right time is an important requirement for the efficiency of business processes.

1.2. Objectives and procedure

The goal of this study is to get an entire overview of the elements of today's aerodromes. A modern airport runs a variety of processes to serve clients and assure a hassle-free operation. This study generates an understanding of the main operational facilities at an aerodrome, their

processes, and their information demand and information supply as well as the information flow between them. For the understanding of the data connections and information flows the study will provide a broad view on the interfaces between processes and / or actors. Based upon the as-is analysis a gap-analysis was to be performed to identify possible lacks of data connections and/or data flows. Based on the identified information gaps, it was be possible to propose enhancements for the handling of information. These were the basis for the formulation of process optimizations. To achieve these goals, ECAD interviewed several experts of Frankfurt airport and Deutsche Lufthansa. The consultation of a major German airport and a major German airline gives this study a competitive advantage because both companies operate at the major hub Frankfurt. Due to the highly complex structure of a hub system, the setting in Frankfurt subsumes most of the procedures at other airports. Further experts of other companies and airports were contacted. In addition to the interviews data collection in this study was complemented by desk research. Due to the highly complexity of the airport processes and information flows, the airport was divided into three areas:

- Terminal,
- Baggage Handling System,
- Apron

The study 'Airport Optimization' is divided into three chapters, showing

1) an overview of the elements of today's airports,
2) an overall view on the collaboration of the airport's elements and
3) potentials for optimizations in relation to information flow and availability.

The second chapter basically presents the main processes, the main infrastructure and the main actors. In addition, the main tasks of the latter are mentioned. Further on control centers as the 'nerve centers' at the airports, which guarantee smooth operational processes, are considered in this study. That is why the most important centers are designated and described by means of their tasks and, if possible, their single workstations. Due to the increasing penetration of technology in all parts of aviation business, additionally, the main databases, communication technologies and systems, which are in operation at the Frankfurt airport, are pointed out. The third chapter, consequently, shows the interrelationships between the airport's elements, which have been identified in the second chapter. Always two of the three elements processes, infrastructure and actors are examined with respect to how they are interrelated:

1) Actors ⇔ Processes
2) Processes ⇔ Infrastructure
3) Actors ⇔ Infrastructure

First, the actors, that are involved in the different processes and the interfaces between them are identified and illustrated including a detailed description of processes.

The illustrations give information about

- the actors, systems, databases etc, who / which communicate with each other,
- about the information exchanged and
- about the physical realization of the communication.

Second, tables are developed to illustrate, which infrastructure and facilities respectively are involved in each process. Third, detailed interrelationships between the actors and the different infrastructural elements at the airport are displayed in form of matrices. The forth chapter presents gaps between availability and demand of information. To identify potentials for optimization, a two track approach is pursued:

1) gaps / potentials of optimization, which were identified in the interviews,
2) future developments and innovations at airports, which were compiled by desk research.

According to the tasks the collected information is brought together. For all tasks the designated interviews with experts are essential for quantity and quality of the results. Especially the gap analysis is depending on statements of interview partners. Alternatively potentials for optimization can be identified by desk research. Based on the results of the gap analysis the Darmstadt Technical University demonstrated the benefits of information exchange and planned and performed a simulated real-world scenario.

2. INVESTIGATION OF MODERN AERODROME'S MAIN ELEMENTS

The operation of an airport demands an efficient management of the complex processes as well as innovations, in order to remain competitive for the future. Therefore a coordinated interaction of all stakeholders concerning the passenger and aircraft handling is necessary, to have an optimal use of the airport infrastructure and to plan monitor and control processes with the support of information technology. Only that way integrated services can be offered to the customers and the requirements of the customers can be met flexibly. The goal of this chapter is to get an entire overview of the elements of today's aerodromes. To achieve this goal the task formulation is subdivided into three subtasks:

1.1 all-embracing list of processes containing a description of the process flows,
1.2 list of operational facilities (infrastructure),
1.3 research of the aerodrome's actors and roles.

Due to the airport's large infrastructure, its many actors and complex processes the airport will be examined divided up into the following areas.

- Terminal
- Baggage Handling System
- Apron

As a result of this division a clear and structured presentation is possible. Within the area 'Terminal' all elements, which are involved in the departure and arrival processes of the passenger, are described corresponding to the requirements of the subtasks. The second examined area of the airport is the 'Baggage Handling System' (BHS). 'Apron' represents the third area in this study. It contains amongst others all ramp services as well as taxiing of aircrafts. Besides the three subtasks the study illustrates the main control centers and the main systems, i.e. communication technologies and IT infrastructures, at Frankfurt Airport. The processes,

infrastructure, actors, systems and the control centers, which are present at Frankfurt Airport, will be elaborated in the following chapters. Sources of the information that are presented in this chapter, are ECAD knowledge and information provided by the interviewed experts.

2.1. Processes at a modern aerodrome

The results of subtask 1.1 'all-embracing list of processes containing a description of the process flows' are presented in two parts:

- chapter 2.1 deals with listing of processes separated into terminal, baggage handling system and apron
- chapter 2.2 describes process flows for same areas.

2.1.1. Terminal

TAB 1 shows the processes, which occur in the terminal building related to passenger processes for dep. and arr.

1	Ticket issue
2	Baggage store
3	Queue Management
4	Check-in
5	Priority check-in
6	Self-service check-in (SSCI)
7	Baggage screening (in front of check-in)
8	Baggage drop
9	Oversize / Excess baggage drop
10	Boarding pass control
11	Security check
12	Emigration
13	Customs, departure
14	Health check
15	Boarding
16	Transfer passenger treatment
17	Flight Management
18	Providing for VIP-layover (lounges)
19	Immigration
20	Lost & found service
21	Customs, arrival
22	Retailing
23	Passenger / terminal announcements
24	Information of passenger I (at kiosk)
25	Information of passenger II (on foot in the terminal)
26	Police operation
27	Fire protection
28	Terminal security
29	Porter service
30	Treatment of special groups of passengers
31	VIP-treatment
32	Providing baggage carts
33	Passenger transport in the terminal
34	Passenger guidance
35	Terminal surveillance
36	Terminal cleaning
37	Maintaining terminal infrastructure

TAB 1. Listing of Terminal processes

2.1.2. Baggage handling system

The baggage handling system has to sort pieces of baggage belonging to inbound, transfer and outbound passengers and transport them to the terminals as well as to the inbound and outbound aircraft. The whole process starts at the check-in or baggage drop and ends at the system's sampling points in the terminal or at the apron. The single processes, which are needed to meet these demands, are illustrated in TAB 2.

1	Check-in
2	Priority check-in
3	Self-service check-in (SSCI)
4	Baggage screening (in front of check-in)
5	Baggage drop
6	Oversize / excess baggage drop
7	Lost & found service
8	BHS maintenance
9	Baggage loading (BHS → dollies load devices)
10	BHS operation / surveillance
11	100 % baggage X-ray
12	Baggage transport

TAB 2. Listing of baggage handling system processes

2.1.3. Apron

The airside area covers all parts of an airport, which are accessible for aircrafts, such as runways, taxiways, ramps, freight center and hangar. The apron serves as a parking and dispatching area for aircrafts. Main task at the apron is the turnaround and dispatching of an aircraft respectively. This process covers all procedures, which are necessary, in order to get an aircraft ready for take-off within shortest time. The time, which the aircraft has to remain on the ground (minimum ground time), thereby depends on the type of aircraft and is defined by the manufacturer. At the apron, different services such as the dispatching of the aircraft as well as the dispatching of the baggage and freight take place. Their fields of application are amongst others, loading and unloading of the aircraft, the transport of crews and passengers etc. These and other processes at the apron are shown in TAB 3.

1	Flight relevant tasks
2	Flight attendance
3	Weather information
4	Driving passenger bridge
5	Driving passenger stairs
6	Passenger transport
7	Crew transport
8	VIP transport
9	Short connex service for passengers and baggage
10	Catering
11	Baggage loading I (BHS → dollies load devices)
12	Unit load device control
13	Baggage transport
14	Baggage loading II (dollies load devices → aircraft)
15	Providing wheel chocks
16	Ground power
17	Ramp supervision
18	Pushback
19	Cooling / heating
20	Starting
21	De-icing I (station)
22	De-icing II (vehicle)

23	Toilet service
24	Cargo & mail loading I (cargo center → dollies)
25	Cargo & mail transport
26	Cargo & mail loading II (dollies → aircraft)
27	Cleaning and cabin setting
28	Water service
29	Fuelling I (pipeline)
30	Fueling II (vehicle)
31	Follow me
32	Marshalling
33	Friction test
34	Taxi- and runway cleaning
35	Snow clearing
36	Fire protection
37	Walk around
38	Security supervision
39	Medical service
40	Task force
41	Aircraft maintenance

TAB 3. Listing of apron processes

2.2. Description of the process flows

After having listed the single processes, the succession of these processes are of special interest in this chapter. The illustration and description of the process flows are presented analogue to the division of the aerodrome into the same three areas terminal, baggage handling system and apron with the exception that the passenger processes in the terminal is examined broken down into departure and arrival. Thus the presented process flows are the following:

- passenger process, departure,
- passenger process, arrival,
- baggage handling process,
- apron processes.

2.3. Infrastructure at a modern aerodrome

It is today acknowledged that aviation, far from being a traffic mode for an elite group, is essential for sustainable development of trade and tourism. In this context, it is from outstanding importance that airport infrastructure grows in anticipation of the rising needs of the air transport industry. Due to the fact that the air transport serves a time-sensitive market the quality of airport infrastructure is a vital component of the overall transportation network. A typical airport infrastructure is complex, and contains a variety of components. Generally, many of the facilities of an airport are operated by different organizations and companies. This chapter presents a listing of infrastructure elements at a modern aerodrome. The listing of infrastructure is divided into the three areas terminal, baggage handling system and apron

Further the listings of infrastructure elements are divided into the three following categories:

- area,
- facility,
- equipment.

The category ‘area’ describes surface areas at the terminal, baggage handling system and apron, e.g. area for certain processes (security control etc.) or queuing areas. ‘Facilities’ are fixed arrangements such as counters for check-in or immigration or baggage carousels. The third category ‘equipment’ differs from the facility by its movable character. Examples for this category are the baggage tag printer at check-in or the follow me vehicle.

2.4. Actors of a modern aerodrome

At a modern aerodrome there is a variety of actors involved in the handling operations. The two main players at the airports are the airport operator and the airlines. The airport operator provides employees for check-in, information, apron control etc. The airline is represented by e.g. check-in agents, flight attendants and pilots. Besides those two players you can find third parties: Police, ground handling service providers, concessionaires, several subcontractors etc. Last but not least the passenger is one of the most important actors at airports. He has to run through all passenger processes from check-in to boarding. Airport operators, planners and designers are struggling how to make passenger terminals that combine good value and a basis for a high level of cooperation of the different actors at a modern aerodrome. The goal of all actors is to provide good service and efficiency to meet the needs of all stakeholders and accommodate regulations.

2.5. Control Centers

Beside the single actors at the terminal, the baggage handling system and the apron, several control centers are necessary at the airport to control, steer and coordinate the passenger, crew, baggage, cargo and aircraft handling. In this subsection the following main control centers are described:

- apron control,
- air traffic control,
- hub control center,
- airport operation center,
- baggage control.

2.6. Systems

The IT products and system platforms for the today’s and future requirements of airport management are essential for reliable telecommunications as well as for smooth operational processes at the airport. It is vital to airports to have implemented an application-oriented research and innovation management. The systems operated are in the following areas:

- Trans-sectoral systems
- at the terminal
- at the baggage handling system
- at the apron

3. INVESTIGATION OF INFORMATION AVAILABILITY, DEMAND, AND FLOW

Due to the multifaceted nature of airport processes, the information flows and interrelationships between the different airport’s elements, which are involved in the processes, are very critical. The objective of this chapter is to shed some light on these information flows and interrelationships. To achieve this objective, data collected from interviews and desk research was analyzed using Microsoft Visio illustrations, tables and matrices. An overall view on the collaboration of the airport’s elements,

which have been detected in chapter 2, is presented in this chapter. Due to the highly complex connections between the airport's elements and the mass of information flows, the illustrations and descriptions of the processes can show only the highest level of the interactions between the elements. Further it was merely possible to show a variety of processes, which are listed in chapter 2.1. The reason for this circumstance is on the one hand the pile of processes at the airports, which cannot be displayed within the scope of this study, and on the other hand the limited time for the interviews, that did not allow going into detail for every process. If certain processes should be examined more detailed, cooperation with an airport or an airline is recommended. In the detailed report of this study the interrelationships of processes and actors, interrelationships of processes and facilities as well as interrelationships actors and facilities were considered and described in detail and due to the huge size of diagrams omitted in this paper.

4. GAP ANALYSIS INFORMATION FLOW AND AVAILABILITY

In chapter 4 the as-is situation at the airports, in particular at Frankfurt airport, is described. After having listed the processes, actors and infrastructures as well as their interfaces, this chapter is dedicated to the identification of gaps or in other words the potentials for optimization at airports. Attention is focused on the identification of gaps regarding data connections, data storage, information transfer, systems used at the airports etc. Based on this analysis, proposals for resolving the identified gaps were gathered by expert interviews, where possible. Due to the limited cooperation of possible interview partners, a twofold approach is pursued to identify potentials for optimization and to name proposals for solution. First, gaps and potentials of optimization respectively, which were stated in the interviews, are invoked in subsection 4.1. Second trends and future developments at airports compiled by desk research are described in the following subsection. Finally the study outlines possible long-term future developments for airport environments. Therefore assumptions of the airport landscape in about ten years are made and what requirements result of these developments. Generally two main subjects, which are in the need for improvement, have been identified during the execution of this study:

- optimization of IT systems and infrastructure and
- improvement of collaboration between airport stakeholders.

The latter goal has often to be accompanied by IT improvements. The benefits of a well planned and integrated IT system can be indicated at the operational and financial scope of an airport. Operationally, e.g. a decrease in personnel, a better support of business operations, a maximization of utilization of assets and the improvement of regulation compliance can be achieved. Financially the personnel as well as the capital and recurring expenses can be decreased and consequent the revenue collection can be improved by a well-working IT landscape. The second main potential for optimization is the improvement of collaboration between airport stakeholders. The goal of all stakeholders of the airport are frictionless processes. Frictions caused by poor communications, inefficient processes, unrealistic expectations, conflicting goals and regulations must be solved by an improved cooperation between the stakeholders supported by automation, process integration and, as mentioned above, improved IT solutions.

4.1. Potential for optimization identified in the interviews

This subsection deals with potentials for optimization, which have been won by the interviews with experts. The results show potentials for nearly every part of the airport. However, topics regarding navigation and communication and the involved IT as well as optimization of cooperation are patterned mainly. A vision, which was quoted by almost every interviewed expert, is the optimization of cooperation between the stakeholders of the airport (airline, airport operator, air traffic control, federal police etc.) due to dynamic changes in the aviation sector. The director of the hub control center (HCC) got to the heart of it: 'In spite of competitive goals act together purposeful!'. That sounds very easy but seems nearly impossible because of secretiveness of the various stakeholders and the legislation. In the following the 'gaps' or potentials for optimization are described. The explanations contain the problem descriptions and methods of solution. If possible, pre-existing products regarding the problem are mentioned. If a detailed analysis should be executed to close a 'gap', this must be task of a separate study. TAB 4. summarizes the potentials for optimization, which were stated in the interviews clustered into the two main subjects, where need for improvement has been identified:

- optimization of IT systems and infrastructure and
- improvement of collaboration between airport stakeholders.

No.	Optimization of IT systems
1	Navigation of apron vehicles and personnel
2	Near Field Communication
3	Location of equipment
4	Telemetry
5	Digital transfer of weight & balance-data
6	Improvement of irregularity broadcasts
No.	**Improvement of collaboration**
7	Integration of the airlines into the ground handling services
8	Communication between control center and apron
9	Integrative communication platform
10	Optimization of steering and planning of passenger flow
11	Trans-modal dispatching of baggage (door to door-service)
No.	**Miscellaneous**
12	Evaluation of effects of single processes
13	Optimization of space efficiency
14	Control and supervision of ground handling processes

TAB 4. Potential for optimization identified in the interviews

4.1.1. Potentials for optimization regarding Information Technology (IT)

1. Navigation of apron vehicles and personnel
Today only the emergency and fire cars are equipped with

a navigation system (TACSYS–ETNA). Other apron vehicles cannot be navigated, so that their actual position can, if at all, be detected by status reports. At Frankfurt airport it is only possible to locate the vehicles by areas. A RFID capture at the gates between apron and other operating areas allows only an insufficient location. It was stated in the interviews that – for an optimized arrangement of personnel and infrastructure (e.g. vehicles) on the apron – the navigation of apron vehicles and personnel would be a great improvement. Due to the immense cost pressure on airport operators and ground service provider, exerted by airlines, the navigation could be a great approach to reduce costs. For example the dragged dollies at the baggage transport could be recorded and located automatically [1]. The new handling system at the airport Berlin Brandenburg International (BBI), which plans to start operation in 2011, contains such navigation technology. Thus it should be possible to navigate the vehicles at the apron exactly. In the control center the vehicles can be identified by colored points on a large monitor.

2. Near Field Communication
Today many airports have to grapple with a limited landside capacity. Due to the facts that the number of passengers increases and the requirements on airports regarding security rise, the terminal capacity will not be sufficient anymore at some airports; especially, if it is considered that many airports need additional areas for retail in order to increase their non-aviation turnover. Therefore the airport operator and airlines seeks for simplifying and speeding up terminal processes. Near Field Communication (NFC) is a new, short-range wireless connectivity technology for the contactless change of data between electronic devices. The NFC is both a 'read and write' technology. NFC devices, which are close to another, determine independently, how they can exchange data. Connectivity is automatically established. Today mobile phones or personal digital assistants (PDA) seem to be the best solution for devices because the majority of passengers owns such a device and the number of owners still increases. The advantages of this fast interaction between two devices can be applied to many handling processes at the airport. Fields of applications can be the support of information services as well as fast and secure payments. The device simply has to be tapped against the automated check-in kiosk at the airport and the request and exchange of data will begin. Due to the 'read and write' technology the check-in kiosk not only receives the relevant data. The machine can also transmit information regarding gate, departure etc. to the passenger. Hereby check-in times could be drastically reduced and queuing areas could be minimized. Another process improvement could be achieved at the boarding. Instead of today's manner of using a 2D-barcode or automatic boarding by inserting the ticket into a reader, NFC can check the authority faster and without employment of staff. In the future even passport data could be stored on the chips in the devices for an access control based on biometric data. Due to the fact that it is possible to make fast and secure payments, the vision of a cashless airport or cabin can become reality. The main advantages of NFC, simplicity and speed to create a connection, can make a lot processes at the airport easier and more cost effective.

3. Location of Equipment
The Frankfurt airport complains about the ongoing loss of certain equipment at the airport. Especially baggage trolleys used by passengers and dollies respectively are concerned [1]. The baggage trolleys are left behind everywhere at or even outside the airport site. The dollies disappear without explanation. In order to provide an adequate number of trolleys and dollies the airport operator has to order new ones year by year. The operator could be remedied by a location system for the disappearing equipments. A solution for an outside and inside detection of equipment would be an improvement.

4. Telemetry
Today Frankfurt airport uses mobile devices in the vehicles to transmit their status in terms of the execution of order. Technical data of the vehicle itself is not be transmitted yet. The expert of ground handling at Fraport imagines a use of telemetry to support and analyze the processes at the apron. By measuring quantities, transmitting the measured value to a station, and there interpreting, indicating, recording and analyzing quantities measured would be an improvement. That way, the employees in the control centers, who are responsible for the arrangement of the vehicles, could recognize at any time whether the vehicle concerned is in operation or how much fuel is left in the tank. Even information about the current technical condition could be transmitted telemetrically. A substantial saving potential could be achieved by the optimization of the maintenance cost and the improved operational efficiency. At the moment the Munich airport is testing the employment of such a system with 68 ground power devices in a pilot project [2].

5. Digital transfer of weight & balance-data
The pilot always consults specific aircraft weight and balance data for flight planning. The weight and balance sheet records the distribution of weight in an aircraft and shows the center of gravity of an aircraft at takeoff and landing. Today the data transfer of the weight & balance sheet is partly done verbally via radio from the ramp agent via the airline operation center to the pilot. To overcome the technical and operational limitations of this procedure in delivering information to the cockpit, digital data link should be used in the future. An automated transmission of weight and balance data has just been developed at Frankfurt airport, but only for aircrafts, which are equipped with the Aircraft Communications Addressing and Reporting System (ACARS). By the installation and operation of a digital weight and balance data transmission system, the airplane safety can be optimized. By means of an automatically transmitted complete load sheet, the aircraft can be trimmed for a safe takeoff, a stable and economical flight and a safe landing. Additionally, the operation cost can be reduced by automation of the data transfer.

6. Improvement of irregularity broadcasts
In the Hub Control Center (HCC) the expenditure of human labor is very high in the event of an irregularity broadcast does not contact all relevant employees at once [3]. In that case the employee of the HCC, who has commenced the broadcast, has to phone colleagues, he could not contact, innumerable times until he has succeeded. A system, which ensures, that all relevant actors in the Hub Control Center as well as at the terminal and apron are informed about the irregularities and further actions, would ease the employee's work noticeably. Furthermore a faster conversion of the planned actions would be another advantage of such a system.

4.1.2. Potentials for optimization regarding improved cooperation

7. Integration of airlines into the ground handling services
General data such as flight data or parking position is provided by the INFOplus database. Therefore all stakeholders are well informed. However, the ground handling service itself is very unintelligible for the customer namely the airlines. Today only ordering and status requests are possible over the internet for a few ground handling services. Due to the fact that many companies are involved in an aircraft turnaround an overall depiction has not been realized yet. For better information the airline should be integrated in all ground handling processes. A platform, where all relevant information regarding the processes merges, could be a solution to make the processes at the apron clear to everybody. Further features such as the automatic collection and display of the variety of timestamps could be implemented. Further requirements on the platform must be identified by all stakeholders together.

8. Communication between control center and apron
An adequate communication is the basis for well functioning processes at the airport. Especially the communication between the control centers and the apron, that means the vehicles and personnel, is of great importance for a fast and secure dispatching of the aircrafts. The interview partners of Lufthansa gave different statements if an optimization of the physical realizations is necessary. The HCC expert said that despite the improvements of the communication via trunked radio, telephone or UMTS, such as WIFI and therefore bigger bandwidth could increase and improve the number of transmitted data [3]. At present the ramp agent of the deutsche Lufthansa receives information on a display in his vehicle via UMTS. Due to the little bandwidth it is only possible to transmit a limited amount of data. A further example is Lufthansa's Integrated Ground Cockpit Communication (IGCC). This solution consists of an intranet maintained by means of a content management system, which all involved employees including the pilot have access to. Additionally a voice of over IP system is integrated, so that certain employees (e.g. pilot, ramp agent, employment line etc.) can communicate with the system via telephone orders. That means that the IGCC is available only via voice function for important employees, which are involved in the ground handling process. Then again the experts of the Lufthansa ground handling department processes stated that the current physical realizations between the control centers and the actors at the apron would be totally sufficient. This issue is to be analyzed in detail due to the different statements. In the course of the described improvement of the communication, the Fraport ground handling department sees a mobile digital device, which is able to receive all kind of data independent on physical realization (GPRS, UMTS,WIFI, radio etc.), as desirable.

9. Integrative communication platform
The Lufthansa experts [4], working in the department 'Ground Handling Processes (Worldwide)', criticize the variety of different software, which is used by the stakeholders at the airport. Due to that fact and the non-compatibility of the software, there are accordingly no interfaces for communication or data exchange. The Lufthansa experts think of a superior integrative communication platform that allows an improved communication at the airport. IT should be a facilitator and not a barrier, critical processes could be simplified by improved system collaboration; IT systems should offer simple interfaces. The uniform instrument of communication would save a lot of manpower and is a preliminary stage of the 'centralized airport database', which is described in subsection 'future developments and innovations at airports' (see 3.2)

10. Optimization of steering & planning of passenger flow
A continuous passenger flow without queuing is the goal of airport operators and airlines to offer the passenger a better experience at the airports. Airport infrastructure has not kept pace with increasing traffic volume, and is expected to lag further in mid-term future. Due to limited runway capacity, the airlines are motivated to move to larger aircrafts (e.g. Airbus 380) with the result of increased passenger volumes in the terminals. The operation of larger aircraft mainly appears at major 'hub' airports in the 'hub and spoke' systems operated by network carriers in order to maximize passenger flow through the limited airport facilities. Therefore, Lufthansa's experts for passenger processes [5] demand an improvement of the steering and planning of passenger flow by its supervision and the planning of infrastructure and personnel resources. Today the actors of the airport operators, handling agents, airlines and Federal Police are lacking information and flexibility. Every stakeholder should be informed about foreseeable peaks of passenger volume and should be able to react by a flexible operation of infrastructure and personnel. At the moment there is a very static planning independent on the size of the passenger flow. For example the Federal Police has very fixed shifts for their employees, so that any sudden gain of personnel is not possible. On the other hand not every stakeholder is well informed about the expected passenger volume. All these 'gaps' must be closed to create an optimal passenger flow. Camera surveillance for detecting peaks and queuing can support achieving this goal. A system that analyses the dynamic interaction between passenger flows in relation to the availability of resources could be implemented as well. These improvements can go into action various places at the terminals where bottlenecks and queues appear: check-in, emigration, immigration, security control etc.

11. Trans-modal dispatching of baggage
Passengers often feel uncomfortable as long as they have to carry their baggage to the check-in at the airport. When they have reached the counter they might have had a stressful journey with their baggage before entering the aircraft at all. Additionally the airlines often offer special packages including the journey to the airport by rail, which can be very stressful with baggage. These new developments in the intermodality must be taken into account according to the Fraport department 'baggage systems' [6]. A home delivery service, which picks the baggage at home and delivers it to the passenger's final destination, can result in a great relief for the traveler. By this the passengers are given the opportunity to travel from their home to their destination without being burdened by baggage. A logistical and technical solution could be developed for such a hands-free travel. The baggage must be picked up at the passenger's residence, equipped with an e-tag, inspected and temporary stored at the airport until the passenger checks in, which automatically triggers the loading of the baggage into the

aircraft. At the destination the baggage has to be delivered to the passenger's residence, too, if this service can be offered there. Technically the passenger must be able to make a reservation with the airport operator and airline respectively. This could happen over the internet amongst others.

4.1.3. Miscellaneous potentials for optimization

12. Evaluation of effects of single processes
The processes at the airport, especially at the apron, and the airline business are structured in a complex way. Each process is affected by several other sub-processes, actors and other effects. If delays and other irregularities are analyzed, it is often very difficult to separate a single effect out of the whole process landscape. Due to the interaction of many processes it seems hard to reduce occurrences to one trigger. Vice versa it is also difficult to filter the dynamic of a single process. Especially the management of the Hub Control Center, where many processes merge, stated the requirement for a tool that can analyze the mass of data of the particular processes [6]. The today's systems of Lufthansa seem not to be sufficient for a very detailed analysis of processes. Therefore the development of a process evaluation network based on very detailed examination of each single process as well as of the process contexts and effects would be an optimization for Lufthansa and also for other companies at the airport. The network could be examined not only for airline related processes.

13. Optimization of space efficiency
As mentioned above runways and terminal capacity often will not increase as fast as the passenger volumes. Beside these capacity constraints there are also limited areas for ground handling operations at the apron. The optimization of the use of the existing surface can improve the situation, which is complicated by the appearance of several companies at the apron. The department for ground handling services of Fraport stated that the solution would have to include on the one hand organizational and on the other hand technical measures. Looking at the organizational potentials for optimization, the use of the existing zones, such as maintenance areas, distribution areas, apron roads etc. have to be adjusted optimally to the dispatching operations. The effective allocation of surfaces should be time-saving as well as project-oriented. Short ways for an optimal use of the resources will be a cost-reducing step. Technically the arrangement of the apron infrastructure and actors must be supported by a superior system.

14. Control and supervision of ground handling processes
Many airports have reached their capacity limit due to the continuous air traffic growth in the last decades. In order to be able to meet the future passenger and aircraft volume appropriately, Frankfurt airport has put the Departure management system 'DMAN FRA' into operation. According to the Fraport experts for the ground handling processes, it would be useful to implement a supervision of the aircraft dispatching in order to monitor the processes regarding DMAN. The development of a control and evaluation system for DMAN could help to control, to detect potentials for optimization and to improve the system. Other mainly new introduced processes at the airport could also be analyzed.

4.2. Future developments and innovations

There are several obvious and serious factors that has reshaped the aviation industry, e.g. 9/11 tragedies, SARS etc. But even more relevant are long-term impacts such as airline deregulation, legalizations or the increasing capacity problems at airports. A major challenge will be to maximize the use of existing airport infrastructure and to create a travel experience for passengers. This subsection deals with the future airport landscape. A two track breakdown was chosen to show future development and innovation at airports. The first track shows general developments at and requirements of airports for the future (see 4.2.1). Current projects of aviation organizations, airports etc. with an innovation character are presented in subsection 4.2.2. This approach demonstrates a variety of challenges, which the stakeholders of airport processes will have to face in future.

4.2.1. Trends and future developments

In the last subsection detailed potentials for optimizations are described. Now general fields are pointed out, which should focus airports, airlines and other parties, which are involved in airport processes, in future. TAB 5 lists some trends and future developments, which are described thereafter.

No.	Trends and future developments
1	Navigation of passengers
2	Intelligent camera surveillance systems
3	Biometry
4	Centralized airport database
5	'Outsource as much as possible to the passenger'
6	One-stop-shop
7	Efficient and sufficient baggage handling systems
8	Very light jets

TAB 5. Trends and future developments at airports

1. Navigation of passengers
A very recent subject is the navigation and location of passengers. Hereby improvements along the whole process chain of the passenger – from the beginning of the journey over entering of the aircraft to the final destination – can be achieved. Due to the different locations of the passenger (at home, in the car, in the terminal etc.), a total solution requires a mixture of indoor and outdoor navigation. The passengers could be navigated to their flight at the airport from the beginning of his journey. By the navigation and location of cars the travelers could be guided to the airport on the fastest route. After arriving at the airport they could be led to an appropriate parking lot close to the relevant check-in counters of their chosen airline. The navigation of passengers using public transport is also possible. The guidance could be done by information about means of transportation, departure and changing times etc. In the terminal the passenger would be guided from the parking lot and station respectively to the first element of the passenger process, normally the check-in. Then the navigation to the relevant gate would be the next step. At the destination again a navigational support on the passengers' guidance to their destination would go into action. Because the system should be operated in real-time mode, that means that information and data will be updated continuously, short-term changes such as

change of the gate, departure time etc. could be considered. Additionally information concerning retail or advertisement could be implemented in such a service. A well functioning navigation of passengers could lead to a higher level of service for the customer and as a consequence of that to image benefits for the airport and the airline. Dependent on the cost reduction potential due to this service, different business models could be examined.

2. Intelligent camera surveillance systems
Today camera surveillance systems offer a great spectrum of services that is far beyond supervision of certain areas by looking at several monitors. Furthermore the industry uses, of course, cameras to oversee areas but newly, behind the cameras, there are software systems and algorithms, which alert employees according to pre-defined procedures or act independently and save manpower as a consequence of that. First security measures can be identified as a field of application at the airport. Second the intelligent camera surveillance systems can go into action for the arrangement of infrastructure and personnel. For example the system can count people waiting in front of security control or check-in counters and propose to open an additional counter or lane, if a certain number of passengers is achieved. Generally it is possible to pre-define a variety of limits or procedures (e.g. a car enters a one-way street in the wrong direction), which will be followed by pre-defined actions. Hereby, a surplus value for the passenger, airport operator and airline can be produced. The intelligent camera surveillance systems are able on that respect to create a 'win-win-win' situation.

3. Biometry
The biometrical technology is considered to be the hope for the future for internal security. Persons can be identified nearly clearly by fingerprint, iris scan and facial recognition. In a few years the biometric monitoring of passengers should be standard. Thus flying becomes safer. However it will be also more indiscreetly as the personal biometric data is stored in a multitude of places creating new requirements on data protection. No passwords, PIN, or TAN can be forgotten or spied, no keys and access authorization can be lost or stolen anymore due to the biometric recognition. Only the person, whose physical characteristics agree with the data stored in the safety system, gains admission. Also data acquisition is very simple: The passengers just have to put their finger on the scanner or to pass by the face scanner. Besides the security control and emigration for passengers, the access control for employees is identified as a field of application for biometry. Since the access controls to the apron have been intensified, the same advantages can be achieved as in the passenger processes: cost reduction and increase in security.

4. Centralized airport database
Many airports have already recognized that the installation of an airport operational database as a central hub for the integration of systems throughout an airport is crucial in order to have an enterprise-wide data overview. The database uses automation tools to collect data from all major airport systems: operational, retail, environmental and administrative. In addition it provides highly available data storage and distribution in a controlled and structured way and information required for the efficient and cost-effective management of the complete airport environment. The database described above, which is used at several airports worldwide, is mainly limited to the airport operator's data. In the future, an installation of a centralized airport database, where data of all stakeholders of the relevant airport processes merges, can optimize the processes and save costs. Today poor communications and consequent inefficient processes cause friction. The harmonization of different systems would lead to faster handling of passengers and faster dispatching of aircrafts, whereby, for example, delays could be reduced. Figure 3 1 shows possible stakeholders of a centralized airport database, which could include data and information concerning, amongst others, reference, contracts, business rules, profiles, flight schedules.

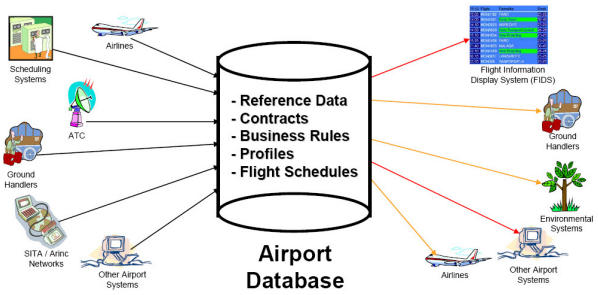

BILD 1. Possible stakeholders of a centralized airport database (Source: Unisys (2006))

The implementation of a centralized airport database is one step to the vision of an optimal cooperation between all stakeholders at the airport stated in subsection 4.1.

5. 'Outsource as much as possible to the passenger'
Philippe Wilmart, marketing director of the Marseille-Provence airport describes the current process goals with his statement 'outsource as much as possible to the passengers' [7]. Regarding the passenger processes a shifting of the processes from the airline and airport operator respectively to the passenger takes place. In the course of an increasing automation, self service check-in has already become standard. The passenger sometimes has to carry the baggage to the aircraft by himself. The aviation industry looks for solutions to save manpower, surface and related costs. By shifting a part of their tasks to the traveler they have already succeeded in this endeavor. For the future additional solutions of outsourcing processes to the passenger might support achieving the goals described above. In combination with improved passenger processes (see 'one-stop-shop in the following) the airlines and airport operators can achieve a great improvement of passenger processes.

6. One-stop-shop
Besides the outsourcing of processes to the passenger the optimization of processes and the optimal use of surface in the terminal are of great importance due to the fact that the processes should be speeded up and the airport operators want to increase their income by retailing. A big development for checkpoints of the future will be combining several technologies into one device. Mostly it is called 'tunnel of truth, some use the term 'checkpoint in a box'. Not only will one system combine and interpret several types of data, but the hardware will take up far less space. This idea includes all security measures such as emigration and x-ray detection. If the system would not only deal with security measures but

also with check-in and baggage drop, all relevant departure processes would be integrated. The so-called 'one-stop-shop' means the completion of certain tasks at only one contact point. An adaptation of this principle on passenger handling would include that check-in, baggage drop, security and emigration would take place spatially limited. Conditions for a realization of such a 'one-stop-shop' are the use of check-in kiosks, automated baggage drops and automated biometry supported passport control. Because all processes would possibly be spatially limited, the setting of equipment and the planning of queuing areas have to be well-considered. Otherwise the solution will end in handicaps in the process chain. By this principle the airport saves surface and the passenger unnecessary ways and time. Ideally the airport operator should have more surfaces for retailing.

7. Efficient and sufficient baggage handling systems
In the next years until 2025 passenger growth will increase by 4.9% per year [8]. Additionally increasingly larger types of aircraft will be operated, airlines optimize their seat load factors and the number of the flight movements rises. Therefore the capacities of BHS are to be extended - according to the airport and terminal developments. An expansion of late-night check-in, re-booking of baggage in the BHS as well as increasing quantities results in an increased storage requirement of baggage. The optimization of the baggage handling times is thereby of great importance. Since large hubs compete for transfer passenger, a small Minimum Connecting Time (MCT) plays a crucial role. Reliable processes must be improved due to rising quantities, increasingly longer transportation ways, a number of drastically risen (more time-critically) interfaces as well as late arrivals. Developments in the control and computer technology require a continuous removal of old systems. Shorter product life cycles require flexible and compatible solutions with new hardware.

8. Very Light Jets
The already existing spectrum of means of transport within the constantly growing segment of business aviation is supplemented by the new aircraft category 'Very Light Jet' (VLJ). Due to modern technology, the aircraft manufacturers succeeded in manufacturing lighter business jets with low operational costs and very reasonable production costs. The VLJs with their new characteristics allow a new kind of travel and can possibly create a new market segment: 'point to point on demand by air taxi services'. A new market segment using relatively new kinds of aircrafts will have a lot of special requirements at airport operators, ground handlers and air traffic control. This will result in accommodations of infrastructure, processes, take off and departure procedures etc. at airports, where air taxi services will be operated.

4.2.2. Projects with innovation character

Some of the challenges mentioned before have already been faced in projects. In the following five projects, which deal with innovations in the aviation industry and airport processes in special, are presented. An overview of the projects shows TAB 6.

No	Projects with innovation character
1	Simplifying Passenger Travel
2	e- Airport in Narita International Airport
3	mobilITät (mobility)
4	Future Traveler Tribes 2020
5	Operational Evolution Plan

TAB 6. Projects with innovation character

4.3. Meeting long-term future demand

This final subsection deals with ideas about what the airports of the future might be confronted with. The visions of airport operators, airlines and other stakeholders are effortless efficiency, space-age design, high technology, no queues and a great experience for the passengers. From today's view the development directs to a penetration of technology throughout the airport to make these visions come true.

TAB 7 shows five examples, how future demands could look like. The selected topics are described more detailed in the following.

No	Future demand
1	Accommodation of unmanned aerial vehicles
2	Departure hall in the city, runways on the green field
3	Multi-use traveler card for transportation
4	Networking of future airport systems

TAB 7. Long-term future demand

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