STRUCTURED APPROACH TOWARDS DESIGNING PASSENGER FRIENDLY AIRPORT TERMINALS

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Abstract

This paper aims at analyzing various passenger-specific tradeoffs between expectations of the different passenger groups and the level of efficiency and quality of service available at an airport. The challenge many airport operators face today is to incorporate distinct functions and facilities within one layout in order to optimize it for a variety of or only one specific passenger group(s). The methodology developed in this paper may assist in assessing future terminal layouts by providing a framework to evaluate the effects of design choices on passengers' overall satisfaction. Providing these insights may enable the improvement of the passenger experience in "airports of the future". The results derived in this paper are based on a passenger survey conducted at Munich Airport, Germany[1]. This particular survey identified the importance different passenger groups place on various aspects regarding passenger handling processes or availability of various services and facilities within the terminal. These results are then complemented by previous studies on passenger expectations and how these can be met.

1. INTRODUCTION

Despite several crises in the past decades, air traffic has been growing steadily and passenger numbers have been increasing at airports all over the world. The future challenge of the aviation industry, both for airlines and airports, is to accommodate this growth. Especially airport infrastructure might pose a capacity constraint if not adjusted accordingly. Potential congestion and delays on the ground can be avoided by expanding existing airport infrastructure and by increasing the operational efficiency of aviation related processes at the airport. Airport operators also have to incorporate the requirements of various users of the airport infrastructure such as airlines or passengers, and find solutions how to best address arising trade-offs between interest groups.
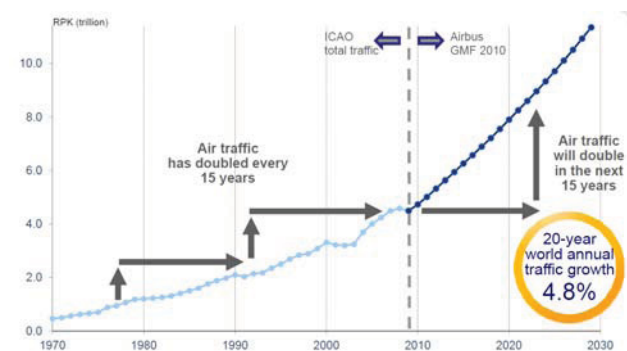

BILD 1.   Air traffic development 1970-2010 (Airbus 2010)

Previous literature is concerned with the analysis of different terminal concepts and how airport buildings have to incorporate various services and facilities both in terms of passengers and airlines (see for example: Wells 2004, Mensen 2007, Kazda 2007). In addition to that, there have been studies regarding passenger service requirements and the level of service quality at various airports (see Dresner 2006, Brilha 2008, Schwetje 2010, Shaw 2008). These studies investigate particular passengers' expectations and needs regarding air travel and their stay at the airport. Some of them focus on certain segments such as business passengers (Dresner 2006) whereas others deal with requirements that arise from an ageing society (Schwetje 2010). Furthermore, research into the expectations of transfer passengers is of growing importance and some studies have been dedicated to this particular topic (see Barros 2007).

The approach taken in this paper goes beyond what is already available in the literature. It analyses the perceptions and expectations of distinct passenger groups such as business and private as well as transfer and embarking. The results are applied to test the suitability of various terminal concepts in fulfilling specific passenger expectations. Combining the insights into passenger perceptions and the ideas behind specific terminal designs, enable the development of a framework which will help to assess passenger expectations and how these can be conceptualized within passenger friendly terminal concepts. In the following analysis we will concentrate on specific terminal concepts and varying passenger requirements as well as expectations in terms of basic layout, arrangement of passenger processes and other services and facilities within an airport. Based on the general findings outlined above and a passenger survey conducted at Munich Airport, Germany (MUC), we develop this particular framework to analyze terminal concepts by depicting key passenger needs. This approach aims at

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providing a helpful framework for airport designers when assessing trade-offs in regard to passenger requirements. This will give insights into the role an "airport of the future" can play in the improvement of the air travel experience.

The paper is structured into four major parts. Section 2 analyses the findings from the passenger survey conducted at Munich Airport (MUC). Passenger requirements and expectations are classified based on their travel purpose and ranked according to the importance passengers place on aspects regarding passenger handling processes, orientation and information within the terminal as well as the availability of various services and facilities. In section 3, the above results are complemented by various studies from the literature. This helps to draw a thorough picture of the variance in needs of the different passenger groups. Following that, in section 4 there is an analysis of terminal concepts currently in place at various airports in the world and how these cater for the diverse passenger requirements. In the last section, a framework is developed to evaluate various new and expanding terminal concepts. This particular tool intends to help airport designers to deal with the complexity of passenger expectations and requirements regarding the functionality of airport terminals and hence translate them into particular terminal layouts.

2. CASE STUDY MUC

Munich Airport (MUC) was chosen as it includes two different terminals, one of which is a joint venture between an airline (Lufthansa) and the airport authority (Munich Airport) with regard to terminal design and operations (terminal 2). The airport was built on a green field and commenced operations in 1992 with terminal 1. In 2003, terminal 2 opened with a focus on Lufthansa and its Star Alliance partners. In 2010, the passenger volume reached a historical peak of almost 35 million passengers. 11 million passengers used terminal 1 and almost 24 million terminal 2 (MUC Media 2011). According to these figures, MUC ranks second in Germany after Frankfurt Airport and seventh on a European scale. Since MUC evolved into a hub airport it serves very distinct passenger and airline requirements. Passengers, for example, use this airport as origin or destination as well as for transfer purposes. The airport operator therefore had to consider several trade-offs when designing the two terminals.

The survey conducted at MUC aimed at grasping the diversity of expectations and perceptions which make passenger centric design so challenging. The purpose was to identify the importance which distinct passenger groups place on aspects regarding passenger handling processes, as well as aviation and non-aviation services available in the different terminals.

2.1. Set up of the survey

The survey took place in February 2011 at Munich Airport in a period of about ten days including working days as well as the weekend. Passengers were interviewed throughout the whole day in order to display peak as well as off-peak traffic and to enclose the different passenger types at this airport. The interviews took place in the security area of terminal 1 and 2. The duration of each interview was up to 10 minutes in which the passengers

had to answer about 35 to 40 questions. The questions were asked and documented by the interviewers; the passengers did not have to fill out a questionnaire. The survey addressed 300 passengers and the results were weighted according to the prevalent structures at Munich Airport such as terminal passenger share and trip purpose (business, private, transfer, embarking).

The questionnaire is divided into two main parts. The first part addresses several aspects regarding so called structural data such as passengers' age. This section is also concerned with other issues such as passengers' activities in the terminal or how often the interviewed passengers fly per year.
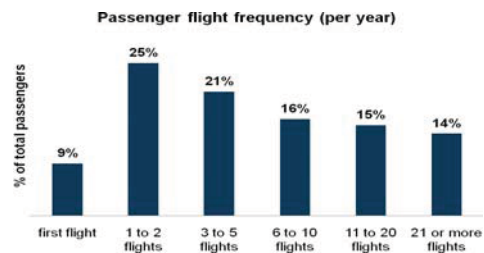

BILD 2. Passengers' flight frequency at Munich Airport (source: own survey)

The data generated from the survey illustrates that a quarter of the passengers at MUC travel by plane once or twice a year, compared to 21 per cent of travellers flying three to five times a year (see BILD 2). Almost a third of the people taking part in the survey travel by plane more than eleven times a year and can be considered as so called frequent flyers.

The findings of the survey also show that more than 50 per cent of passengers interviewed are up to 39 years old (see BILD 3), followed by passengers between 40 and 59 years which make up a share of 36 per cent.
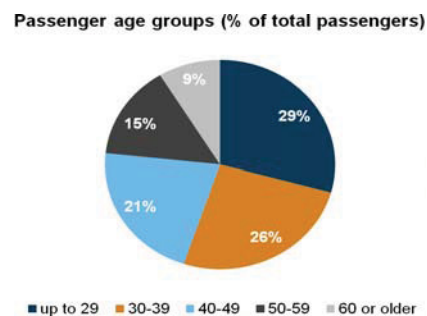

BILD 3. Passenger age groups at Munich Airport (source: own survey)

The second part of the questionnaire deals with the importance passengers' place on various aspects in regard to their journey throughout the airport. Passengers were asked to rank several aspects on a scale ranging from "very important" to "not important at all" according to their individual perception. The relevant aspects are grouped into several categories such as catering facilities (shops, restaurants), information and way finding within the terminal as well as amenities and services available during waiting time. According to the results obtained from the survey, the aspects within each category can be

ranked according to the importance. Furthermore, the importance placed on various aspects can be differentiated by passenger group.

The following section will elaborate on the different findings regarding the importance of various aspects and the ranking by the different passenger groups.

2.2. Passengers' evaluation and ranking of different aspects

The passenger survey conducted at Munich Airport yielded several interesting findings in terms of passenger expectations. The survey addresses several different categories that are relevant and important for different groups of passengers. The first category relates to passenger processes and addresses waiting time at the various steps within the passenger handling process. The second category is called information and orientation within the terminal and includes aspects such as the availability of flight information screens or ease of orientation within the terminal. Furthermore, the third category includes activities and facilities passengers make use of during their waiting or dwell time. Examples within this group are the availability of lounges or personalised entertainment systems. The fourth category covers retail and catering facilities in the terminal and includes factors such as the diversity of these facilities or the choice of shops available in the terminal. In addition to that, passengers have been grouped into different categories according to their travel purpose, i.e. business and private as well as transfer and embarking/ originating. Each of the above aspects has then been analysed within each passenger group in order to derive a ranking and compare this between the depicted passenger types.

2.2.1. Business and private passengers

Business passengers account for about 44 per cent at MUC – 30 per cent of travellers in terminal 1 are on a business trip, compared to 50 per cent in terminal 2. These passengers often travel at peak times, place importance on fast processing within the airport and stay rather shortly at the airport prior to departure. Private passengers, accounting for 56 per cent at MUC (50 per cent of travellers in terminal 2 and 70 per cent in terminal 1), arrive earlier at the airport prior to departure, place greater emphasis on low ticket fares, i.e. they are more price elastic, and are therefore more flexible regarding departure times at the airport. In terms of baggage, these two groups also show distinct behaviour at Munich Airport. People travelling for private reasons mostly check in luggage (more than 90 per cent) compared to those on a business trip which often only carry hand luggage (about 32 per cent) (MUC Media 2011).

Rank	Business passengers	Private passengers
1	Minimization of waiting time at check-in	Thoroughness of security inspection
2	Minimization of waiting time at security check	Minimization of waiting time at check-in
3	Thoroughness of security inspection	Minimization of waiting time at security check

TAB 1. Priorities regarding passenger processes (source: own survey)

According to the survey at MUC and the resulting analysis, issues such as waiting time at the check-in counters or security related activities are very important for a high share of both business and private passengers. Each group places high importance on short waiting times at the check-in facilities – 93 per cent and 86 per cent respectively. The thoroughness of security control plays a minor role for business passengers in comparison to the other relevant aspects. For this group, minimization of waiting time in general is most important. Private passengers, on the other hand, place higher importance on security inspections than on minimized waiting times (see TAB 1).

Rank	Business passengers	Private passengers
1	Availability of flight information screens	Availability of staff
2	Accessibility of gates in the terminal	Availability of flight information screens
3	Availability of staff	Accessibility of gates in the terminal
4	Seating opportunities at the gate	Seating opportunities at the gate

TAB 2. Priorities regarding aspects relating to information and orientation within the terminal (source: own survey)

In regard to information and orientation (see TAB 2), the emphasis each group places on the distinct aspects differs slightly. Business passengers rank the availability of information screens as most important in this category whereas private passengers consider the availability of staff as being essential to a satisfying travel experience.

2.2.2. Transfer and embarking passengers

Transfer passengers make up a share of 37 per cent of passenger volume at Munich Airport. However, in terminal 1 only four per cent of passengers transfer between flights compared to 51 per cent in terminal 1 (MUC Media 2011). These two passenger groups use the airport to start or end their journey (embarking passengers) or to change aircraft in order to get to their (final) destination (transfer passenger).

TAB 3 shows that both transfer and embarking passengers rate aspects that belong to the category "information and orientation within the terminal" as being most important. There are, however, differences regarding the specific aspects depicted in this category. For transfer passengers the availability of flight information screens ranks highest regarding the importance. Contrasting that, embarking passengers value the ease of orientation as the most important aspect. For both groups the overall importance is decreasing from aspects regarding information and orientation in the terminal, to activities and facilities and to retail and catering facilities in the terminal.

Rank	Transfer passengers	Embarking passengers
1	Availability of flight information screens	Ease of orientation in the terminal
2	Ease of orientation in the terminal	Availability of flight information screens
3	Availability of staff	Availability of staff
4	Seating opportunities at the gate	Seating opportunities at the gate
5	Availability of WLAN/ Internet	Availability of WLAN/ Internet
6	Accessibility of shops within the terminal	Availability of kids corner
7	Diversity of catering facilities offered	Diversity of catering facilities offered
8	Public use of various entertainment media	Public use of various entertainment media
9	Availability of kids corner	Accessibility of shops within the terminal
10	Choice of shops in the terminal	Choice of shops in the terminal
11	Choice of products in the different shops	Choice of products in the different shops
12	Availability of lounges	Extra time available for shopping
13	Extra time available for shopping	Availability of lounges

TAB 3. Priorities of transfer and embarking passengers (source: own survey)

Overall, the most important aspects for all four passenger groups are those regarding information and orientation in the terminal as well as passenger processes. Aspects related to retail services and facilities as well as entertainment offerings are ranked as being less important.

The next section will complement these findings using previous studies on specific passenger groups and associated characteristics and requirements. The resulting detailed picture of the relevant aspects, services and facilities may assist airport designers in terms of their planning decisions of airport terminals.

3. PASSENGER REQUIREMENTS AND EXPECTATIONS

From a passenger point of view, general expectations regarding the functionality of a terminal include short walking distances within the terminal, information for passengers during various processes, fast and convenient connections for transfer passengers, the mix and quantity of aviation and non-aviation services, availability of seats, cleanliness (of terminal), ease of way finding, people mover serviceability and certain security service standards. The importance placed on these aspects varies according to the depicted passenger groups and will be further outlined below.

3.1. Business and private passengers

Previous literature and analyses have mostly focused on the so called "value of time" in order to differentiate between passenger groups. In transport economics, this

term denotes the opportunity cost of the time a traveller spends on his journey. It reflects the value of the working or non-working time, i.e. the amount of money a traveller is willing to pay in order to save time, or the amount that a traveller would accept as a compensation for the time lost during the journey (Small 2007). According to this definition, business passengers tend to place a higher value on time than leisure passengers (Dresner 2006). This in turn implies that they might want to optimise the time spent on their journey, including the time at the airport, even further. Minimisation of waiting times when proceeding through the different passenger handling processes, high flight frequencies and short access times to the airport are thus general requirements of a business passenger. The high value of time might also induce this type of passenger to spend as little time as possible at the airport before the departure of his flight. For example, data from MUC on passengers' length of stay shows that the majority of business passengers spend only up to one hour thirty minutes at the airport prior to departure (MUC Media 2011). A high share of these passengers (35 per cent) spends between 30 minutes and one hour at the airport whereas 29 per cent spend between an hour and one hour thirty minutes at the airport (see BILD 4).

In addition to this, business passengers in general tend to travel in peak times, i.e. early in the morning or late in the afternoon. Thus they get to attend business meetings in different cities within one or two days. The total length of a business trip therefore may be rather short. In combination with the fact that business passengers travel on a more frequent basis than leisure passengers, the former often just carry hand luggage instead of checking in baggage. Shorter trips require fewer necessities and frequent fliers are more familiar with adequate travel arrangements, i.e. they "travel light" (Dresner 2006). At Munich Airport, about 32 per cent of business travellers travel with hand luggage only, compared to 68 per cent that check in baggage (MUC Media 2011). Other general criteria relevant for business passengers might be the availability of short term and easily accessible car parking as well as certain passenger services such as baggage services, executive lounges, individual transport to the aircraft, specialised shops and facilities as well as designated working areas (Brilha 2008).

Compared to business passengers, private or leisure passengers are assumed to have a lower value of time. This might be due to several reasons since this particular value depends on the trip purpose, demographic and socioeconomic characteristics of the trip maker, time of day, or the total duration of the trip (Small 2007). The trip purpose might be holidays or visiting friends and relatives. Therefore these passengers are not as dependant on high flight frequency as business passengers which have to be at a precise time at a certain location (e.g. for a meeting) (Dresner 2006). When undertaking a trip for private reasons, passengers might be more flexible and hence attach a lower value to different aspects of the trip. The total duration of the trip, for example, plays an important role. Considering a two-week holiday, the time spent at the airport makes up only a small share of total travel time of the leisure passenger. In comparison to that, the time necessary for the various procedures at the airport accounts for a high share of a business passenger's one day trip. The fact that leisure passengers on average undertake longer journeys than business passengers

might also imply that they take along more luggage to be checked in instead of just hand luggage. Figures from Munich Airport verify this statement: More than 90 per cent of private passengers check in some baggage whereas less than 70 per cent of business travellers do so (MUC Media 2011). Hence, the share of leisure passengers at Munich Airport travelling only with hand luggage is fairly small.

Since the amount of trips taken per year is generally higher for business than leisure passengers, business travellers are on average more familiar with necessary travel arrangements. Leisure travellers, on the other hand, might arrive early in order to have sufficient time to go through the various passenger procedures and handle the airport facilities appropriately since these are often not that familiar (Dresner 2006).
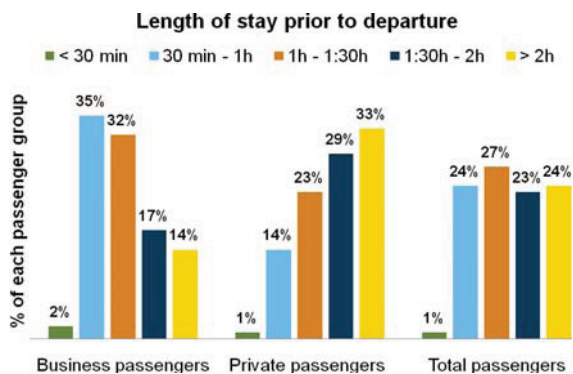

BILD 4.   Passengers' length of stay prior to departure (source: MUC Media 2011)

Munich Airport data confirms this distinct travel behaviour: The highest share of people travelling for private reasons, i.e. 62 per cent, spends more than one hour thirty minutes at the airport prior to departure. Only about 15 per cent of this passenger group stay between 30 minutes and one hour compared to 24 per cent staying between an hour and one hour thirty minutes. The length of stay thus varies according to passenger type. (see BILD 4)

Additional relevant factors for leisure passengers or those visiting friends and relatives might be the easy access to the terminal due to carrying along luggage. The availability of long-term parking at reasonable rates also contributes to passengers' overall perception of the airport's quality. Furthermore, a long dwell time at the airport might induce increased demand for entertainment and retail services within the terminal (Brilha 2008).

3.2.   Transfer and embarking passengers

Currently, there are not many studies on the specific requirements and needs of transfer passengers. A case study by Barros (2007) at Bangladesh Airport (BIA) evaluates the priorities of transfer passengers at this particular airport. General assumptions in terms of transfer passengers' requirements include short walking distances between gates as well as keeping connecting time to a minimum. The latter aspect is not only improving the service quality for passengers but also has a positive effect on the efficiency of airline operations. At BIA the most important criterion for transfer passengers was the

courtesy and helpfulness of the security staff. Following that they listed the quality of flight information displays which are supposed to provide information about the connecting flights. The level of quality is defined by the availability of accurate and up-to-the-minute information as well as the ease of finding and reading these displays (Barros 2007). Passengers at BIA have access to sufficient seating opportunities in the transfer area which might have been the reason that this aspect was not rated as being important. However, passengers not having these opportunities might place great importance on this fact and therefore it should be considered by airport planners as well.

Embarking passengers, either travelling for business or private reasons, have often been the focus of studies dealing with passenger requirements. This group belongs to the so called origin and destination (O&D) traffic and can either travel for business or for private reasons. This will in turn have an effect on the expectations they have about the functionality and design of a terminal.

3.3.   Other requirements

In the future, new types of needs and requirements may arise from sub-segments of the leisure air travel market. There has not been much research on these various segments yet but they might pose challenges for the airport operator in terms of aligning facilities and services at the airport. Shaw (2008) states that the stereotypical family model going on holiday is disappearing and is being replaced by other forms of travel and passengers such as elderly passengers, budget travel, young people, and singles or so called "empty nesters" whose children are not living at home anymore and who have the monetary means to travel. Each of these segments might require individual and tailored approaches regarding airport service quality (Shaw 2008).

One group whose requirements are of growing importance are the elderly passengers. A study by Schwetje (2010) looks in detail into elderly passengers' requirements along the complete journey, starting with the access to the airport and ending with the arrival at the destination airport. In terms of stay at the airport, the report highlights several aspects which were of high importance or caused problems for this passenger group. First of all, the announcements via loudspeakers at the airport are not always fully understandable and long waiting times at check-in queues or troublesome security checks cause some level of discomfort for these passengers. Furthermore, elderly travellers state to have orientation problems such as finding the right terminals, gates and check-in counters. Long walking distances to the designated gates also might cause problems to these passengers. From their viewpoint, the airport operator therefore has to address issues such as better signage, sufficient information facilities and services as well as staffed check-in counters. The facilities as well as services mostly used by senior passengers are the washrooms, seating opportunities, restaurants, shopping and information facilities, as well as staff at the information desk for inquiries.

4. CURRENT TERMINAL CONCEPTS

An airport terminal has to fulfil a wide range of requirements and expectations as can be seen from the analyses conducted above. The traditional function of an airport terminal is to provide a connection between landside and airside transportation. This includes the necessary infrastructure and facilities as well as services for passengers, airlines, air freight companies and other parties involved. Passenger processes, for example, require check-in and security facilities, or baggage handling (Doganis 1992). Furthermore, an airport is supposed to provide the infrastructure for landing and take-off of aircraft, maintenance facilities and infrastructure regarding efficient ground movement of aircraft (Neufville 2003). The provision of non-aviation activities is of growing importance considering the functionality of airport terminals since airport operators derive revenues from the aviation as well as the non-aviation business. The latter activities or services include retail facilities, restaurants, travel agencies, medical centres, business centres or convenience stores and can usually be found within the whole terminal building.

The following section outlines various terminal concepts and the implications for passenger processes and activities.

4.1. Linear terminal

The linear terminal concept evolved from the historical terminal design of a single unit. With increasing passenger numbers and demand for air traffic, the number of airline services offered at an airport rose, resulting in the extension of the single-unit terminal in a linear fashion (Wells 2004). These terminals can either be arranged in a straight line or in a curvilinear shape. This type of layout is predominantly suited for point-to-point operations (domestic operations) due to simple passenger handling processes (Kazda, Caves 2007). Usually, passengers are able to arrive directly in front of the terminal, access the building and proceed directly to their respective gates (Mensen 2007). Ensuring a minimum walking distance for passengers is one of the main objectives of this concept. The fact that aircraft are parked directly at the airside of the terminal, i.e. "nose-in" (Wells 2004), contributes to ensuring short ways for passengers. However, if passenger numbers and hence required aircraft stands are increasing, linear terminals become very long which in turn causes the reverse effect, i.e. long walking distances for passengers. This effect can be avoided by applying a different or slightly amended layout.

4.2. Decentralized terminal layout

The so called decentralized terminal layout may help to overcome the problems arising from a simple linear structure. Within this layout, the terminal is still arranged linearly but contains multiple individual modules that are independent of each other (Kazda, Caves 2007) (see BILD 2). As in the case of terminal 1 at Munich Airport which was mainly built for embarking and arriving passengers, the designers had in mind that people can access the airport in the same way as they access a train station. This is ensured by several parallel modules of which each contains only a limited amount of gates and check-in

counters. Due to this specific layout passengers arrive directly at the entry of the unit at which their flight departs, immediately encounter the check-in facilities and then process on quickly to the designated gates. Passenger handling facilities and associated procedures are duplicated in each module.
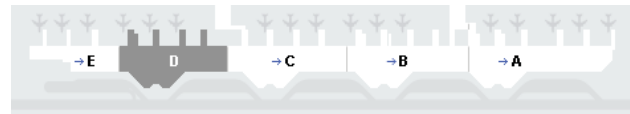

BILD 5.   Decentralized terminal concept (MUC Airport)

Fast passenger processing is hence ensured by the short distances and less "distraction" (e.g. shops, restaurants) along the way. Business passengers may therefore prefer this kind of structure during off-peak hours since it allows them to minimise the time spent at the airport. Considering business passengers a modular structure allows them to drive right in front of the terminal, walk in, pass the security check and terminate directly at the gate. Leisure or private passengers originating at an airport may find the clearly arranged structure and layout of a decentralized or modular structure as represented by terminal 1 at Munich Airport also suitable for their needs. The waiting time at the check-in counters and the security inspection as well as the ease of finding the way are important aspects for these passengers. Therefore, the short walking distances due to the modular structure and the quick spatial succession of processes represent a good reflection of what leisure travellers expect from an airport operator.

Regarding the various passenger expectations, modularity or decentralization ensures:

1) Short walking distances for O&D passengers.
2) Quick spatial succession of processes, which is good for passengers with a high value of time (business).
3) Clearly arranged and easy layout, which eases the orientation and is therefore important for all passenger groups.
4) Modules dedicated to specific carrier operations such as low cost or regional.

However, there might also be disadvantages resulting from this particular layout. Due to the duplication of all relevant passenger processes in each unit high staffing levels and investment in multiple passenger handling processes are required. Furthermore, there might be congestion and thus delays during peak hours since the modular structure does not allow for extension of capacities. This represents a severe drawback for business passengers in particular which place high importance on fast processing. In addition to that, transfer passengers may face problems when switching flights within a modular design. Since the entities are independent of each other, transfer passengers have to leave the security area of one module in order to proceed at another module which can be very time consuming, especially if security checks have to be passed again.

4.3. Centralized terminal concept

The drawbacks outlined above can be overcome by offering passenger handling processes centrally. Such a centralized terminal concept can be found at Munich Airport terminal 2 (see BILD 6). The layout supports the

requirements of transfer as well as embarking passengers. All arriving or departing passenger have to go to the same location to check in luggage or pass security controls, regardless of their designated gate. Transferring easily between different gates is guaranteed by the linear configuration of the gates. Passengers switching aircraft therefore do not have to leave the security area within the terminal.
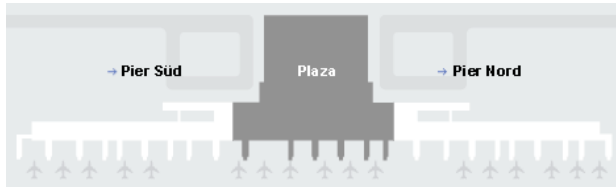

BILD 6.   Centralized terminal concept (MUC Airport)

Business travellers might benefit from this layout since congestion occurring during peak times, i.e. early in the morning or late in the afternoon, can be alleviated by extending capacities in terms of relevant passenger handling processes. Congestion might arise at so called bottlenecks which are, for example, the check-in counters or the security lines. A high amount of travellers at a certain time of day leads to capacity shortages at these facilities and therefore delays. If all relevant passenger handling processes and associated facilities as well as services are located within a central spot, e.g. all security lines arranged along each other, capacity can be expanded during peak times whereas some of the lines are kept close during off-peak hours.

A centralized terminal structure therefore provides some major advantages:

1) Facilitated, efficient transfer passenger flows.
2) Shorter distances and fewer processes for transfer passengers.
3) Robustness of passenger handling processes with respect to peak-hour congestion, which ensures efficient embarking passenger flows
4) No duplication of basic facilities necessary and therefore more room for variety of non-aviation services, which is advantageous for the general atmosphere, and important for transfer passengers with a longer duration of stay as well as embarking passengers that have a high length of stay prior to departure

4.4.   Pier or satellite terminal

A pier terminal concept also evolved from single-unit terminals. It usually comprises the main terminal building as well as additional buildings that are attached to the main one – so called piers (Wells 2004). In comparison to the linear form outlined above, a pier concept allows for more aircraft stands right at the building and not at some apron position away from the terminal (Mensen 2007). Pier concepts also inhibit the decentralization concept since aviation services and facilities relevant for passenger processes may be located in the different concourses. Disadvantages arise for passengers transferring at this particular airport if they arrive at concourse A and depart at concourse C, for example, due to the long walking distances they have to overcome (see BILD 7).
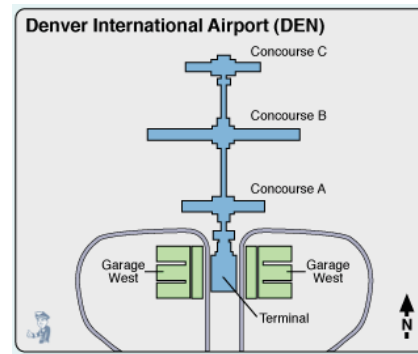

BILD 7.   (T-)Pier terminal at Denver Airport (source: Airport Terminal Maps)

Satellite terminal concepts consist of a main terminal building where all passenger related processes are executed and a so called satellite which is connected to the landside terminal by piers (e.g. including moving walkways) or by some form of shuttle service that moves passengers between terminal and satellite (see BILD 5). Hence, this concept benefited from the creation of underground corridors or the implementation of so called automated passenger movement systems, i.e. people mover (Wells 2004).

BILD 8.   Satellite terminals at Tampa Airport (source: Airport Terminal Maps)

Satellite terminals do not necessarily require a duplication of passenger related processes and procedures. Furthermore, it allows the construction of a terminal extension using free space and therefore does not have to be adjacent to the existing building. This also allows aircraft to move freely between the main terminal building and the satellites located in rather remote positions (Wells 2004). Drawbacks of the concept depicted above arise due to long walking distances between different satellites or if there is no sufficient amount of people movers between the terminal and the satellite. Furthermore, confusion for passengers might arise when trying to find their gate or switching aircraft between flights.

Nowadays, at many airports a combination of various concepts can be found. This is due to the fact that most airports are historically grown and are not build from the scratch. The requirements an airport and thus the associated terminals face vary in regard to traffic volume, type of traffic and type of passengers. Furthermore, the level up to which an airport can fulfil these expectations depends on issues such as the available land capacity, regulations and investment costs. Many airports have

different types of terminals in order to meet changing passenger and airline requirements.

5. FRAMEWORK DEVELOPMENT

The framework which is developed in this section intends to deliver a tool for airport designers with which to assess new and expanding terminal concepts. It contains the identification of those processes, facilities and services within a terminal that are related to the derived requirements and needs and therefore of priority for each of the defined groups. The first step in the framework development is the categorization of aspects regarding passenger expectations and satisfaction which have been identified in the previous sections. The left column in TAB 5 is thus concerned with the different processes and facilities which affect passengers' travel experience at the airport. Next, these different categories are characterized by distinct aspects (second row from the left in TAB 5). The feasible conversion of these aspects in terms of terminal design is very important since the assessment framework intends to provide a tool for decision making. Furthermore, the optimization of these aspects helps to design terminals in a passenger friendly way. The column "prioritized aspects" helps to identify those aspects that are particularly relevant for the passenger group(s) prevalent at an airport. According to this category, trade-offs between various aspects can be identified and addressed accordingly at an early stage in the planning process. For example, short walking distances, i.e. quick spatial succession of processes, might imply little available space in general since everything is kept within close proximity. The lack of adequate space, however, may prevent the establishment of a wide variety of retail outlets and restaurants as required by some passengers. Furthermore, only a confined amount of facilities related to passenger processes can be put up which in turn might cause congestion during peak hours. The columns on the right hand side depict the new terminal layout and one or several reference layouts which excel in particular categories. Both the new and the reference layout(s) can score according to the scale outlined below (TAB 4).

The reference layouts – centralized and decentralized design, which have been elaborated on above – are incorporated in the decision-making framework in order to offer alternative options or considerations for airport terminal planners. It allows them to look in detail why the particular reference layout scores high in comparison to the new layout in terms of a particular aspect. It might thus give new insights into layout aspects and possibilities.

Score	Explanation
-3	Does not fit relevant passenger expectations
-1	Inconsistent with relevant passenger expectations
0	Neutral, does not apply
1	Consistent with relevant passenger expectations
3	Fully consistent with passenger expectations

TAB 4. Scale applied within assessment framework

The application of the developed framework by airport designers might be structured as followed. As a first step, an airport planner has to decide which categories and aspects are important for the airport under consideration.

An airport business model and hence an existing or new terminal concept might be directed towards a specific passenger group such as business travellers or towards a variety of different passenger types. Nowadays, there are low-cost terminals which are designed particularly for the low-cost traveller and do not comprise a wide range of services and facilities. Contrasting that, terminals dedicated to business traffic have a different layout and offer specific services to their customers which might not be profitable in a low-cost terminal. The types and variety of passengers serviced within a terminal determine the importance placed on the multiple aspects outlined in TAB 5. Since distinct groups vary with regard to their travel expectations, an airport designer might find some of the aspects as being of high relevance whereas other aspects might be rather neglected. This, in turn, has an effect on how the layout and relevant processes are designed. Furthermore, airports and hence terminals handle distinct amounts of traffic. Some airports face several peaks during the day and therefore reach capacity limits. Others have free capacity during all of the day and therefore do not have to worry about congestion. However, some terminal layouts are capable of handling large amounts of passenger traffic without incurring congestion whereas other terminal layouts reach capacity limits fairly quickly with increasing passenger volume.

Regarding these aspects – passenger volume and structure – airport planners can apply passenger figures (actual and forecast) for existing terminals which are to be redesigned. For newly developing terminal concepts figures can be assumed according to existing similar business models and terminal layouts.

According to that, an airport planner first might prioritize different categories or aspects which are relevant in terms of the passenger groups addressed in the terminal concept. He can now evaluate how the different aspects such as check-in facilities in the relevant layout contribute to or prevent the realization of minimum waiting times. Within the airport, passengers often have to wait at so called bottlenecks which can include check-in facilities, both for passengers and for luggage, security controls or immigration counters. Queues might build up during peak hours, e.g. early in the morning, since there might be a lot of business passengers travelling at this time of the day. Especially for this passenger type fast processing within the airport is of importance and therefore presents a crucial criterion for airport planners and operators. Regarding this situation, the airport planner can now assess whether the way these facilities are integrated into the terminal layout can cause congestion at some point. Regarding security controls, for example, relevant questions for airport planners might include:

- Within my layout, do I have the spatial capacity to have a sufficient amount of these facilities that enable efficient passenger handling throughout the day – during peak and off-peak hours?
- Does the layout allow for quick adjustment to changes in passenger volume?
- Do I meet the requirements of the different passenger groups which might vary in regard to these facilities?

The same approach and questions apply when considering the other aspects such as check-in facilities or

immigration within the "minimization of waiting time" category.

Aspects for decision making		Prioritized aspects	New layout	Centralized layout	Decentralized layout
Minimization of waiting time	check-in			3	1
	security			3	1
	immigration			3	1
	luggage check-in			3	1
	luggage reclaim			3	3
Processing within terminal	access to gates			1	3
	accessibility between gates			3	1
	accessibility between buildings			0	0
	accessibility between zones (e.g. Schengen/ Non-Schengen)			3	-1
	walking distances			1	1
	availability of people mover			3	3
Information/ orientation	flight information screens			3	3
	staffed information counters			1	1
Accessibility	terminal access			3	3
	parking			1	1
Non-aviation services	Amount of retail services and facilities (shops, restaurants)			3	1
	Choice and variety of retailing			3	1
	Accessibility of retail facilities			1	1

TAB 5. Assessment framework for terminal design evaluation (own depiction)

The category "processing within the terminal" includes aspects such as the accessibility of gates and the connection between these within the terminal. Since terminals can consist of several zones, e.g. Schengen and Non-Schengen, or even several buildings it is important for airport planners to ensure an easy and fast connection between these. These aspects also determine whether passengers feel comfortable within the terminal and consider the layout as being passenger friendly. In order to evaluate whether the aspects in this particular category match various passenger expectations outlined above, the airport planner might assess the following questions:

• Which factors inhibit or hinder the accessibility of gates/ the connection between gates, zones or buildings?
• How can the layout contribute to keeping walking distances for passengers to a minimum?

Processing within the terminal may also be supported by various forms of information made available to passengers. The availability of information and related services contribute to easing a passenger's journey within the terminal as well as to ensuring efficient passenger flows. Aspects to be evaluated might include:

• Does the terminal layout allow for a sufficient amount of information such as flight information screens and information counters?
• Within the layout can these information services be placed in a way to guarantee easy access by passengers?

In regard to non-aviation facilities, the business model of an airport is of relevance since a strong focus on revenue generation from non-aviation facilities and services requires the provision of adequate capacities. However, if these facilities restrict the capacity needed to ensure smooth and satisfactory passenger operations, airport planners face a trade-off in terms of the aspects that contribute to a satisfactory passenger experience. Relevant issues for an airport planner in terms of shops, restaurants and other such facilities therefore might be:

• Which layout allows for the incorporation of non-aviation services and to what degree?
• What are potential arrangements of shops and restaurants in order to guarantee a satisfactory passenger experience for the different groups?

Taking the framework depicted above and addressing the relevant aspects allows an airport planner to assess the suitability of the terminal layout accordingly. In the example shown above, the minimization of waiting time in terms of check-in facilities scores "3" within the centralized layout, compared to a score of "1" in the decentralized layout. The reasoning behind this has been outlined in section 4 and refers to the possible alleviation of congestion during peak hours within a centralized terminal layout. The aspect "access to the gates within the terminal" scores higher in a decentralized layout than in a centralized one. The reason for this is given by the shorter distances in the former design which allow passengers to proceed quickly from terminal entry to the relevant gate. The comparison between different reference layouts and the new/ evolving terminal design might provide the airport planner with new options and considerations as to how to overcome possible disruption and trade-offs that negatively affect passenger satisfaction.

Carefully addressing the above aspects when evaluating different terminal layouts can help to optimise the design for both a particular passenger group and its associated requirements as well as for a wide variety of passengers needs, depending on the type and amount of traffic an airport and hence a terminal caters for.

6. SUMMARY AND CONCLUSIONS

As the previous analysis has shown, there are several trade-offs airport planners might face when designing or amending terminal layouts. At the planning stage of airports and terminals it is not only important to consider previous passenger traffic both in terms of numbers and types but also to take into account future development of these categories. Not only might traffic volume increase but the type of traffic may change significantly as the airport moves from being a mere origin and destination airport to a hub system, for example. Transfer passengers require distinct handling procedures than originating passengers, which resulted in the different layouts of terminal 1 and terminal 2 at Munich Airport, for example. Furthermore, interests of business and leisure passengers vary. Leisure passengers are, for example, more price

sensitive than business passengers and prefer low ticket fares. In order to attain these, they choose the appropriate time and maybe even destination. Business passengers, on the other hand, do not have this variety of choosing but have to stick to those flights and times that suit their scheduled meetings. An airport operator hence has to carefully balance these distinct interests within one airport or even terminal. Capacity issues also play an important role in the design of airports. In many European countries airports have already reached their capacity limits and quite often there is not much room for expansion left. Therefore, airports have to find a way to better accommodate additional traffic volume without expanding airport infrastructure.

Munich Airport serves as an example for different terminal concepts that intend to address different passenger segments. At the time of planning and construction, considerations regarding development of traffic volume and structure differed, which in turn resulted in conceptually different terminal layouts. Both layouts bear advantages as well as disadvantages regarding their configuration, their facilities and services. The terminals' perception depends on the distinct passenger views that are considered in this report. As a result, the overall layout as well as the configuration of services and facilities has to be carefully assessed and aligned with current and future passenger requirements. The needs and requirements of the different passenger groups have to be balanced carefully in order to achieve high passenger service quality. For an airport that has to serve all different passenger and airline groups it seems reasonable to combine both layout concepts – as in the case of Munich Airport. The paper aimed at developing an assessment tool that incorporates these various passenger expectations and a scale against which to evaluate the level of fulfilment in terms of terminal layouts. The associated framework which was developed in section 5 provides a structured approach for airport planners towards assessing and prioritising various passenger expectations and requirements. For example, an airport business model and hence the associated terminal concept may address the specific requirements of a particular passenger group, e.g. business passengers. Keeping this customer segment in mind an airport designer can optimize the layout, processes, facilities and services accordingly. Trade-offs between various aspects become apparent in the framework and can be dealt with by adjusting the conceptual layout. Future new terminals or amendments of existing ones can thus be assessed in order to provide a passenger friendly terminal concept including all relevant processes, facilities and services. Choosing a design which fulfils these expectations may also require the transformation of existing airport business models to being even more tailored to each airport's specific needs.

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