FUTURE AIRPORT CAPACITY UTILIZATION IN GERMANY: PEAKED CONGESTION AND/OR IDLE CAPACITY

Eckhard Urbatzka and Dieter Wilken
German Aerospace Center (DLR)
Institute of Transport Research
Cologne, Germany

ABSTRACT

The air traffic situation at German airports is characterised by intense capacity utilisation at the most important airports and rather low utilisation at many other airports. Although since 2001 overall traffic stagnates, air transport movements (ATMs) at hub airports are growing further. In this paper, we will describe airport traffic and capacity, discuss traffic forecasts and compare future volumes of ATMs with capacity at German airports. Means of de-peaking the spatial utilisation of airports will be presented. It will be shown that in less than 10 years time Germany needs additional runway capacity, which will most likely not be provided. Lacking this solution supply spreading measures and business models are discussed.

INTRODUCTION

The present situation in air transportation in Europe, and in Germany in particular, is characterised by diverging phenomena. After many years of strong growth the demand for air transport services is stagnating in some markets and even going down in others. All together, the traffic at the 18 international airports of Germany has reached a peak volume of 142 million passengers in the year 2000. In the two following years the traffic has dropped to 135 million passengers. This trend continues at present even as

Eckhard Urbatzka studied Aeronautics and Astronautics at the Technical University of Berlin in Germany. He is member of the Scientific Staff of the Air Transport Division in the Institute of Transport Research of the German Aerospace Center (DLR).

Dieter Wilken, MSc, studied Civil Engineering at the Technical Universities of Aachen and München in Germany, and Transportation Engineering at the University of California, Berkeley, USA. He is head of the Air Transport Division in the Institute of Transport Research of the German Aerospace Center (DLR).

new demand-reducing factors, such as the proliferation of the SARS disease in Asia, cause many potential passengers to refrain from travelling.

While the overall demand is declining the demand for low fare services—as offered by low cost carriers (LCCs)—is growing strongly. After Ryanair more or less introduced this kind of no frill services in Germany in 1999 several other start-ups took up this supply idea in 2002 and have attracted a great and growing number of passengers, primarily on services to Berlin and European destinations such as London, Milano, Pisa, and Barcelona. This means that the decline of demand occurs solely on services of the traditional network airlines, although they, too, have started to offer low fare services on a growing number of traffic relations.

Airport capacity has been a scarce resource at some of the busiest airports even before the year 2000. With the decline of traffic the bottleneck situation did decrease, however, severe traffic delays continued to prevail in daily peak hours at Frankfurt and Düsseldorf and to some degree at Berlin-Tegel. More importantly, while the overall traffic decreased, air transport movements (ATMs) at the congested hub airport Frankfurt and at the secondary hub München went up by 3% from 2000 to 2002. At all other non-hub airports ATMs went down by almost 6% in the two year period of weak demand. Traffic was thus concentrated and channelled through the hub airports, whereas most of the other airports—with the exception of Düsseldorf and Berlin-Tegel—do not have severe capacity problems and would welcome more traffic. Only recently did traffic begin to grow at those airports where LCCs started services, in particular in Köln/Bonn.

Air traffic forecasters assume that the traffic will resume to the former growth trend again, although with a changed supply pattern. It seems that LCCs will successfully operate and take up a growing part of the total market. Given the present capacity problems and the political difficulties to enhancing airport capacity, the question is whether or not airports will be able to accommodate the traffic growth without deteriorating the quality of service to levels intolerable to passengers and airlines. Do the busiest airports continue to struggle with the need for more capacity while the other airports—with ample capacity—are unable to reach higher market shares?

In the following, we will (a) describe airport traffic and capacity, (b) compare traffic volumes with capacity, (c) discuss long term forecasts of air transport demand, (d) describe two scenario dependant forecasts of flight movements at German airports, (e) compare future peak hour volumes of ATMs with the capacity of these airports, and finally, (f) discuss whether or not there are possibilities of spreading the utilisation of airport capacity more evenly.

TRAFFIC VOLUMES AND STRUCTURE AT THE INTERNATIONAL AIRPORTS IN GERMANY

Germany, a country with a population of about 82 million people and a size of nearly 360,000 square kilometers, has a dense network of classified airports. The highest category is made up by 18 international airports which—together with some 10 so-called regional airports—serve primarily the public air transport system with scheduled and charter services on domestic and border crossing traffic relations. Most of the traffic is handled by the 18 international airports although at some of the regional airports, like in Paderborn and Hahn, traffic volumes are exceeding 1 million passengers per year. Hahn has been converted from a military base to a civil airport and has been chosen by Ryanair as a hub in Germany.

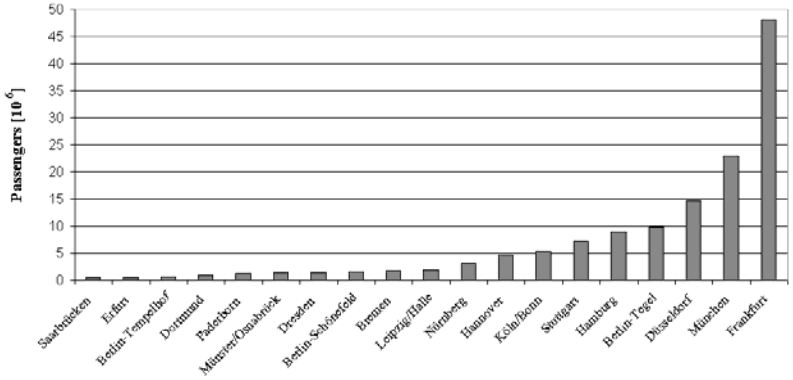
In 2002, the international airports handled a traffic volume of 135 million passengers enplaned and deplaned and about 2 million flight movements in primarily scheduled services. Since 1992, the second year after the reunification of Germany, passenger traffic has grown by 56% (4.5% annually) and the ATM volume by 32% (2.8 % annually). Air transport has thus grown much faster than the classic modes of rail and car, however, the growth came to a halt in 2001 after 9/11.

In figures 1 and 2, passenger volumes and ATMs of German international airports in 2002 are shown, ranked by the size of traffic volume. The biggest airport is Frankfurt with 48 million passengers and 458,000 flight movements of which around 60% belonged to the home-carrier Lufthansa which operates its main hub there. Due to capacity problems—Frankfurt has two parallel runways and a third runway used exclusively for take-offs, with operations dependant on each other—Lufthansa transferred a growing part of its hub operations to München, the second biggest airport in Germany, with 344,000 ATMs (and 23 million passenger). As a consequence, München airport augmented the traffic volume from 2000 to 2002 by 7.8%, whereas the total ATM volume of Germany decreased by 2.5% in the same period. The Frankfurt traffic volume stayed about constant in these years.

Before München became an airport with growing hub functions it was Düsseldorf airport that ranked second after Frankfurt. In 2002, Düsseldorf had a traffic volume of 14.6 million passengers and 190,000 ATMs. Great deals of the passengers are using the airport for tourism flights, primarily into Mediterranean resort areas. The catchment area of Düsseldorf airport is the Rhine-Ruhr District with about 10 million people, predominantly living in urban areas, which it has to share with other airports, in particular Köln/Bonn and Dortmund. Like Frankfurt and Berlin-Tegel, Düsseldorf has two parallel runways separated by about 500 metres so that flight operations are not independent. In contrast to these airports, Düsseldorf can normally

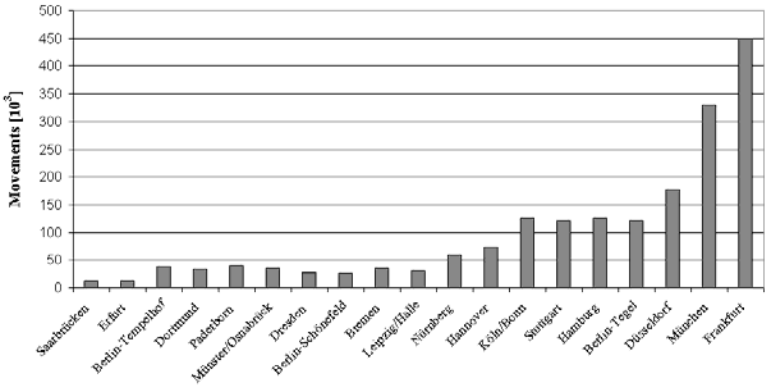
use only one runway, since administrative regulation has set forth the total capacity equal to a single-runway capacity.

Figure 1. Number of passengers at German international airports in 2002



Source: *Annual statistics 2002.* (2003). Stuttgart, Germany: German Airport Association.

Figure 2. Number of air transport movements at German international airports in 2002



Source: *Annual statistics 2002.* (2003). Stuttgart, Germany: German Airport Association.

In Berlin, 12 million passengers and 213,000 flight movements were handled by an airport system consisting of Berlin-Tegel, the main airport, Tempelhof and Schönefeld. While Tegel carries more than 80% of the total passenger traffic (and 60% of ATMs) and operates near terminal capacity, traffic demand in Tempelhof and Schönefeld is declining. Since the reunification of Germany and the fall of the Berlin Wall, the States of Berlin and Brandenburg plan a single airport for Berlin at Schönefeld with enough

capacity and lower environmental damage than Tegel and Tempelhof cause, up to the present, however, the planning has not yet reached an advanced stage.

Hamburg and Stuttgart are two other busy airports, with almost 9 and 7 million passengers, respectively. Hamburg has a runway system consisting of two runways crossing each other which handled 150,000 movements in 2002, roughly the same traffic volume as Stuttgart (144,000 ATMs) which has to rely on a single runway. At both airports, non-commercial flight movements account for about 25,000 movements. A great part of these movements may be suppressed and diverted to other airports if lack of runway capacity would become a problem for scheduled and non-scheduled commercial operations, as has been the case already in Frankfurt and in Düsseldorf.

The airports Köln/Bonn and Hannover have open parallel runway systems allowing for independent operations, with 85,000 movements in 2002 they handled volumes well below the capacity limit. Leipzig airport also has two runways; they are, however, not parallel but located at an angle to each other. For the time being, the second runway is used more for environmental than for capacity reasons; the traffic volume of Leipzig was not higher than about 40,000 ATMs in 2002.

All other international airports have single runways for the traffic with scheduled and charter flights. They are located in Bremen, Dortmund, Dresden, Erfurt, Münster, Nürnberg and Saarbrücken, with traffic volumes ranging from 78,000 in Nürnberg and 15,000 in Saarbrücken. Dortmund has been added to the category of international airports only recently when it was supplied with a runway long enough to handle flights with aircraft types typically operated in scheduled and charter traffic, that is, the B 737 and A 320 family.

In addition to the network of international airports there are 10 regional airports which serve to some degree the same task; that is, to provide access to the national and international services in scheduled and charter traffic. Altogether these airports handled 64,000 movements, which carried 4 million passengers, about 3% of the total air traffic volume of Germany.

It can be concluded from the preceding that Germany has a substantial number of regionally distributed airports—almost 30 airports with nearly 40 runways serving the public air transport system of a population of over 80 million people—but with the traffic heavily concentrated at a few airports, which are more or less working at capacity level. More than one-third of the German passenger traffic is handled by Frankfurt alone, and almost two-thirds of the total is served by the three airports at Frankfurt, München and Düsseldorf. There are 27 airports that handle only about one-third of total passenger traffic. Are there chances or inherent mechanisms to

change this concentration towards a more evenly distributed utilisation of airport infrastructure?

LONG-TERM DEVELOPMENT OF AIR TRANSPORT DEMAND

The past development of commercial air traffic was characterised over many years by strong growth both world wide, as well as in Germany. Only since the year 2001 has the growth trend been interrupted by a stagnation phase caused by several factors: in particular 9/11, the weak economic situation, the Iraq war, and, more recently, the SARS disease in Asia. The former growth varied by market segment and region, and was dependant on the unit in which the traffic is described. The transport volume (passengers, freight, flights) had not grown at the same pace as traffic performance, measured in passenger kilometres (kms), tonne (metric ton) kms, or flight kms, since air travellers have used flights to ever more distant destinations.

Forecasts of the traffic of a region or an airport refer normally to the traffic volume, that is, in particular, the number of passengers transported and the number of flights. As an example of a regional forecast, we will shortly describe the long-term forecast of the German Aerospace Center (DLR) for Germany. This forecast includes travel demand, passenger traffic volumes and the number of flights at the international airports of Germany for different scenarios. On the other hand, global forecasts deal typically with the traffic performance; a well-known example of this type is the forecast of the International Civil Aviation Organisation (ICAO). We describe shortly the most recent ICAO forecast, which has been elaborated by the Forecast and Economic Analysis Support Group (FESG) of the Committee on Aviation and Environmental Protection (CAEP).

Global ICAO/CAEP- Forecast 2020

The ICAO/CAEP-Forecast is a result of work within ICAO and the Forecast and Economic Analysis Support Group (FESG) of ICAO/CAEP and has been finalised in early 2003; that is, before the Iraq war and the spreading of the SARS disease. The group took into account, however, world wide economic development as seen by various institutions at that time. The forecast method corresponds with the one that has been used often times in ICAO-Forecasts (see, for example, ICAO, 2001).

The method consists basically of a function describing the global air travel demand (passenger kms) in relation to the world wide gross domestic product (GDP) in real terms and the average passenger-revenue-per-passenger kms (yield) in real terms in scheduled air services. In addition, forecasts available from Boeing, Airbus, Rolls Royce and Pratt & Whitney, and former ICAO forecasts were consulted and model results were adjusted

when appropriate in the light of discrepancies between forecasts. The results of this so-called consensus forecast of FESG are presented in Table 1.

Table 1. Global forecast of air travel demand, 2000-2020

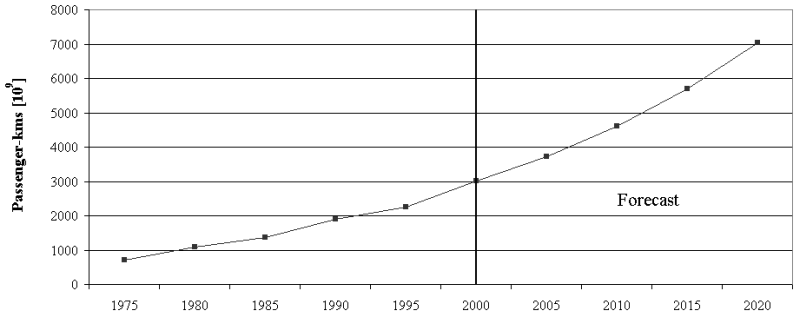
Average Annual Growth Rate	*Growth Factor*	*2000-2020*
International	*4.9*	*2.6*
Domestic	*3.5*	*2.0*
Total	*4.3*	*2.3*

Source: *Traffic and fleet forecast.* (2001). Montreal: ICAO Committee on Aviation Environmental Protection, Forecast and Economic Analysis Support Group.

Regarding the development over time it was assumed that the growth in the first five-year period would be much smaller than in the following periods and would slow down again towards the year 2020. Altogether the passenger traffic (passenger kms) will increase in the 20-year forecast period by 130%. Since the traffic declined world wide in 2001 and 2002 the total growth is higher in the 18-year period.

As can be seen in Figure 3, ICAO/CAEP has thus forecast a long lasting growth of world wide travel demand, despite the ongoing development of factors affecting air traffic negatively. This long-term trend follows the past trend which was also characterised by strong growth over a long period: In the 30-year period from 1971 to 2001 global air traffic has grown by the factor of six!

Figure 3. Forecast of scheduled air traffic world wide until 2020



Source: *Traffic and fleet forecast.* (2001). Montreal: ICAO Committee on Aviation Environmental Protection, Forecast and Economic Analysis Support Group.

This ICAO/CAEP forecast is based, among others, in the methodological hypothesis of unrestrained conditions in the air traffic system. This basic assumption becomes more and more questionable as the

busy airports world wide approach capacity levels. In order to verify the significance of the forecast, a volume-capacity comparison should be conducted—an exercise probably too cumbersome to carry out globally. For Germany, this has been done in the DLR-Forecast.

DLR-Forecast of German Air Traffic 2010

The DLR-Forecasts serve—among others—the planning of federal transport networks of the Federal Government and the airport planning of the States (Länder) of Germany. The methodological approach includes the forecast of demand (journeys by air, freight), of passenger flows on origin-destination (O-D) routes, their assignment to the links served, and the estimation of flights on these links based on passenger volumes, and thus the traffic of passengers and flight movements (take-offs and landings) at airports.

The background of the demand forecast is the *unconstrained reference scenario,* the main hypothesis of which is the provision of sufficient capacity at airports and in air space so that airlines can develop their offer reflecting, first of all, demand preferences. The main reason for basing the forecast on this hypothesis is the fact that the methodology of forecasting demand does not require a feedback procedure caused by limited capacity. It is in following scenarios that the hypothesis is questioned and strategies of market adaptation of airlines and reactions of travellers on supply changes in relation to system bottlenecks are assumed. A suppression of demand, however, has been excluded in all forecast scenarios.

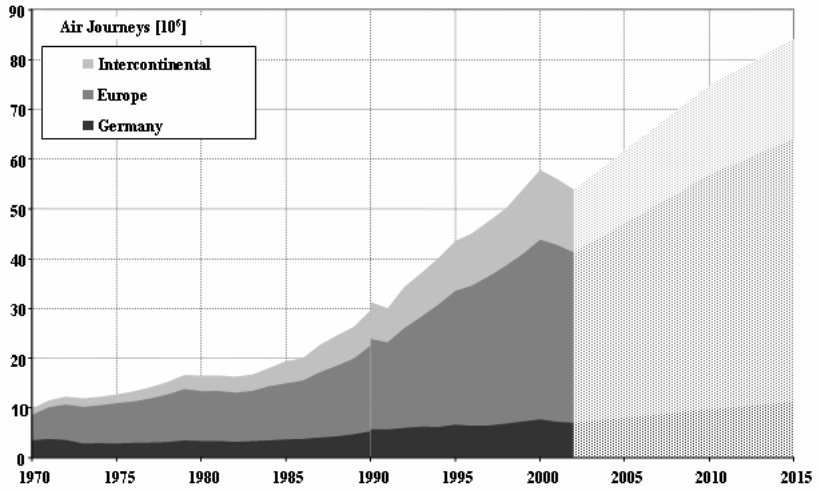
For the year 2015 the global air travel demand of Germany has been forecast as well; under unconstrained system conditions the total demand for air transport will reach a volume of about 84 million journeys in that year, this being 9 million journeys more than in 2010. Although the pace of growth will retard somewhat as compared with the period before we still have to face a considerable amount of additional traffic in that decade.

In the past the demand has grown to its peak level so far of 58 million air journeys in the year 2000, since then the demand dropped to 54 million in 2002. As compared with the year 2000 the demand will grow annually by an average of 1.7 million journeys until the year 2010, however, compared with 2002, the annual growth is more than 2 million. This is somewhat less than in the 1990s when the growth was strongest over a period of 9 years between 1991 and 2000, but corresponds roughly with the absolute annual growth in the 20-year period from 1980 until 2000.

The future number of passengers enplaning and deplaning at the German airports selected for the forecast (18 international airports in the past, 16 international airports in the future with one airport in Berlin, plus the 4 regional airports Kiel, Paderborn, Friedrichshafen and Augsburg) which

correspond to the demand described above (75 million journeys) amounts to about 185 millions in 2010, in the year 2000 this volume was 144 million passengers (in 2002: 137 million).

Figure 4. Development of air travel demand of Germany



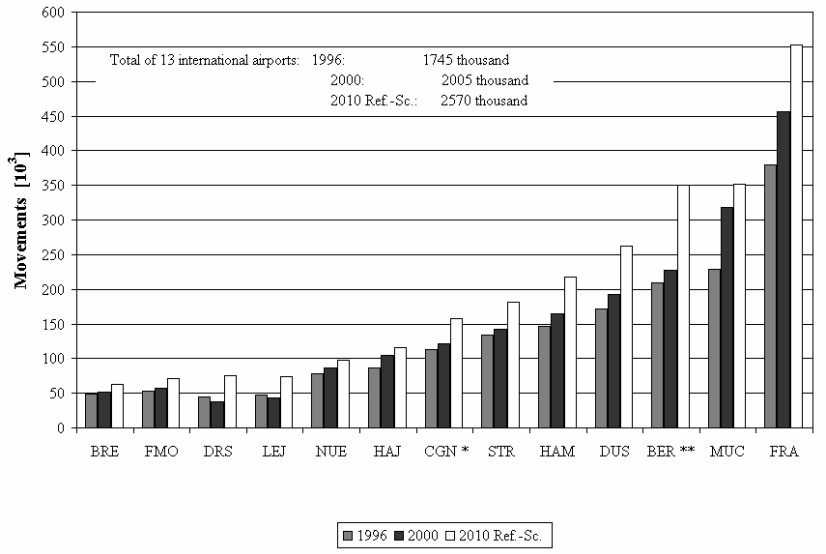
Sources: *Monthly air transport statistics 1970-2002*. (2003). Wiesbaden, Germany: Federal Statitical Office; Urbatzka, E., Focke, H., Stader, A., and Wilken, D. (1999). *Air transport scenarios reflecting capacity constraints at German airports.* Koln: DRL.

The total number of ATMs at airports consists of take-offs and landings of passenger flights in scheduled and charter traffic, freight and mail flights, and other flights in commercial and non-commercial traffic. In 2000, these flights amounted to 2.1 million take-offs and landings on the airports selected (2002: 2.05 million), and traffic has doubled in the 15-year period from 1985 to 2000.

In the unconstrained reference scenario the number of passenger flights in the year 2010 is estimated on the basis of a continued liberalization of markets and frequency competition among airlines. This means for the procedure of calculating flights that the variable mean size of aircraft in service on any link (as expressed in the seat capacity per flight) stays rather constant, as has been the case on liberalized markets in recent years. A similar hypothesis is retained for the variable average load factor, which varies strongly between link types, however not significantly over time. There has been though a slight increase of the load factor on intercontinental flights.

With these assumptions the passenger flight volume at the primarily international airports in Germany will grow from 1.4 million ATMs in 1996—a base year of the forecast— respectively from 1.7 million ATMs in 2000 to more than 2.2 million passenger flight movements in 2010. Including all other movements we can expect around 3 million take-offs and landings in 2010, given the capacity at airports and in the controlled air space allowed for it. In this reference scenario, Frankfurt, the main hub airport of Germany, would have to handle 550,000 movements, while München, being mainly an O-D traffic airport, could expect 350,000 movements (see Figure 5). As can be seen, too, the actual development in München has already gone in another direction; due to the actual capacity problems at the principal hub at Frankfurt, Lufthansa has moved a growing part of hub-related operations to München. This was the main reason for the strong growth of ATMs there; no other airport had a comparable strong growth during the last years as München.

Figure 5. Number of air transport movements at German international airports in 1996, 2000 and 2010



* CGN without freighters during the night
** BER = 3 air-ports, in 2010: one airport BBI

Source: *Montlhy Air Transport Statistics: 1996.* (2000). Wiesbaden, Germany: Federal Statistical Office**;** Urbatzka, E., Focke, H., Stader, A., and Wilken, D. (1999). *Air transport scenarios reflecting capacity constraints at German airports.* Koln: DRL.

The strong increase in flight movements in Berlin is partly caused by the assumption that, from a catchment area of around 3.5 million people, Berlin would have a single airport with enough capacity to attract a great number of O-D services on European and intercontinental relations. Berlin has instead three airports and many domestic services which serve also as feeder links for European and intercontinental services, in particular via Frankfurt and München. The fact is that Berlin has not yet a single direct scheduled link to an intercontinental destination.

What can be seen in Figure 5 as well is the continuing concentration of services at a few airports; that is, Frankfurt, München, Berlin and Düsseldorf. The assumptions of the reference scenario are such that both O-D services and hub-and-spoke services will be offered in a competitive market environment. Therefore, a greater deconcentration of services could not be expected as a result of the reference scenario.

CAPACITY SURPLUS AND CONSTRAINTS

The question is now whether or not the airports can accommodate the forecast traffic volume. Regarding the different system elements of an airport concerning capacity the runway system seems to be the most critical one. In Germany, terminal or apron capacity can normally be augmented without problems in most cases, whereas for the expansion of runway capacity, a public project approval procedure is necessary. This approval process is very complex and time consuming. Examples are the construction of the runway west at Frankfurt or the realisation of the new München airport which took nearly 30 years from first plans until the beginning of operations.

Runway capacity is not a constant term but rather a function of a lot of variables like the configuration of aircraft in terms of size and propulsion, ratio of take-off and landing, rules of air traffic control (ATC), weather conditions, etc. Therefore, in order to compare runway demand (in terms of air transport movements) with capacity (of the runway system), the composition of aircraft must be the same in the demand forecast as in the capacity function. The comparison of demand and capacity can be realised on a yearly or hourly basis. A comparison on a yearly base can only be used for rough planning of airports, for instance, whereas to determine capacity reserves of a runway system, a smaller time unit is required. It is good practice to measure the capacity as an hourly value.

For the present year, runway capacity is established by the German Air Traffic Control Organisation (DFS) according to the local air navigation infrastructure (DFS-capacity) and by the Federal Ministry of Transport (coordinated capacity) for the Scheduling Coordinator who uses these values for the strategic planning of take-off and landing slots at the coordinated

international airports (Figure 6). The difference of the two concepts—DFS-capacity and coordinated capacity—is that the DFS-capacity value is related to the local air navigation infrastructure whereas the coordinated capacity value takes account of all actual restraining factors of the airport. For the years to come, capacity forecasts are needed which are based on the same assumptions regarding the aircraft size composition and traffic mix as traffic forecasts. Such capacity forecasts are not yet available.

Figure 6. Hourly runway capacity values for German airports, Winter season 2000/2001

Airport	Runway System	Runway Length	CC	DFS
		[meters]		
Berlin--Schönefeld	single; parallel not in use	3000/(2700)	24	30
Berlin--Tegel	parallel (dependent)	2400/3000	34	36
Berlin--Tempelhof	parallel (dependent)	2100 (1700)/2100	30	30
Hamburg	2 intersecting	3250/3670	51	54
Bremen	single	2040	15	30
Hannover	parallel	2340/3800	40	60
Münster/Osnabrück	single	2170	22	25
Düsseldorf	parallel (dependent)	2700/3000	38	38
Köln/Bonn	parallel + intersecting	1865/3815 + 2460	52	52
Frankfurt	parallel (dependent) + TO	4000/4000 + 4000	78	78
Stuttgart	single	3345	36	40
Nürnberg	single	2700	30	30
München	parallel	4000/4000	82	82
Leipzig/Halle	dual (dependent)	2500/3600	20	40
Dresden	single	2500	18	30
Dortmund	single	2000	n.a.	n.a.
Saarbrücken	single	2000	20	20
Erfurt	single	2600	18	22

CC - Coordinated Capacity Value
DFS - German Air Traffic Control Organization (DFS) Capacity Value
TO – Take-off
n.a. – not available
Source: *Manual of airport capacity*. (2001). Frankfurt, Germany: German Air Traffic Control Organisation. *Aeronautical information publication.* (2001). Frankfurt, Germany: German Air Traffic Control Organization.

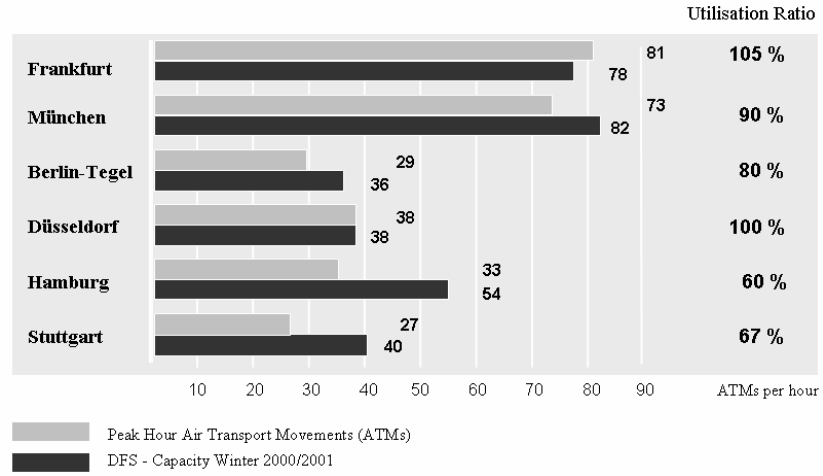
In long-term forecasts, traffic volumes are typically estimated on an annual basis. Therefore, the annual number of ATMs has to be converted into peak hour loadings. The question is then which peak hour to select. Choosing the hour with the highest traffic volume in a year creates a danger of over dimensioning facilities in a planning situation; on the other hand, if the hour of average daily traffic is compared with the runway capacity then an airport planned accordingly would have to struggle with over-loadings and thus losses in operational quality. Hence, DLR did not choose the hour with the highest traffic of a year but rather a highly charged hour within all operating hours of an airport in the course of a year which has about 6,500 to 8,500 operating hours depending on night curfew. The empirical functions

differentiated by runway system type showed that the quantity of flights in this hour corresponds to the value that is ranking at the 300th place of all operating hours. We use this hour—defined as the 5%-peak hour—as a typical peak hour for the volume-capacity comparison.

CAPACITY UTILISATION IN THE UNCONSTRAINED REFERENCE SCENARIO 2010

For answering the question of whether the forecast ATMs in the 5%-peak hour can be handled by the airport runway system, these peak hours are compared with capacities of the busiest airports in Germany. Regarding the year 2000—the year with the highest demand so far and not yet influenced by terror, economic slump and war as the following years—one can see that Frankfurt and Düsseldorf handle 81 and 38 movements in the peak hour, respectively, which is similar to the capacity value ATC has determined for the runway systems in this period (Figure 7). The other airports, shown in the diagram, still have a capacity surplus, especially Hamburg and Stuttgart.

Figure 7. Volume versus capacity comparison of German airports, 2000



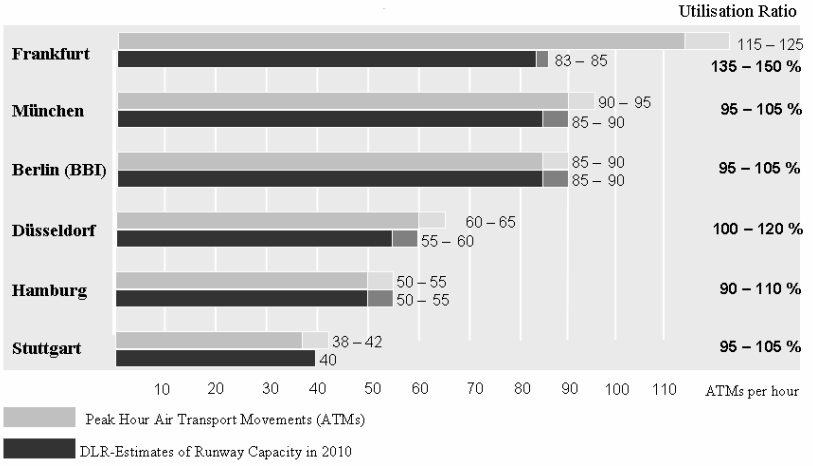
Sources: *Aeronautical information publication.* (2001). Frankfurt, Germany: German Air Traffic Control Organisation; calculation of peak hour movements by DLR.

For the year 2010 the picture will change dramatically. The result of the volume-capacity comparison in the unconstrained reference scenario shows that the forecast ATMs of the six busiest airports are nearly at or exceed the runway capacity if there is no expansion of the present capacity (Figure 8). Lacking capacity functions for future traffic and ATC-conditions, we have estimated capacity values of the runway systems for 2010 on the basis of

discussions about the development of past capacity values over time, of future traffic composition and of the likely regulatory environment of ATC.

Düsseldorf remains overloaded even if both runways can be used without restrictions. The ATMs at Frankfurt, the main hub in Germany, exceed the present runway capacity by about 50%, if there is no capacity expansion. München will reach the capacity level in the reference scenario in 2010 with traffic serving primarily the O-D-demand of its own catchment area. München will certainly become overloaded if the airport will, in addition, have to take over hub functions, as is already the case with Lufthansa hub operations via München. The airports of Hamburg, Stuttgart and Berlin—along with the new Berlin-Brandenburg International (BBI) airport still planned and regarded as the only operating airport in Berlin after start-up—will hardly be able to handle the movements estimated in the reference scenario. This means that, in reality, this transport scenario is of a theoretic nature only and will not and cannot materialise, since capacity over-loadings of this order of magnitude cannot be handled by the runway systems.

Figure 8. Volume versus capacity comparison of German airports, for the unconstrained reference scenario, 2010



CAPACITY UTILISATION IN THE CAPACITY INFLUENCED SUPPLY AND MARKET SCENARIO 2010

Therefore, two additional—capacity influenced—scenarios have been written with the aim to reduce movements at the two most overloaded airports: the supply scenario and the market scenario. In the supply scenario,

there is an increase of the load factor and aircraft size—within plausible margins—on flights from and to Frankfurt and Düsseldorf. In the market scenario, there is also a change of airport choice for holiday travel—attractive offers of tourist flights from smaller airports in the catchment areas of these airports—and a close and successful co-operation of air and rail offering high speed rail services as alternative to short haul.

The measures applied cause a reduction of approximately 200,000 ATMs as a whole as compared to the reference scenario, of which about 45,000 ATMs are at Düsseldorf and about 100,000 ATMs are at Frankfurt. The reduction of movements in Düsseldorf is traced back mainly to the change in airport choice, and in Frankfurt to the substitution of short haul flights by high speed trains to and from Köln/Bonn, Stuttgart, and Düsseldorf. The reduced flight movement volumes are well below the values of the reference scenario for these airports but traffic loadings in the typical peak hour remain at or above the capacity level. The other four busy airports also remain near the capacity barrier of the runway system or exceed the hourly capacity further on (Figure 9). This means that the daily occurring traffic peaks can be dealt with only by tolerating problems in operations and tolerating severe delays to passengers and flights.

With the demand continuing to grow in the coming years—as has been described earlier—there is the question how the air traffic system in Germany can be handled in the future. Can the hub-and-spoke concept, as it is pursued today, be continued under circumstances where the traffic levels in general surpass those of today by about 50%?

Frankfurt, as the main hub in Germany, intends to build a fourth runway. The project approval procedure shall start this year; the new runway shall operate in 2006/07. In return for the capacity expansion, Frankfurt is prepared to trade in a night curfew. The new runway will bring the capacity of the runway system to about 120 movements per hour. It is supposed that after a short phase of free traffic conditions Frankfurt will again run to the capacity limit. Our forecast movements for 2010 already points to this fact.

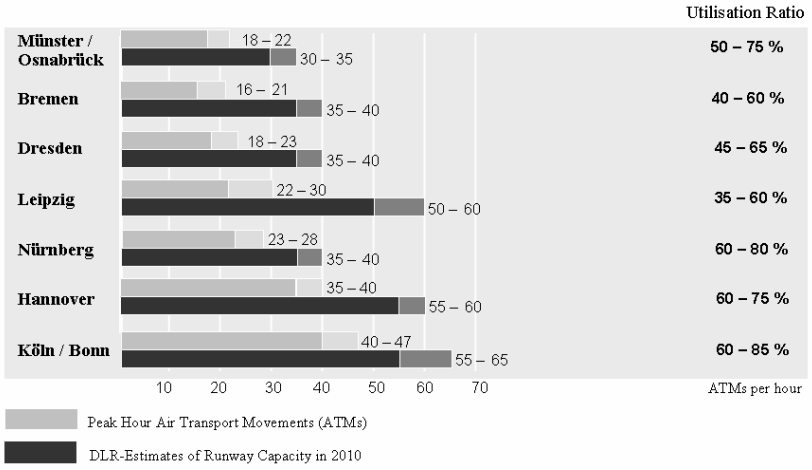
Düsseldorf airport has a parallel—dependent—runway system with an estimated capacity of about 55 to 60 movements per hour. Today Düsseldorf is not allowed to use both runways without restrictions. There is an administrative regulation limiting the hourly movements to 38. But even if Düsseldorf should get the permission for an unrestricted operation, the airport will remain overloaded.

In our forecast, München was given a flight offer structure without any adaptation to bottlenecks. Meanwhile a spatial redistribution of hub-traffic has begun, and München attains the role of a second hub in Germany. Therefore, being nearly overloaded in the future scenarios already without the hub-function, the airport is forced to enlarge the capacity earlier than planned. München intends to build a third runway, however, has not yet

made such plans public. Regarding the duration of the administrative and legal process for obtaining a building permission in general, the start-up of the new runway seems to be in the long-term future.

Figure 9. Volume versus capacity comparison of German airports, for the capacity influenced market scenario, 2010

Figure 10. Volume versus capacity comparison of German international airports, in the unconstrained reference scenario, 2010



Until now, only the busiest airports in Germany are considered. But what happens with the other German airports. Are they able to provide the necessary capacity reserves?

In Figure 10, the utilisation of seven other international airports is shown for the unconstrained reference scenario. All these airports still have capacity reserves. Three of them—Köln/Bonn, Hannover, and Leipzig/Halle—have two or three runways with runway lengths which are qualified for aircraft used in intercontinental flights. Most of the countries in Europe and of the holiday regions in North Africa are reachable from the other four airports.

WOULD LOW COST CARRIERS EASE THE CONGESTION PROBLEM?

While the traffic stagnation and reduction since the year 2000 eased the current capacity situation at Frankfurt and Düsseldorf, forecasts of those institutions that are normally involved in the forecast task unanimously indicate a continuation of the former growth trend of air travel demand. As a result of the scenario dependent forecasts of traffic and traffic loadings at the German airports we have to retain that one-third of the international airports of Germany, which handle three-quarters of the total air traffic, will have no capacity reserves in the coming years in a situation of continued demand growth. Further adaptations of operations, like higher loading factors and greater seat capacity of flights and of airport infrastructure will be needed. And it seems that the ongoing pursuit of the hub-and-spoke concept cannot be continued like that in Germany if the hub airports are not in a position of enlarging their runway capacity substantially.

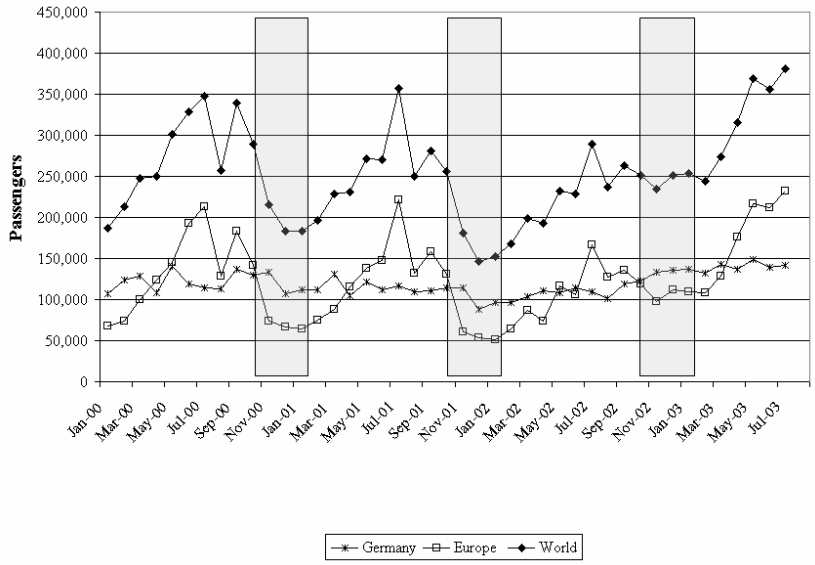
The situation of weak demand development has been used by low cost carriers to enter the German market and offer services from a few airports with great capacity surplus to destinations in Germany, like Berlin-Tegel in particular, and in Europe, like London-Stansted, Milan (Bergamo and Malpensa), Pisa, Florence, Rome, Barcelona and other destinations primarily in Italy and Spain. Ryanair has began a low fare business from Hahn airport in 1999, an airport, that had almost no traffic until 1999. In that year it had less than 100,000 passengers on scheduled services; and in 2002 it had about 1.4 million passengers, almost all of them on Ryanair services.

In autumn 2002 the new low cost carrier (LCC) German Wings started services from the well-established airport Köln/Bonn in a similar way as Ryanair has done before from the newcomer airport Hahn. Köln/Bonn is an airport with high capacity in the runway system, the terminal and parking facilities, with good surface access, and most of all, with a great catchment area reaching to the Rhine-Ruhr District. In December 2002, the start-up LCC Hapag Lloyd Express followed the Ryanair and German Wings

example and competed directly with German Wings on a number of traffic relations from Köln/Bonn.

Like in Hahn we can observe in Köln/Bonn a strong demand generation as a consequence of low fare offers of the LCCs. Ryanair has generated a travel volume of more than one million passengers within two years in Hahn and traffic development in Köln/Bonn shows similar generation effects (see Figure 11). The typical seasonal pattern of traffic can be seen for the years 2000 and 2001, with the sharp decline of traffic in October/November and the low traffic levels in winter, this pattern, however, is not repeated at the end of 2002 when the LCCs had started their business at Köln/Bonn. In the winter months of 2002/2003 traffic was about 100,000 passengers per month higher than in the preceding winter months. Assuming this trend continues over the year we can expect a demand generation of over one million passengers per year, like in Hahn.

Figure 11. Passengers per month from Köln/Bonn airport to sixteen international airports in Germany, Europe and the world



Source: *Monthly air transport statistics: 2000-2003.* (2003). Wiesbaden, Germany: Federal Statistical Office/

The most well known example of market stimulation of low fare services is the traffic development on the route London-to-Dublin, where Ryanair started services in 1986. Before that date traffic volume had been stable with about one million passengers per year. After the market entry of

Ryanair, passenger numbers doubled within 5 years and quadrupled within a period of 15 years. The generation was caused by a sharp price reduction from about BP 200—before to as low as BP 50—per round trip with Ryanair. There are sources giving the average yield of Ryanair services from Hahn to European destinations being in the order of 50 euros per leg.

There is evidence that LCCs have a great market potential and that the business model of traditional network carriers will not disappear—network carriers will continue to exist and operate world wide networks—but will serve a declining share of the total market (Binggeli, 2003; Franke, 2003; Tretheway, 2003). In the U.S. the market with the longest experience with LCCs, in particular Southwest, the market share of LCCs as measured in passenger volume is in the order of 20% to 25% whereas in Europe this share is much lower (around 5%), however, with a strong tendency to grow. According to estimates of Tretheway (2003), Bingelli (2003) and others, LCCs may achieve a market share in Europe of around 50% in the long run, this being combined with a strong market stimulation. At the same time we will observe a diversification of the full service network carriers, with the objective to capture a part of the LCC market.

The future business model in European air transportation may look like a diversified spectrum of airlines coming from traditional network carriers, operating in alliances; regional carriers, independent or affiliates of network carriers; tourism or charter carriers, and low cost carriers, in which network carriers concentrate on interconnected global and, in particular, intercontinental services (Ehmer, 2003). From network carriers outsourced carriers will take over the feeder function on heavy demand hub routes. Regional carriers continue to feed hub airports for the network carriers and serve small demand hub-by-pass routes. LCCs will serve more and more hub-by-pass domestic and direct European routes, thereby avoiding direct competition with hub carriers and congested airports. In addition, tourism carriers continuing their traditional holiday package services will offer seat-only services on tourist relations and partly compete with LCCs.

Given the traffic generation prospect of LCCs on the one hand and the airport bottleneck prospect on the other hand, will there be an ease of the capacity problem due to LCC operations? The answer is uncertain at this early stage of LCC market penetration in Europe, it seems, however, that LCCs will also in the future concentrate their services on airports with ample capacity, where they have freedom of getting slots as needed, have fast turn-around times and can possibly keep down airport fees due to the interest of the airport owner to attract business. They may face a problem in serving markets of hub and busy airports like Berlin-Tegel and Düsseldorf because of lack of available slots and lack of low airport fees and because of potential competition with other carriers, in particular network carriers.

We can assume therefore that LCCs will not aggravate the capacity problem, but will not contribute to alleviate this problem either. They will generate substantial demand, however, not on routes connected with airports with capacity problems. As such they may help to reduce the discrepancy of airport utilisation, but without a strong effect on taking away demand from hub airports. They may attract traffic which is handled today by congested airports without hub function, like Düsseldorf, if alleviator airports are located in the same region suited for LCC operations, like Mönchengladbach.

EXPECTATIONS: CONGESTION OF EXPANSION

If one would add up the runways of the international and selected regional airports of Germany (about 40 runways) to determine the total capacity and compare the total ATM volume with capacity the result would be a great surplus of capacity. Such a result is of theoretical value only, since runway capacity is needed near the areas of demand generation and attraction. We have shown that at present Frankfurt—the busiest hub airport—and Düsseldorf—a busy airport with primarily O-D traffic—are working at capacity level and cannot satisfy additional demand from traffic which has to use alternative airports, but would prefer these airports if possible. Lufthansa, the hub operator in Frankfurt, is diverting hub services to München in an attempt to interconnect their market with the global alliance network via two airports.

While the traffic stagnation and reduction since the year 2000 ease the current bottleneck situation at Frankfurt and Düsseldorf, forecasts indicate a continuation of the former growth trend of air travel demand. A prime result of the scenario dependent traffic forecasts is that one-third of the international airports of Germany, which handle three-quarters of the total air traffic, will have no capacity reserves in the coming years in a situation of continued demand growth. In other words, the six busiest airports of Germany will not have sufficient capacity to handle the future demand if no additional runways are built. As the market scenario has shown there are means available to airlines to adapt to the shortage of capacity, for instance by operating bigger aircraft with higher load factors, these measures can be applied, however, only to a certain degree. The reduction of flight movements in the market scenario as compared with the reference scenario does not yield operating conditions which can be regarded satisfactory. Daily occurring traffic peaks will prevail, with intolerable delays for passengers and flights.

Two of the six overloaded airports are Frankfurt and München, which are already today used as hub airports. In case of no capacity enlargement, it is quite clear that the hub-and-spoke concept as pursued so far cannot

continue like that and will have to be changed in the direction of a network with more direct connections. Charter and tourism carriers and LLCs follow the concept of direct services, more or less, but traditional network carriers still prefer the realization of connectivity between networks of alliance members and of intra-airline O-D relations through hub-and-spoke operations.

Of the six new runways needed, in addition to those existing at the overloaded airports, two are likely to be realized: in Frankfurt and in München. For the other non-hub airports, especially in Düsseldorf, no public plans exist to enhance runway capacity. This is partly caused by the fact that airport owners—which are often public entities—do not have the means to overcome the resistance of the public living in the surroundings of the airport against new airport infrastructure. Those living near the airport are afraid of the negative effects of aircraft operations, like noise and emissions. Airport expansion is often not an economic problem but an environmental one. It may be, however, that new slot allocation procedures based on trading would alleviate the peak traffic problem in general by diverting traffic to less congested airports and thus, take care of a spreading of services over the network.

Another way of air supply spreading has been taken up by LCCs already by choosing non-congested airports for their predominantly direct service business. In doing so, they pull away some demand from network carriers and thus from the hub-and-spoke network; their main effect is, however, to serve with low fares a public which did not participate in flying normal scheduled services (with high prices) before. Southwest does not claim to compete intensively with other airlines—they leave the market when Southwest enters the market—but with the private car. In balance it seems that LCCs will not contribute to alleviate the capacity problem of the hub and other busy airports, but will give non-congested airports a chance to augment their business substantially.

If the objective of transport policy remains oriented towards satisfying demand then enlargements of capacity at the most important airports of Germany will have to be realized. With air demand growing in the order of 50% to 100% in the long run it is rather evident that additional runway capacity is needed, in particular in the Düsseldorf and Frankfurt area, however, additional measures like supply spreading to other non-congested airports through new business models of carriers are an essential remedy of the capacity crisis at some busy airports, too. It is in the same context that there are many airports with ample capacity which would prefer to increase their market shares rather than to loose them as has been the case in the past.

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