Measuring and Benchmarking European Airport Productivity

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1 Introduction

Today's airports are expansive and expensive infrastructures, which have considerable positive and negative impacts on population and the environment. In the vicinity, an airport and its (growing) traffic could seriously affect the local neighborhood by decreasing its local air quality and increasing aircraft noise annoyance. On the other hand airports - regionally and globally - represent the most vital interfaces for different modes of transportation, which of course mainly includes the transport of passengers, mail and cargo.

In the past we have seen almost unconstrained exponential growth of air transportation in the western industrialized world, which has been fueled by the deregulation and partial privatization of air transportation in the late 1970s in the U.S. and in the early 1990s in Europe. Today the North-American and European markets and main connecting routes have matured quite considerably, therefore the future growth of demand will happen in the Asian and in the Middle-Eastern markets together with increasing wealth, consumption and education. China, India and the oil-rich countries on the Arabian Peninsula already today invest billions of Euros in airport infrastructure to boost and support their economic development. A functional and efficient infrastructure is mandatory for future growth in all economies (ACI 2010).

The European market will not stagnate at the current level; Europe will continue to serve as a gateway between North- and South American airports and Asia, and it will grow at a comparably lower average degree of maybe 3-4% annually in terms of total domestic or international flights and of around 4-5% annually in terms of total passengers. There will be considerable high growth at eastern European airports (EUROCONTROL 2009b). This results in a doubling of traffic or passengers in the next 16 or 20 years, putting current congested airports under enormous pressure. The question for European institutions and policy is: Do European airports have the needed capacity to serve future demand or will there be a widening capacity gap (Figure 1) (ACI 2010) (EUROCONTROL 2009b)?

2 Airport Productivity and Demand

When looking at the enterprise "airport" it is plausible to divide the outputs into the following two streams of "products", which should be analyzed separately, because each stream requires different staffing, infrastructure and investments, and are operated under separate rules and regulations:

Airside Productivity - measured in number of arrivals and departures or total movements over time and includes the aircraft handling on the airside, between the runways, apron, aircraft parking positions and gates, which is coordinated by local air traffic control.

Landside Productivity - measured in number of passengers, tons of cargo and tons of mail over time and includes passenger or cargo handling on the landside between the parked aircraft, the gates and inside the terminal or cargo facilities coordinated by ground handling and logistics companies or airport management.

The International Air Transport Association (IATA) suggests the first step of analyzing the output of an airport should involve busy period traffic observations, which are required for detailed airport capacity planning of the airside and at the landside (de Neufville 2003, pp. 851) (IATA 1981) (TRB 2010a). It must be noted that for a holistic view of airport capacity and demand, the airside and the landside must be assessed in combination, otherwise the picture will lack consistency and might lead to ambivalent conclusions (de Neufville 2003, p. 607).

2.1 Airside Productivity and Capacity

The airside and the runway system explicitly, is the most critical requirement for the operation of an airport. Regarding the provision of new runway capacity, a timeframe of approximately ten years is required, for planning, legal approval, property acquisitions and construction (EU COMMISSION 2007). Therefore capacity bottlenecks must be recognized and predicted years in advance.

Perhaps the most important prerequisite for the analysis of airports is the projected or actual flight schedule at each airport. Flight schedule information should include the following information: Airline name, aircraft type, time of arrival or departure, destination and origin and flight number (TRB 2010a, p.91) (IATA 2004, p.93). Popular sources for schedule data for European airports are the Official Airline Guide (OAG) for scheduled flights or FlightStats.com for scheduled and actual flights.
With available flight schedule data over longer periods of time, preferably over several days, weeks or months, but at least one representative “design” peak day, many observations on airport performance, runway and terminal efficiency, aircraft mix, demand variability or seasonality can be made. Through airline and aircraft type coding and decoding further information on aircraft weight, number of available seats, engine type and emissions can be linked (TRB 2010a).

Daily demand profiles are typically plotted by the hour of day over a twenty-four hour period. To emphasize the importance of these patterns and to show the simplicity to read its information, figure 2 shows the hourly flights at London-Heathrow, with up to 95 total scheduled flights per hour. Due to the European airspace closure between April 15th and April 22nd 2010, which resulted from the eruption and following ash cloud of Island’s volcano Eyjafjallajoekull, most of the scheduled flights on these days were cancelled (flight schedule pull from flightstats.com; April 16th data not included) (de Neufville 2003, p. 468) (TRB 2010b). Annual traffic data can be collected from Eurostat statistical database for most European airports (EU Commission 2010).

2.2 Landside Productivity and Capacity

The assessment of landside productivity includes service quality measures of processes inside the airport terminal (Table 1). These are not easy to calculate or estimate without detailed information on processing speeds and availability of the various servers, e.g. check-in counters or baggage claim units (de Neufville, pp. 655) (IATA 2004, p. 189). For best results a passenger simulation study from the terminal corridors, waiting halls, checkpoints and gates should be conducted with realistic assumptions regarding passenger flows, dwell time, available terminal space and waiting queues (IATA 2004, pp. 178) (FAA 1988, pp. 15).

A general measure in practice for terminal efficiency is the Minimum Connecting Time, which is used in the flight booking process to adequately connect transfer flights, offering the quickest travel route for passengers (TRB 1987, p. 143). Table 2 shows the Minimum Connecting Times from the Amadeus booking system for connections among and inside airports in the greater London area.

It is striking that international connection flights from one terminal to the other at London-Heathrow (LHR) airport can span between 45 minutes (Terminal 1 to Terminal 1) and 2 hours (Terminal 1, 2, 3, and 4 to Terminal 5). Therefore a large city like London with an airport system of five airports might offer more comfortable connections over the alternative airports London-Stansted (STN), London-Gatwick (LGW) or London-City (LCY) or London Luton (LTN).

2.3 Aeronautical and Non-Aeronautical Revenues

The division between airside and landside can also be made related to airport revenues, where a large portion of aeronautical (airside) revenues results from the aircraft landing, parking, passenger handling, or noise charges. Non-aeronautical (landside) revenues to the contrary result from fuel and other concessions, food and beverage sales, car parking, shopping and through leases and rents (Table 3). Already half of the revenues at many European airports result from non-aviation activities, which makes them less dependent on landing charges, but more dependent on a steady stream of passengers (ICAO 2006). The financial term in making the deviation between aeronautical and non-aeronautical revenues for price-cap regulation and accounting reasons, is the dual till approach (Czerny 2004). To enrich the experience of spending time and money at the airport, huge investments in attractive terminal design are being made, this will be more so important with the implementation of ground delay programs as it is being done in the U.S. national airspace system (FAA 2010).

3 Airport Peer Groups based on Runway Capacity

When dealing with different airports in size, location and stage of maturity it becomes obvious that a comparison among airports, e.g. benchmarking, is a difficult undertaking. This is even truer for financial comparisons, where different landing fees, accounting standards, national laws and regulations, levels of outsourcing and level of privatization frequently distort the study results. Various sources point these complexities out and offer promising solutions regarding the improvement of systematic airport comparison (Graham 2008). For an engineering perspective on airport benchmarking these difficulties exist in other ways, but among European airports comparisons of operations are usually possible. This mainly requires airports being categorized into peer groups with similar characteristics (Tretheway 2006) (Forsyth 2004).

3.1 Aircraft Mix and Minimum Separation

The main limitation for runway operations at airports result from safety separations between successive landing and departing aircrafts on the same runway and lateral separations between parallel runways, due to wake turbulences created by the wingtips of aircrafts. Encountering turbulences from preceding aircrafts during the critical landing phase can lead to serious impacts on the stability of an aircraft in the air and may cause it to roll. This is why air traffic control applies separation minima for aircrafts of different maximum take-off weights (MTOW). As it can be seen in table 4, during approach of an airport a “Small” aircraft (<7 tons MTOW) following a “Large” aircraft (7-136 tons MTOW) will experience a separation minima of approximately 4 nautical miles, in comparison a “Large” aircraft following a “Small” aircraft will be separated by 3 nautical miles (NATS 2009) (Horonjeff 2010). So the mix and sequencing of aircraft types obviously has a direct impact on runway capacity (Table 4).

If aircraft types and corresponding weights are known from the design flight schedule of the airport under investigation, we may derive the shares of aircraft weight and turbulence class – the traffic mix. Figure 3 shows the mix of different aircraft classes at some European airports. Since “Heavy” aircrafts (>136 tons MTOW) in the mix of an airport influence its overall throughput, a mathematical expression, the Mix Index, has been adopted from (FAA 1995). The Mix Index (MI) adds to the (usually predominant) percentage share of “Large” aircrafts in the mix, the three-fold percentage share of “Heavy” aircrafts (Horonjeff 2010, p. 515).

It is important to note that only separation minima under Instrument Flight Rules (IFR) are relevant for European air traffic. IFR conditions offer less capacity than flights operated under Visual Flight Rules (VFR) due to higher required separation minima between following aircraft. In contrast to the U.S., most commercial air traffic in Europe is operated and controlled under instrumental meteorological conditions (EUROCONTROL 2009b).

3.2 Estimating Capacity by Runway Configuration

The FAA Advisory Circular “Airport Capacity and Delay” (FAA 1995) is used to isolate peer groups based on maximum airport productivity measured in airport operations, which are the annual service volume and hourly capacity of an airport (Bubalo 2009).
(FAA 1995) developed a simple technique to estimate the capacity of an airport (for long range planning), where the closest matching of 19 different runway schemes is chosen, which represents the preferential runway system as explained in the Aeronautical Information Publication (AIP) (FAA 1995) (Horonjeff 2010, p. 532) (EUROCONTROL 2010). For each runway scheme (and corresponding mix index) estimates for annual and hourly capacity are listed. Three main groups have been isolated with approximately similar annual airport capacity. Group 1 represents airports with a single runway, which could have an additional crosswind runway for changing wind directions. The extra crosswind runway will therefore not increase the overall runway capacity of an airport significantly. The best-practice in this group is London-Gatwick airport with an estimated capacity of 240,000 flights per year compared to a demand of 259,000 flights per year in 2007. Group 2 represents airports with parallel runways, which are less than 4300 feet (~1.3 kilometers) apart from each other. Most of the airports in this group with a separation of 700-2500 feet and 2500-4300 feet can only be operated dependently due to safety regulations. Wake vortex turbulences caused by aircrafts on one of the dependent runways can be shifted by winds into lateral direction and possibly impact aircraft at the parallel runway. Exceptions are configurations with more than 4300 feet separation, which allow independent operation of the runways and therefore have higher hourly capacities than its peers. The best-practice in Group 2 is London-Heathrow airport with a capacity of 370,000 flights per year and a demand of 476,000 flights in 2007. Group 3 includes all runway systems with complex configurations, which have a minimum of two independent parallel runways plus a third (dependent) parallel runway on one of the sides.

London Gatwick airport (LGW) in a strict sense has two runways, but the AIP of the airport states that the airport only operates one runway under its preferential runway system. The second runway is only used for taxiing aircrafts and emergency landings. So only the FAA methodology, which requires the study of the operational characteristics of an airport, would return the true capacity estimate (Figure 4b). AIP information can be downloaded from the European AIS Database (EAD) for any European airport (EUROCONTROL 2010).

4 Airport Utilization

When looking at the annual capacities from the FAA methodology and the actual flights of different European airports will find that many main airports are highly utilized. If capacity and demand are plotted by the number of runways, as shown in figure 4a, it can be seen, that a doubling of number of runways would not always result in a doubling of capacity, so the classification by the number of runways as an indicator for productivity analysis leaves too much variation for upper and lower levels of capacity.
Figure 4b gives a more detailed picture of different best-practice airports, its runway configuration and utilization. Frankfurt and London Heathrow are extreme examples of airports, which operate significantly over their estimated capacities.

London Gatwick (LGW) airport is a prominent example for a highly productive, but severely congested, single-runway airport. Even globally the 259,000 flights per year in 2007 are without comparison. On busy days this extraordinary performance of London-Gatwick can be observed even better. As a comparison the biggest single-runway airport in the U.S., San-Diego airport (SAN), reaches a far lower number of hourly operations, than its European counterpart. As it can be seen in the hourly arrival and departure plot of busy day traffic, San-Diego airport (Figures 5a) serves up to 41 hourly flights (20 arrivals and 21 departures per hour), and London-Gatwick airport (Figure 5b) reaches 50 flights (25 arrivals and 25 departures) during the peak day.
The practical capacity for the maximum sustainable landing and departures at a particular airport can be estimated by constructing the Capacity Envelop in the "Gilbo Diagram" of a specific airport of interest (Gilbo 1993).
With data of many operating hours the Gilbo diagrams deliver a sufficient estimate of practical capacity in maximum possible arrivals and departures under existing airport conditions. In the case of London-Heathrow airport (Figure 5c) the practical capacity is 100 flights per hour (50 arrivals and 50 departures per hour) and for Munich airport (Figure 5d) 82 flights per hour (41 arrivals and 41 departures per hour). Actually the Gilbo diagram for Munich reveals that the airport achieves its best operational performance with a 64% share of arrivals (57 arrivals per hour) to 36% share of departures (32 departures per hour), resulting in a total of 89 hourly flights. The Gilbo diagrams can be modified to include the frequency of each data point. This has been done by Kellner (2009) to derive so-called "density plots". The density plots can then be used to isolate outliers and to establish confidence intervals, e.g. defining practical capacity as 90% of the envelope (Kellner 2009).

5 Airport Delay and Congestion Costs

Of course table 6 reveals that this high productivity comes at the expense of delay, which in the case of London-Gatwick resulted in ca. 80,000 delay minutes in 2006. Using the "cost per minute of delay" estimations from the EUROCONTROL document "Standard-Inputs for Cost-Benefit Analysis" (EUROCONTROL 2009a) it is possible to derive annual delay costs for the top 21 congested airports in Europe (Table 6). Value of time estimated at 42 Euro per minute of delay results in an approximate total of 3.3 million Euros at London-Gatwick in 2006 ("reactionary delays" not included). It is not surprising that London-Heathrow airport ranks first in table 3, causing an enormous 9-fold delay compared to London-Gatwick (Rank 16th) of 715,761 minutes of delay, resulting in an approximate annual delay cost of 30 million Euros (EUROCONTROL 2008b) (EUROCONTROL 2009a).

But what exactly is the critical relationship between airport capacity and delay? Airport capacity represents the limit of productivity under current conditions in a specific time, usually per hour, per day, per month or per year. An airport operator should make clear that the airport operates and serves demand below a practical capacity, where an acceptable level-of-service, of e.g. five

minutes average delay per flight, is guaranteed for the airport users. The practical or sustainable capacity should never be exceeded for longer periods. As it can be seen in figure 6, the closer an airport operates towards its ultimate or "physical" throughput capacity, the stronger delays increase beyond an acceptable level of service, and eventually theoretically delays reach infinity, which means flights never leave the gate or wait an infinite time in the holding pattern in the airspace. Therefore the arriving and landing aircraft have priority over departing aircraft, due to limited fuel reserves which allow waiting in the holding stack in the airspace only for a certain period of maybe maximum 20 to 30 minutes.
Furthermore it can make a huge difference in service quality measured in average delay per flight, when an airport operates at a capacity utilization of 65%, 75%, 85% or more. The practical capacity usually serves as declared capacity for the slot coordinator and should never exceed 85-90% of the ultimate capacity during consecutive busy hours, otherwise the airport system is unstable and sensitive to changes in demand or available capacity, e.g. due to unscheduled flights, runway incursions or weather (de Neufville 2003).

At congested airports, which are slot coordinated, the amount of hourly capacity must be declared by the airport operator (IATA 2010b). The declared capacity is the common denominator of all processes at an airport involved in serving passengers, aircrafts or cargo. Ideally the declared capacity is close to the practical capacity. It is indeed always possible for demand to exceed capacity for short periods of time, due to fluctuations of demand at the airport. The situation becomes more critical when capacity is utilized more than 100% over a minimum of one hour and measurable waiting queues and delay will develop (Horonjeff 2010).

6 Conclusions

As it could be shown for the European airports London-Heathrow and London-Gatwick the high productivity of both airports comes at the expense of huge amounts of experienced delay and delay costs for the airport users. It is ongoing research of how this externality of highly productive airports can be included in productivity and efficiency analysis to be able to make fair assumptions and comparisons of airports with regard to service quality and externalities. Nevertheless it should be observed how the whole European air traffic network reacts to major changes in airport capacity. It is no doubt that delays will be reduced significantly, if new runways at Frankfurt and London-Heathrow airport go into service on time. A number of airport improvements are planned for European airports, but it remains questionable, if these are sufficient (Figure 7) (EUROCONTROL 2008a).

Another crucial externality of air transportation is annoyance caused by aircraft noise on the communities around airports. Cumulative long-term aircraft noise exposure is made responsible for all kinds of stress symptoms, which could lead to decreased life expectancy, due to cardiovascular diseases (Greiser 2007). Aircraft noise and transportation noise in general and the resulting health effects are currently being studied at EU level under the guidelines of the World Health Organization (EU Commission 2002) (WHO 2009, p. 61).

Further research will deliver more insights in simulating and modeling of environmental impact of airport systems.

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Figures and Tables:

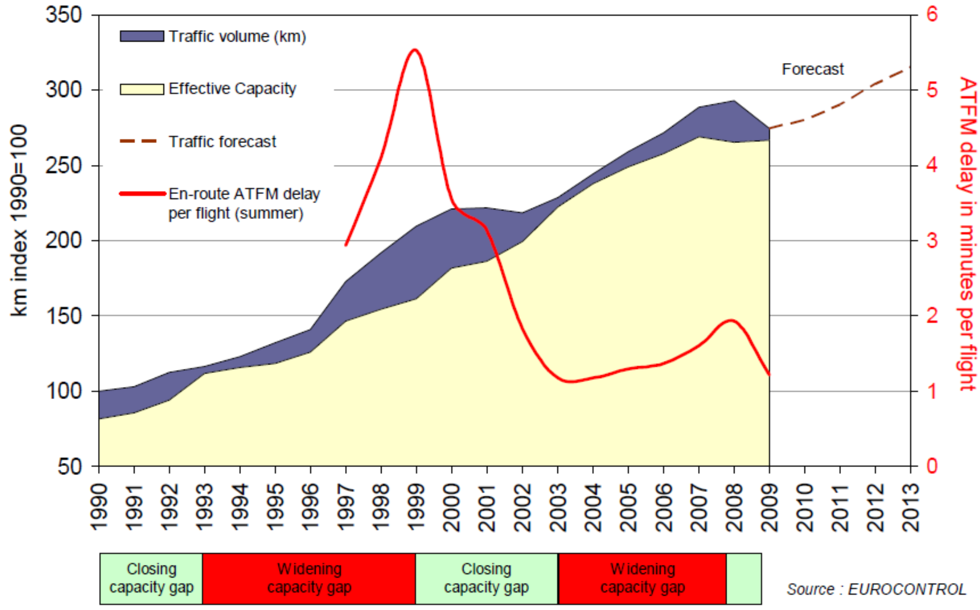
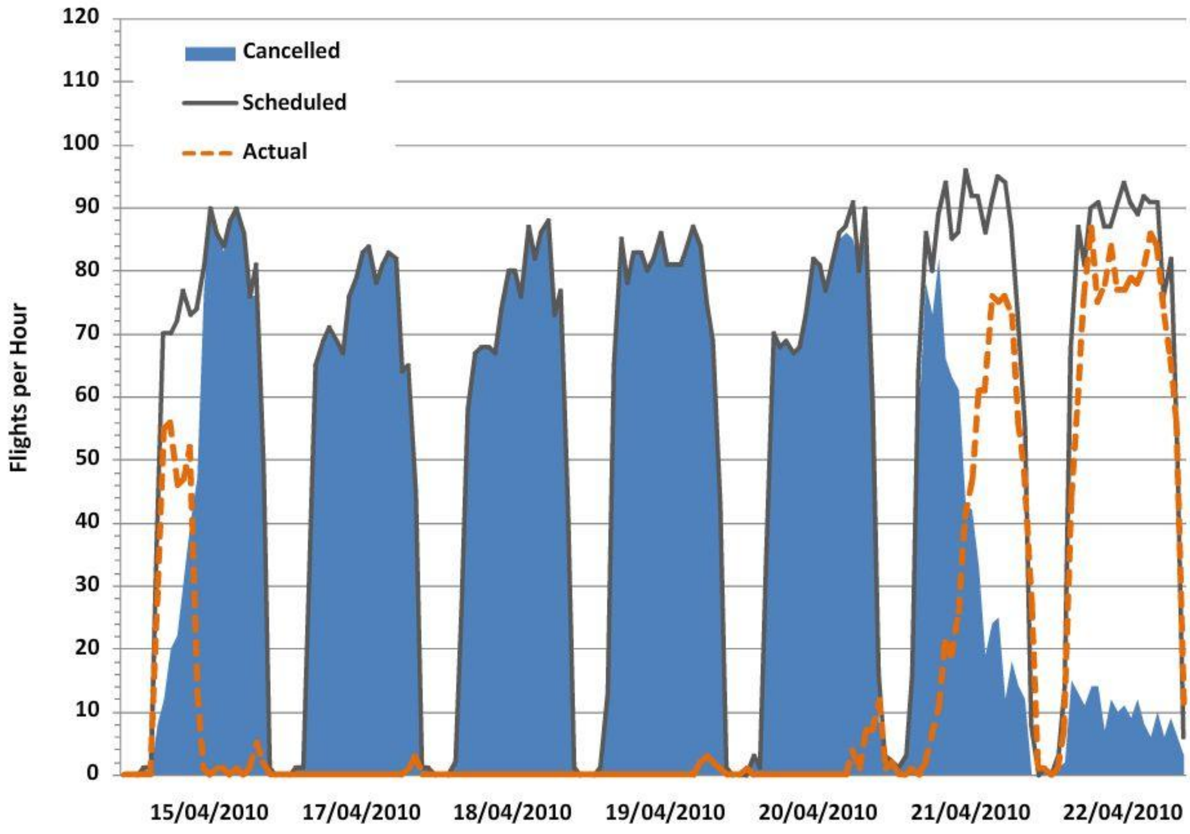
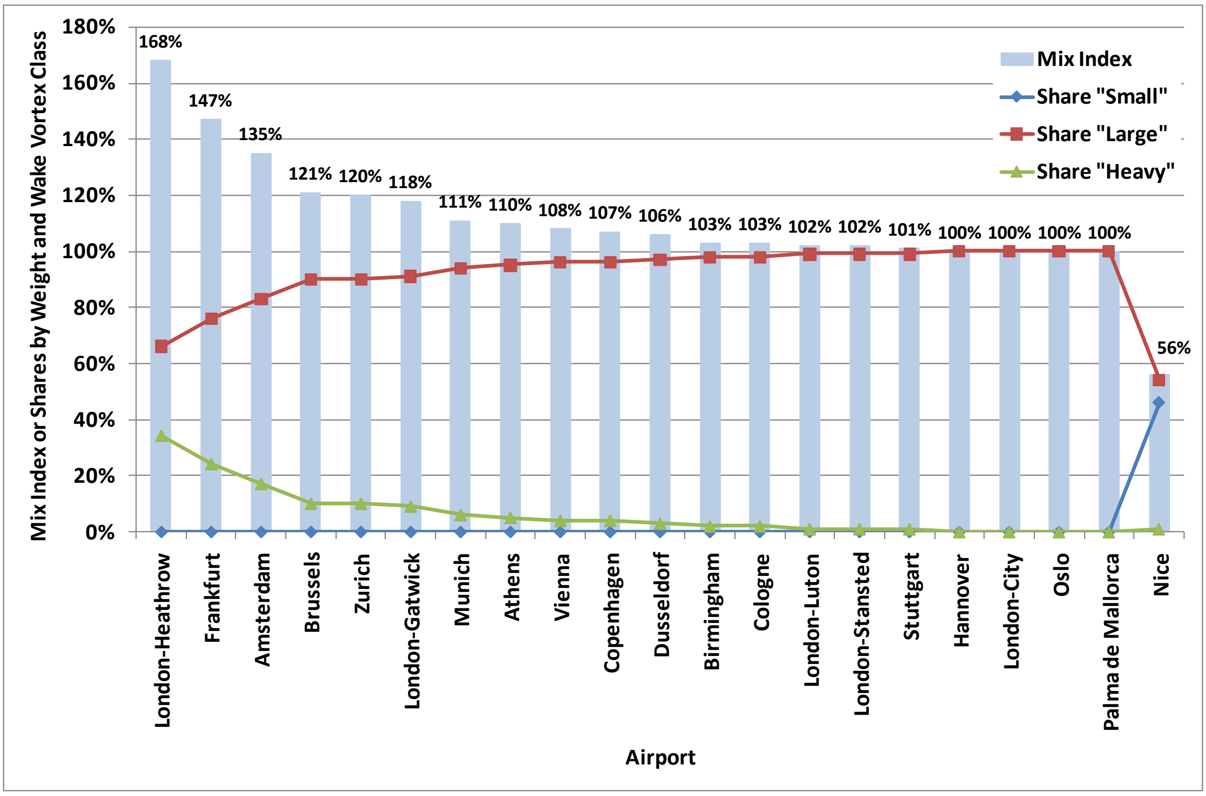


Figure 1: Development of traffic volume and capacity in Europe (EUROCONTROL 2009b; p.44)



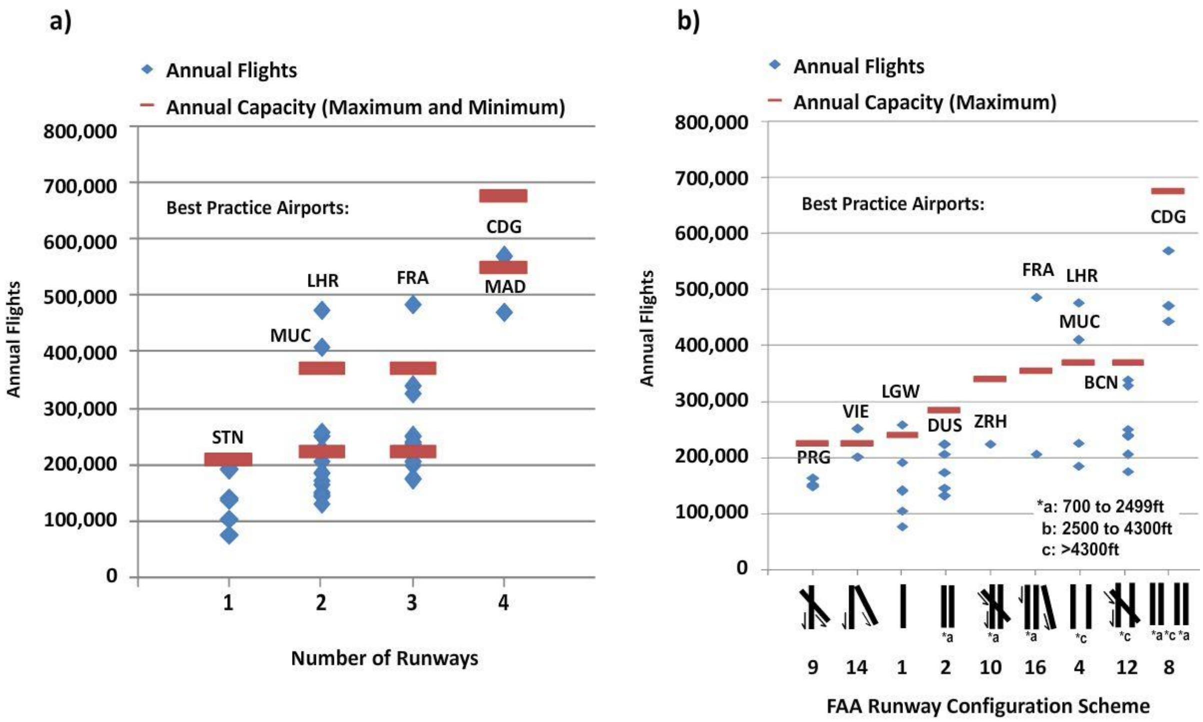
Data: FlightsStats.com

Figure 2: Volcano ash cloud disruption at London-Heathrow airport in April 2010



Source: Bubalo 2009, Official Airline Guide 2009

Figure 3: Traffic Mix and Mix Index of selected European Airports



Source: Bubalo 2010

Figure 4a) and 4b): Comparison Annual Capacity and Demand by FAA Runway Scheme Number and by Number of Runways.

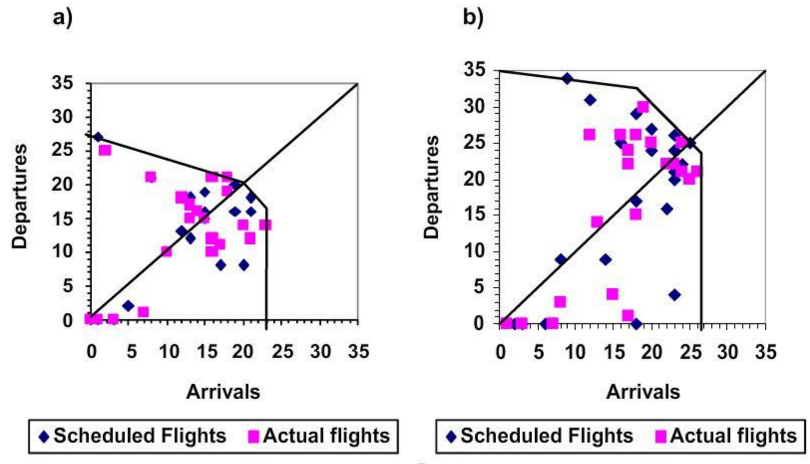


Figure 5: Gilbo Diagram of Single Runway Airports a) San Diego, USA and b) London Gatwick, UK on Busy Day 2010

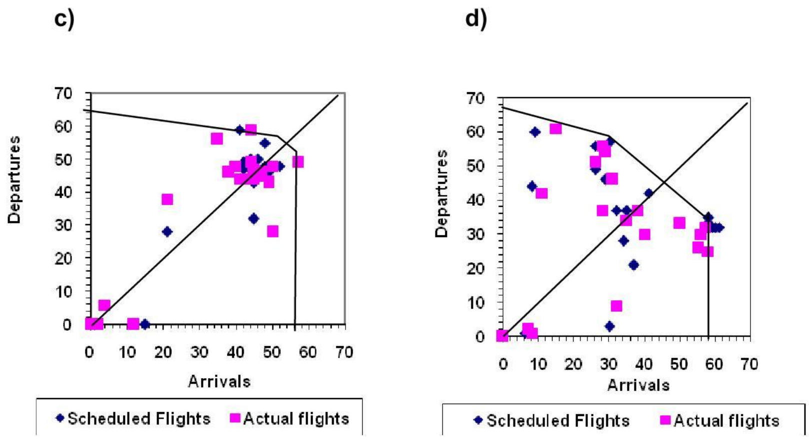
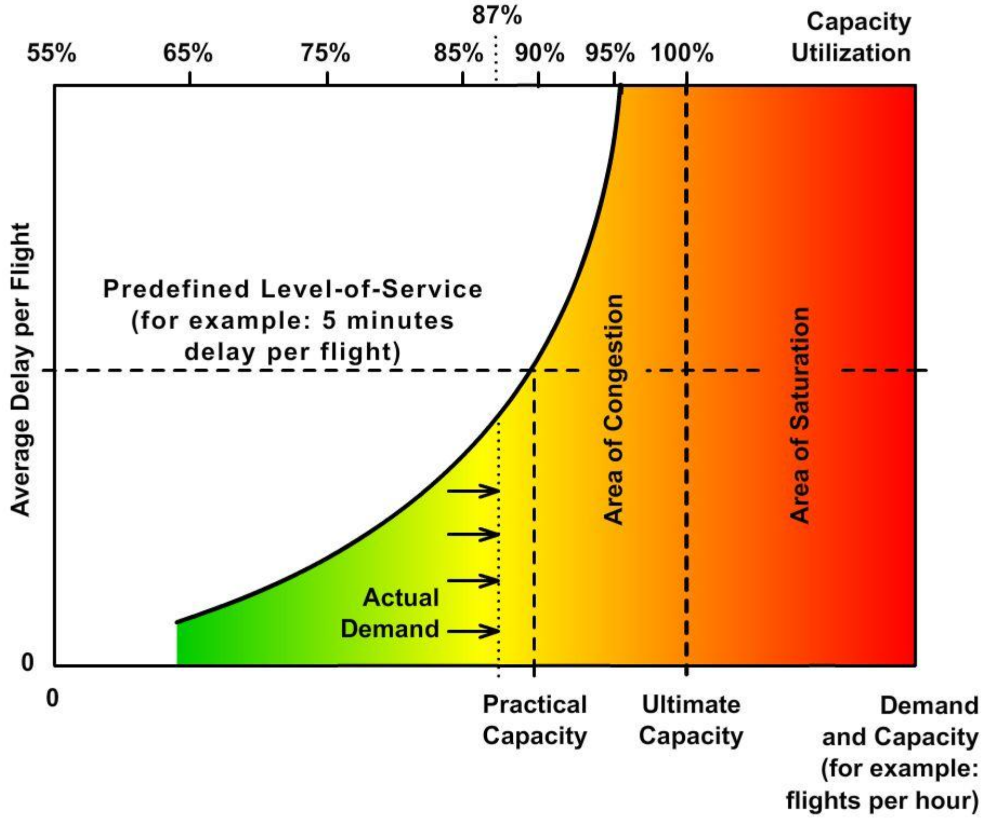


Figure 5: Gilbo Diagram for Parallel Runway Airport c) London Heathrow and d) Munich on Busy Day 2008



Modified from: Horonjeff 2010, p. 488

Figure 6: Fundamental relationship between Demand, Capacity and Delay

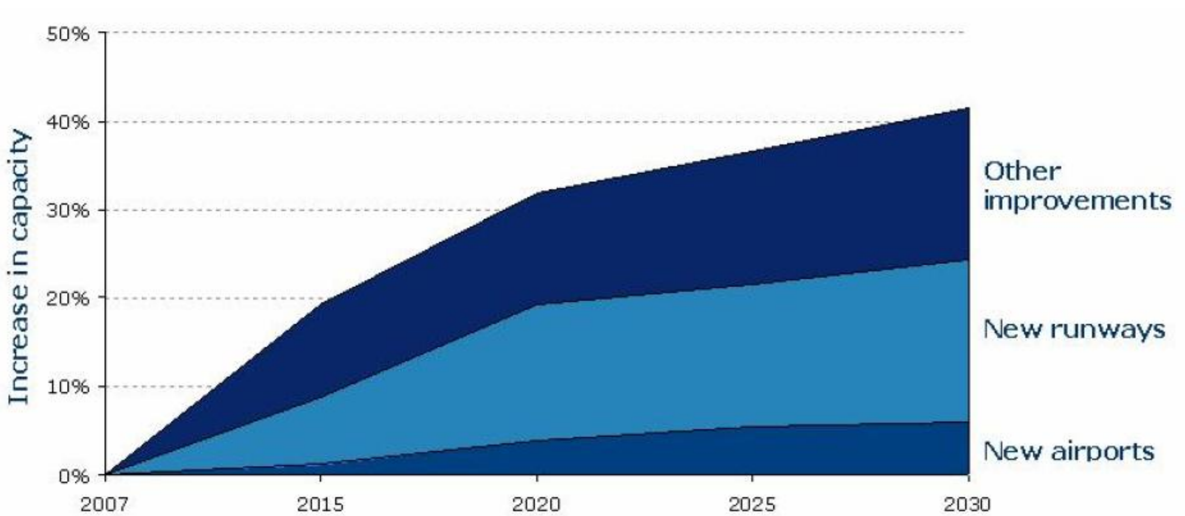


Figure 7: Planned Airport Improvements in Europe (Source: EUROCONTROL 2008a)

Aeronautical Revenues	Non-Aeronautical Revenues
Landing charges	Aviation fuel and oil concessions
Passenger service charges	Restaurants, bars, cafeterias and catering services
Cargo charges	Duty-free shops
Parking & hangar charges	Car parking
Security charges	Other concessions and commercial activities
Noise-related charges	Rentals
Other charges on air traffic operations	Other revenue from non-aeronautical activities (Revenues from ground-handling charges) (Grants and subsidies) (Other Revenues)

Table 1: Airport Revenue Structure (ICAO 2006)

<table>
<tr><th colspan="2">Level of Service and Maximum Waiting Time Guidelines
(in Minutes)</th><th>Check-In Economy</th><th>Check-In Business class</th><th>Passport Control Inbound</th><th>Passport Control Outbound</th><th>Baggage Claim</th><th>Security</th></tr>
<tr><td>A</td><td>An Excellent level of service. Conditions of free flow, no delays and excellent levels of comfort.</td><td rowspan="3">0-12</td><td rowspan="3">0-3</td><td rowspan="3">0-7</td><td rowspan="3">0-5</td><td rowspan="3">0-12</td><td rowspan="3">0-3</td></tr>
<tr><td>B</td><td>High level of service. Conditions of stable flow, very few delays and high levels of comfort.</td></tr>
<tr><td>C</td><td>Good level of service. Conditions of stable flow, acceptable delays and good levels of comfort.</td></tr>
<tr><td>D</td><td>Adequate level of service. Conditions of unstable flow, acceptable delays for short periods of time and adequate levels of comfort.</td><td rowspan="3">12-30</td><td rowspan="3">3-5</td><td rowspan="3">7-15</td><td rowspan="3">5-10</td><td rowspan="3">12-18</td><td rowspan="3">3-7</td></tr>
<tr><td>E</td><td>Inadequate level of service. Conditions of unstable flow, unacceptable delays and inadequate levels of comfort.</td></tr>
<tr><td>F</td><td>Unacceptable level of service. Conditions of cross-flows, system breakdowns and unacceptable delays; an unacceptable level of comfort.</td></tr>
</table>

Table 2: Levels of Service Framework and Maximum Waiting Times (IATA 2004)

Connection	From Terminal	To Terminal	Dom/Dom in H:MM	Dom/Int in H:MM	Int/Dom in H:MM	Int/Int in H:MM
LCY-LCY	-		:30	:30	:30	:30
LCY-LHR	-		3:00	3:00	3:00	3:00
LCY-LTN	-		4:00	4:00	4:00	4:00
LCY-STN	-		4:00	4:00	4:00	4:00
LGW-LCY	-		3:30	3:30	3:30	3:30
LGW-LGW	N-	N	:45	:45	:45	:45
LGW-LGW	S-	S	:40	:45	1:00	:55
LGW-LGW	S-	N	1:15	1:15	1:15	1:15
LGW-LHR	-		2:30	2:30	2:30	2:30
LHR-LCY	-		3:30	3:30	3:30	3:30
LHR-LHR	1-/2-/3-/4-	TN	1:30	1:30	1:30	1:30
LHR-LHR	1-	1	:45	:45	:45	:45
LHR-LHR	2-/3-	1	1:15	1:15	1:15	1:15
LHR-LHR	4-	1	1:00	1:00	1:15	1:00
LHR-LHR	2-	2	---	---	---	1:00
LHR-LHR	3-	2	---	1:15	1:15	1:15
LHR-LHR	3-	3	1:00	1:00	1:00	1:00
LHR-LHR	1-	4	1:30	1:00	1:00	1:00
LHR-LHR	2-/3-	4	1:30	1:30	1:30	1:30
LHR-LHR	4-	4	1:30	:45	:45	:45
LHR-LHR	1-/2-/3-/4-	5	2:00	2:00	2:00	2:00
LHR-LHR	5-	5	1:00	1:00	1:00	1:00
LHR-LTN	-		3:25	3:25	3:25	3:25
LHR-STN	-		3:20	3:20	3:20	3:20
STN-LGW	-		3:00	3:00	3:00	3:00
STN-LHR	-		3:20	3:20	3:20	3:20
STN-LTN	-		4:00	4:00	4:00	4:00
STN-STN	-		:45	:45	:45	:45

Data: Amadeus Booking Platform

Table 3: Minimum Connecting Times at Greater London Area Airports

Trailing	Arrivals-Arrivals (NM)			Departures-Departures (sec)		
Leading	Heavy	Large	Small	Heavy	Large	Small
Heavy	4	5	6	120	120	120
Large	3	3	4	60	60	60
Small	3	3	3	60	60	60

Table 4: Separation Minima for Succeeding Departures in Nautical Miles or Arrivals in Seconds on the same Runway under IFR Conditions (Horonjeff 2010, p. 113).

	Airport Name	IATA	ICAO	Experienced Delay 2006 in Minutes	Annual Delay Costs at 42€ per Minute (Eurocontrol 2009)
1.	LONDON HEATHROW	LHR	EGLL	715761	30,061,962
2.	FRANKFURT MAIN	FRA	EDDF	671693	28,211,106
3.	MILANO MALPENSA	MXP	LIMC	626853	26,327,826
4.	WIEN	VIE	LOWW	534717	22,458,114
5.	ROMA FIUMICINO	FCO	LIRF	464088	19,491,696
6.	MADRID BARAJAS	MAD	LEMD	388094	16,299,948
7.	MUENCHEN	MUC	EDDM	343938	14,445,396
8.	ZURICH	ZRH	LSZH	248709	10,445,778
9.	PARIS ORLY	ORY	LFPO	242897	10,201,674
10.	ISTANBUL - ATATUERK	IST	LTBA	216167	9,079,014
11.	SCHIPHOL	AMS	EHAM	151918	6,380,556
12.	COPENHAGEN/KASTRUP	CPH	EKCH	124148	5,214,216
13.	LONDON CITY	LCY	EGLC	111567	4,685,814
14.	PRAHA RUZYNE	PRG	LKPR	105861	4,446,162
15.	PARIS CH DE GAULLE	CDG	LFPG	81062	3,404,604
16.	LONDON GATWICK	LGW	EGKK	79190	3,325,980
17.	ROMA CIAMPINO	CIA	LIRA	60362	2,535,204
18.	MANCHESTER	MAN	EGCC	59495	2,498,790
19.	TEGEL-BERLIN	TXL	EDDT	55816	2,344,272
20.	LONDON STANSTED	STN	EGSS	53408	2,243,136
21.	PALMA DE MALLORCA	PMI	LEPA	44508	1,869,336
	Total			**5,380,252**	**225,970,584**

Table 5: Annual delays and calculated delay costs of European airports in 2006 (Source: Eurocontrol 2009, Eurocontrol 2008b)