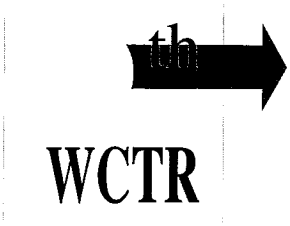

COMPETITION BETWEEN HUB AIRPORTS IN EUROPE AND A METHODOLOGY FOR FORECASTING CONNECTING TRAFFIC

NIGEL DENNIS
University of Westminster
Transport Studies Group
35 Marylebone Road, London NW1 5LS, UK

Abstract

Air passengers making a connecting journey are vigorously contested between rival airlines and airports. This paper aims to examine the performance of the major European hubs and the competitive interactions between them. The theoretical potential of the different European airports as a hub based on the range of services available is identified. Other factors such as geographical location, ground handling times and schedule co-ordination are then evaluated. An analysis of journey times is made via all alternative hubs for a range of intercontinental markets from Europe. The impact of changes in service provision is then considered, leading to a schedule-based methodology for forecasting transfer flows.

INTRODUCTION

Hub and spoke networks have become a critical part of air transport operations since deregulation in the United States. This is principally because they enable a carrier to maximise the number of markets served with a given volume of flights. For example, 100 points linked to a common hub enables service to be provided in more than 5000 different city pair markets. In Europe, hub and spoke networks have existed for many years as a consequence of international boundaries and the restrictions they imposed on traffic rights. Nevertheless, many of these were merely a collection of uncoordinated services that happened to share a common terminus. It is only in the last few years that most European airlines have started to operate and market their networks effectively to carry connecting passengers with both origin and destination outside their home country.

Whereas passengers making a direct flight often have little choice as to the airport used and typically only one or two carriers flying on the route, the situation is somewhat different for transfer traffic. The passenger flying from Berlin to Los Angeles, for example, can choose between eight different hubs in Europe and the United States that provide a one-stop connecting service and a multiplicity of possible airlines. Even where direct flights exist, indirect routings can often still provide a worthwhile alternative in terms of fares or schedules and are hence capturing an increasing share of traffic.

For airport operators, connecting traffic offers the only real opportunity to grow beyond the traffic potential of their own local catchment area. In turn this supports a much wider range of services than would otherwise be possible with accompanying economic benefits as shown by Small (1995). Amsterdam Schiphol for example sees it as vital to the Dutch economy to become a 'mainport' (one of Europe's leading hubs) in the 21st century (Butterworth-Hayes, 1993). The 'footloose' nature of this traffic means that it is one of the few areas in which competition between airports can take place.

Whereas traditionally it has been straightforward to forecast air traffic on a route by route basis, transfer passenger demand is very much more difficult to predict. This is because it is driven by the supply of air services and will shift between alternative hubs and airlines dependent on the relative quality of service and price. Data on connecting flows is scarce outside the US hence various models and estimates become necessary to analyse this traffic.

This paper considers the extent to which hub airports in Europe compete for transfer traffic and the performance of the major airlines. The relationship with scheduling issues, airport facilities and geographical constraints is addressed. A method for estimating changes in transfer traffic under changes in service or infrastructure provision is suggested. Some possible future developments of hubbing in Europe are considered, with particular reference to the shortage of runway capacity at many of Europe's major airports.

MARKETS SERVED

International boundaries have played a major part in shaping the present European air networks. Most passengers from regional airports have historically had to change planes at the national gateway (ie UK traffic would travel via London, German via Frankfurt etc). Long-haul services have also tended to reflect linguistic and colonial links. For example, many Latin American services are available from Madrid but little in the way of routes to Asia; Montreal is well served from Paris but Canadian flights from other European cities focus on Toronto. Deregulation within Europe has meant that most airports of any size are now linked with several hubs in different European countries and for most journeys the

passenger has the option of taking connecting flights through a variety of hubs as well as any direct services.

Despite the advent of long-range twin jets, the coverage of intercontinental services from Europe remains fairly thin. For example, Paris does not have a daily service to Delhi while London is lacking one to Rio; Brussels has no service to Hong Kong and Athens none to Chicago. Only New York is linked with all the major European capitals on a regular basis. This makes the use of hubs necessary even in some relatively large markets. Furthermore, the time taken to change planes is less significant in the context of a 7,000 km journey than for one of 700 km.

Table 1 examines the potential range of services from Europe to each of the world regions via the alternative hubs. It is number of flights rather than capacity that is the critical factor as passenger choice is not increased by merely using a larger aircraft. The product of the frequencies available via each hub has been used as the basis for comparison. For example, consider all European countries to North America. London Gatwick has more transatlantic flights (166 weekly frequencies) than Paris Charles De Gaulle (146). However, Gatwick has only half the number of European flights (1,099) of CDG (2,457). Multiplying these frequencies together gives the hub potential of Gatwick in the Europe-North America market as 182,434 and CDG as 358,722.

The hub potential of each airport out of the total sum across all 18 hubs is the key variable used for comparison (a type of theoretical market share). This measure takes no account of waiting times, distance travelled or airlines used. These will be discussed subsequently.

Table 1 - Hub service from all European countries (figures are column percentages)

to	EU	Rest of Europe	North America	Latin America	Africa	Middle East	Asia	Total non-Europe
via								
Amsterdam	9	9	10	14	10	10	10	10
Athens	2	2	1	-	3	3	1	1
Barcelona	3	1	-	-	2	-	-	-
Brussels	6	5	2	2	9	1	-	3
Copenhagen	7	12	2	-	-	2	4	2
Dusseldorf	3	2	1	2	1	-	-	1
Frankfurt	9	13	18	17	15	14	22	17
Lisbon	1	-	-	2	1	-	-	-
London Gatwick	3	1	6	3	2	2	-	3
London Heathrow	20	18	40	13	22	39	38	35
Madrid	6	2	2	18	3	1	-	3
Manchester	2	1	1	-	-	-	-	-
Milan Linate	3	1	-	-	-	-	-	-
Munich	4	4	1	1	2	1	1	1
Paris CDG	12	12	11	23	17	13	14	14
Rome	4	4	2	3	10	7	3	4
Vienna	2	5	-	-	1	3	1	1
Zurich	4	9	3	2	4	4	5	4

- less than 0.5%
Source: Derived from OAG data for week of 19-25 June 1995

Table 1 shows that Heathrow enjoys a dominant market position in its long-standing role as a hub for services between Europe and North America with 40% of the potential connections; Frankfurt is second with 18%. At the other end of the scale 1% of these connections are via Dusseldorf and less than 0.5% via Barcelona. Heathrow also dominates in the Asia and Middle East markets. To Africa the service is more evenly spread with Paris narrowly behind Heathrow and Rome a significant option. To Latin America, Paris moves into first place closely followed by Madrid, while Heathrow slumps to fifth. The ranking of Heathrow in the African and Latin American markets will have deteriorated further since this time with the recent move of most BA services to Gatwick.

Table 2 considers the level of provision from the five major European markets to long-haul destinations. In each case it is Heathrow together with the national hub that dominates. Paris CDG suffers in the French market from a lack of domestic service (most of the domestic routes being at Orly). Madrid and Rome in contrast have large numbers of domestic flights but poor coverage otherwise. London Heathrow makes a consistently strong showing due to its dominance of intercontinental services. Amsterdam is in its strongest position from the UK (17% of services) but generally falls below 10%. There is a reasonable spread of provision, with at least 3 hubs exceeding 10% of services in each market.

Table 2 - Share by hub of potential connecting services from five major European countries to intercontinental destinations (figures are column percentages)

from	UK	France	Germany	Italy	Spain
via					
Amsterdam	17	9	9	6	7
Athens	-	-	-	-	-
Barcelona	-	-	-	-	3
Brussels	3	3	2	3	3
Copenhagen	1	1	1	1	-
Dusseldorf	-	-	1	-	1
Frankfurt	9	11	26	17	21
Lisbon	-	1	-	-	1
London Gatwick	5	6	1	3	3
London Heathrow	43	41	29	22	26
Madrid	1	3	1	2	23
Manchester	1	-	-	-	-
Milan Linate	-	-	-	-	-
Munich	1	1	3	1	1
Paris CDG	15	17	16	20	6
Rome	1	4	2	20	3
Vienna	-	1	2	1	-
Zurich	2	3	5	3	2

- less than 0.5%
Source: Derived from OAG data for week of 19-25 June 1995

The existence of services is however only part of the equation. To consider how these relate to a passenger's choice in practice a range of other issues have to be considered. The most important of these are the flying time - which is essentially a function of distance travelled - and the transfer time which depends on airport layout, frequencies and the level of schedule co-ordination.

GEOGRAPHICAL LOCATION

Geographical location is critical for a hub airport. A centrally located hub will minimise travelling distances and hence journey times in a large number of markets.

Table 3 is based on the weighted passenger km required to interlink the 36 busiest airports in Western Europe. Istanbul, Las Palmas, Lanzarote and Tenerife Sur are not considered part of the core network and have been excluded. Only one location in Eastern Europe (Moscow) exceeded this threshold and is also excluded.

This is not simply a distance minimisation exercise; airports are given a 'weight' equivalent to the number of passengers handled. London Heathrow with over 50 million passengers per annum therefore exerts more pull on the outcome than Hanover (4 million), for example. Each airport in turn is considered as the hub and the passenger km required to link all the airports in the system calculated. It is the relative position of the different hubs that is of interest.

Table 3 - Increase in weighted passenger km required to interlink 36 major European airports via a hub relative to the optimal location (%)

Hub	Increase in travel distance	Hub	Increase in travel distance	Hub	Increase in travel distance
Brussels	0	Lyon	+21	Dublin	+67
Paris CDG	+2	Hanover	+21	Barcelona	+71
Paris Orly	+2	Munich	+27	Glasgow	+73
Cologne	+3	Birmingham	+27	Rome	+83
Dusseldorf	+4	Milan	+30	Palma	+93
Frankfurt	+6	Hamburg	+30	Madrid	+105
Amsterdam	+7	Manchester	+37	Oslo	+105
Stuttgart	+11	Berlin	+42	Stockholm	+127
London Gatwick	+12	Nice	+43	Malaga	+161
London Heathrow	+12	Marseille	+43	Lisbon	+166
Zurich	+14	Copenhagen	+60	Helsinki	+179
Geneva	+16	Vienna	+65	Athens	+196

The optimal location is Brussels. Paris is almost equally good (+2%) and benefits from being a large traffic generator in its own right - these people do not need to take a connecting flight. Northern Germany is then favoured (Cologne +3%, Dusseldorf +4%, Frankfurt +6%). The worst location for a European hub is, not surprisingly, at Athens where travel distances would be trebled compared to using Brussels. In comparison with a previous study based on the EU prior to recent enlargement (Dennis, 1994), the centre of gravity has moved eastwards, as Paris was then the optimal location. This is due mainly to the inclusion of additional airports and also above average growth rates at a number of central European airports in the last few years.

It is worth noting that the result is sensitive to deviations away from a north west - south east axis. Zurich for example represents only a +14% increase in travel distance over Brussels, whereas Lyon is +21% and Hamburg +30%.

In terms of traffic connecting between long-haul and European flights the result will be similar. The southern markets of Africa and Latin America account for only about 24% of intercontinental passengers from Europe as against 41% on the North Atlantic and 35% to Asia, the Middle East and Pacific (IATA, 1997).

The traditional long-haul hubs of London, Paris, Amsterdam and Frankfurt will therefore continue to enjoy a geographical advantage in the years ahead. Brussels could probably support more service than it does at present. Demand for air travel in Europe is likely to become more dispersed over the coming years as the more peripheral countries in the Mediterranean (eg Spain, Italy, Portugal) and Eastern Europe are likely to have the highest growth rates (IATA, 1995; AEA, 1995). This will have the consequence of moving the optimal hub location further south and east, bringing locations such as Munich and Zurich more firmly into the picture.

TRANSFER TIMES AND SCHEDULE CO-ORDINATION

If the passenger is prepared to wait an indefinite time at the hub, connections can be achieved between all services operating to and from it. In reality, long delays at the transfer airport are unattractive especially where the actual flying time is short. If alternative routes are available, a considerable drain of traffic may be experienced whilst even in a monopoly position, optional demand will still be suppressed. The typical waiting times incurred differ between the various hubs. This is a result of the physical design of the airport, the frequencies available and the schedule operated by the airlines.

The lower bound for the time required to change between two services is measured by the Minimum Connect Time (MCT). These are co-ordinated through IATA and represent the minimum time required between an arrival and departure for the two flights to be bookable as a connection. The MCT takes into account the time required to relocate a passenger and their baggage between flights. Airports with long walking distances will hence have a higher MCT than more compact facilities, although different MCTs may apply depending on the terminals used. Baggage handling systems are often the constraining factor but customs and immigration or security checks can also pose a bottleneck. At Brussels, for example, more immigration desks have been opened to reduce the MCT on Sabena's connections between European flights inside and outside the Schengen area from 40 to 30 minutes. Some MCTs are artificially inflated for competitive reasons - to deter passengers from using them as part of a connection. For example, KLM departures at Heathrow (not a KLM hub) have an MCT of 4 hours! Growing congestion also means that British Airways has actually increased certain MCTs at Heathrow and Gatwick in recent years in order to improve reliability.

Table 4 compares a range of examples. At most single terminal locations such as Amsterdam and Brussels transfers can be accomplished in 30-50 minutes (and as little as 25 minutes on Austrian Airlines at Vienna). In contrast, at multi-terminal airports such as Heathrow the MCT rises to 70-90 minutes when a change of terminals is required. In this difference of time, the passenger could have flown an extra 500 km or more! The allocation of airlines to terminals at Heathrow is particularly inefficient as 67% of passengers who change aircraft also have to change terminals (CAA, 1997). In particular, BA short-haul to long-haul passengers have to make the cumbersome move from Terminal 1 to Terminal 4. At Paris CDG in contrast, all of Air France's services are 'under one roof'.

Table 4 - Minimum Connect Times for ten major European airports

Airport	Terminals	MCT (minutes)
London Heathrow	(within T1, within T4)	45
	(within T2, within T3)	60
	(between terminals)	70-90
Paris CDG	(within T1)	60
	(within T2)	45
	(between terminals)	75
London Gatwick	(within North terminal)	45
	(within South terminal)	40-60
	(between terminals)	75
Rome		45-60
Madrid		45-60
Amsterdam		40-50
Brussels		30-50
Frankfurt		45
Zurich		40
Vienna		25-30

Source: OAG World Airways Guide, July 1998

Although at face value it is the frequencies with which different routes are operated that will also be critical to minimising the waiting time when making a transfer connection, one option that can raise the competitiveness of a hub is to improve the scheduling without actually changing the number of flights. An essential element of any serious attempt to maximise the scope of an airport as a hub involves a concentration of activity into a limited number of peaks or waves during the day. These should see a large number of inbound flights arriving in a short space of time, then departing again as soon as the MCT has elapsed. The transfer time between flights in the same wave will be close to the best attainable. The improvement from grouping flights in this way will be most dramatic at small airports but it can nevertheless offer important advantages to large airlines and airports also. Although the volume of flights at a busy airport such as Heathrow ensures that many connection possibilities will exist by chance, it is only through operating waves of flights that a consistent connecting timetable can be

provided, with services in both directions in each city-pair market and a transfer time close to the optimal.

To demonstrate this, compare the pattern of operations at Heathrow and Amsterdam Schiphol. Heathrow has a flat pattern of activity across the day with around 20 arrivals and 20 departures in each half-hour period. This is the product of the airport being full to capacity and one runway being used for departures and one for landings. Furthermore, British Airways has close to 40% of the slots in each time period. In contrast, Amsterdam's activity is much less smooth with KLM and its partners operating three main connection waves centred on 0930, 1330 and 1830, together with a developing one at 1600. 40 arrivals or departures are operated in each peak half-hour period, almost all of which are by KLM and its partners. An arrival at Schiphol at 1800 will connect to 80 departures within 2 hours whereas one outside the waves at 1030 would manage only 20. Heathrow offers about 30 connections within 2 hours from any given arrival time, which is due also to the high Minimum Connect Times that exist between terminals. Most of the major airports in Northern Europe with the exception of Heathrow now operate some form of wave pattern but in Mediterranean Europe this has yet to be implemented. Even the best European airports compare unfavourably with the concentration achieved at major US hubs however where the peaks are sharper and virtually every flight is constrained to fall within them.

Inevitably it is only the local airline and certain agreeable partners that will conform to this type of schedule. Operators not based at the hub airport have less to gain from the multiplier effects and will be more strongly motivated by requirements of the point to point traffic or their own hub system elsewhere. The grouping of flights into waves also means that the probability of the first outgoing service to any particular destination being by the same airline as the delivering flight is disproportionately high. One of the most important commercial benefits to arise from hub and spoke operations is the extent to which individual airline networks can become self sufficient in meeting demand. Department of Transportation data in the US shows the proportion of on-line connections (passengers who change planes between two flights on the same airline) has risen from 52% prior to deregulation to over 90% today. At Heathrow, with its wide variety of operators, Civil Aviation Authority (CAA) surveys showed that BA-BA connections accounted for only 27% of transfers in 1984. This had risen to 43% in 1991 and is estimated to be nearer 60% today. This means that British Airways' on-line connections at Heathrow generated 4x as many transfer passengers as those involving any other combination of carriers in 1991 and this is likely to be closer to 6x in 1996. It is individual airline networks therefore that increasingly provide the focus for competition between hubs.

AVAILABILITY OF SERVICES AND IMPACT ON JOURNEY TIMES

To assess how these factors come together in practice to influence a passenger's choice of route, schedules in 40 sample markets (Europe-long haul) have been ranked by overall journey time for travel starting on Thursday January 15th 1998. Thursday is the most neutral day of the week for analysis as it generally has average traffic levels and service patterns. The markets were chosen to give a good geographical spread around Europe and the World in relation to the overall patterns of demand (eg more US points were included than African ones). None of the city pairs selected had direct service on the day chosen for study. The aim was to ensure that all hub airlines had a comparable opportunity to compete for this traffic.

Several rules were created for this analysis. Only on-line connections (including code-shares) have been included as these account for the majority of traffic and form the key focus of competition. There is likely to be a close correlation between the ranking of the major airlines and the status of the airport as a whole.

Linkages must satisfy the published IATA Minimum Connect Times but have been compiled with reference to all scheduled flights on each sector, not merely connections published or listed in the OAG. Only connections between non-stop flights are considered as it should often be possible to use the intermediate call as a hub to cut out one stop. It would otherwise also be complicated by US routes where a large number of one-stop through services exist that really involve an additional connection at a US hub. Services requiring a wait of more than 6 hours at the transfer point also have been discarded and this will eliminate any connections requiring a night stop. Connections via hubs outside Europe are treated on the same basis as those within - a passenger from Stockholm to Los Angeles may well find the best connection to be American Airlines via Chicago and it will be identified as such.

A flight cannot be counted more than once in this analysis even it carries multiple codes. If there is more than one on-line connection possibility, it is the European airline that has been taken. (There are relatively few cases where this ambiguity arises).

An airline that provides the fastest routing in every sample market would receive a score of 100%. If an airline has no service in a particular market it scores zero. The score could hence be considered analogous to the position of an airline on the CRS screen.

Table 5 shows the performance of the various airlines at their hub airports and compares the results from a similar exercise carried out for Thursday June 22nd 1995.

Table 5 - Performance of European hub airlines: score based on sample of Europe-intercontinental markets (optimal service = 100%)

Hub airline (airport)	Score 1998	Score 1995	Hub airline (airport)	Score 1998	Score 1995
Lufthansa (Frankfurt)	63%	70%	Lufthansa (Munich)	13%	1%
Air France (Paris CDG)	60%	42%	Austrian (Vienna)	9%	-
KLM (Amsterdam)	59%	50%	Continental (Newark)	8%	-
Swissair (Zurich)	50%	29%	SAS (Copenhagen)	6%	6%
British AW (Heathrow)	47%	55%	USAirways (Philadelphia)	5%	-
Sabena (Brussels)	15%	5%	American (Chicago)	5%	-
Alitalia (Rome)	14%	11%	Delta (Atlanta)	5%	4%
British AW (Gatwick)	13%	10%	Others <5% in 1998	18 hubs	6 hubs

Lufthansa at Frankfurt comes narrowly ahead of its main rivals, followed by Air France at Paris CDG and KLM at Amsterdam. Swissair at Zurich and BA at London Heathrow are the other two major players in the Europe-intercontinental markets. There is then a 'second division' made up of Sabena, Alitalia, BA at London Gatwick and Lufthansa at Munich. The other hubs are only a realistic option in a few specific markets. Although Iberia, for example, has an attractive Latin American network it scores only 4% overall. This is because Latin America is a relatively unimportant market from Europe as a whole, Iberia's long-haul services are poorly scheduled in relation to its European flights and many secondary European points are not linked directly with Madrid at all.

This demonstrates the importance of scheduling and MCTs as Heathrow's theoretical superiority in number of services is eroded when one considers the fastest viable routings in practice. Similarly, KLM does much better than Amsterdam's level of operations alone would suggest.

It is important to note that the figures in the table above are somewhat subject to variations in the sample of markets chosen. The positioning of the major hubs appears to be robust however and it is only in the range below about 10% that the outcome may be seriously distorted. A number of key principles are nevertheless clear.

Compared with 1995, one of the most notable changes has been the improvement of Air France from being the weakest major hub carrier to one of the strongest. This can be attributed to their conversion to

a five wave system in Summer 1996 accompanied by a $22 million investment (in conjunction with Aeroport de Paris) in airport facilities (Beechener, 1996). Swissair is the other dramatic improver and now merits a place alongside the big four. This has been achieved by scrapping the split operation of long-haul services between Zurich and Geneva, in order to concentrate on developing the Zurich hub and boosting European feeder flights and frequencies through the use of smaller Crossair equipment. Aggressive scheduling gives fast connections, especially from the Mediterranean regions - where the local hubs are ineffective and Zurich has a geographical advantage over the gateways in Northern Europe.

The competition has sharpened up since 1995, which accounts for the slight fall in the rankings of Lufthansa at Frankfurt and British Airways at Heathrow. If a faster routing via another hub is now available the position of eg Lufthansa will fall, even though it may be operating the same schedule as before. This is because the scores are relative to the best service available in each market. It is likely that Frankfurt and Heathrow will continue to lose ground as they have little scope for expansion and other hubs will start to catch them up. BA's Heathrow rating may also have suffered from the transfer of thinner routes to Gatwick, eliminating its service altogether in certain connecting markets or requiring a change of airport at London which is not allowed in this analysis.

KLM has improved its score marginally thanks to very competitive European coverage. It is more wedded to the 747 than its main rivals however and in a number of long-haul markets (apart from the US) it fails to achieve a daily frequency, which is becoming something of a handicap.

The secondary hubs have generally also been improving. Lufthansa has now started to develop Munich as a serious additional hub to its Frankfurt base (Jane's Airport Review, 1997), while Sabena has built on its extensive European network to introduce more long-haul flights. Austrian, supported by a range of code-share deals, has moved into intercontinental services and BA has moved more flights to Gatwick - although not in the major markets that tend to be the focus of this analysis. A much greater number of airlines and airports are also able to offer service in at least some markets. 18 other hubs scored 1-5% in the 1998 analysis compared to only 6 in 1995. Newcomers include British Airways at Birmingham where they now have one transatlantic flight and Eastern European carriers such as LOT at Warsaw who are modernising and developing rapidly. A trend towards deregulation globally is opening up additional gateways and services.

Beyond Europe, it is really only the US hubs that have sufficient links to offer a serious alternative and then only for passengers travelling to the Americas. It is interesting to note the relative decline of JFK as more links to US gateways with better domestic connections become available. The compact scale of Europe compared to the other continents means that a back-track in Europe can often prove shorter than using an overseas hub that is not quite en-route. For example, Manchester-Amsterdam-Los Angeles is 9381 km whereas Manchester-Atlanta-Los Angeles is 9652 km. Thus although the US hubs score highly on fast transfer times (except perhaps at JFK) and range of destinations, these are counteracted by the increased flying time in many cases.

There are of course other ways in which hubs can compete besides providing attractive schedules. Leisure passengers can be tempted by heavily discounted fares to consider the most tortuous of routings. In Europe, an airline such as British Airways benefits from being based in the UK and can afford to be aggressive on pricing in high cost markets such as Germany. In contrast, Swissair is more dependent on high yields to balance its costs. Business passengers are more sensitive to time than price but frequent flier programmes have added a new dimension. Someone locked in to British Airways' Air Miles or KLM's Flying Dutchman scheme for example is likely to go out of their way to use them for long-haul travel, even if it involves a connection through a hub.

INTRA-EUROPEAN CONNECTIONS

The suitability of hubs for intra-European traffic is more difficult to assess at the general level. This is due to geography ruling out many hubs for particular journeys (eg few people are likely to travel Manchester-Helsinki via Frankfurt let alone via Athens!). This narrows the effective competition in each market. Secondly, because most of the larger markets in northern Europe are of short distance (under 1000 km) and have plentiful direct service, hubbing becomes irrelevant in these cases. However, this position is likely to change over time. The peripheral markets in Europe are the more underdeveloped and expected to see the strongest growth in the coming years, which will raise average stage lengths. Also congestion at some of the capital cities will force greater use of regional airports, which will only be able to access the whole of Europe via connections through a hub (eg a passenger from Northampton might travel Birmingham or Luton - Amsterdam - Vienna rather than going to London to fly Heathrow - Vienna non stop).

The number of hubs able to offer intra-European connections is somewhat wider than for long-haul. The pattern of services is generally more dispersed than in the long-haul context although there is still an advantage to the national hubs in most cases. Time of day is also a key factor in short-haul markets. Services departing before 0800 or between 1600-1900 can be expected to command a premium traffic, reflecting the importance of minimising lost working hours in this business travel dominated market.

For the reasons outlined above it is difficult to produce a definitive ranking of the hub airlines but some features can be readily identified. Brussels, which comes nowhere as an intercontinental hub, is a key competitor within Europe, reflecting Sabena's strategy of specialising in this market. In contrast, many of the larger hubs are not optimised for short-haul connections (Blacklock, 1990). Swissair at Zurich benefits again from its strength in the southern European markets. Both Sabena and Swissair are also characterised by attractive timings morning and evening. SAS has the Scandinavian market well tied up at Copenhagen and Olympic the Greek market at Athens. London Heathrow is rather peripheral geographically. The main message seems to be that smaller hubs can fulfil a useful regional role but this is still largely dependent on the base airline targeting such traffic.

TRANSFER PASSENGERS - SCHEDULE AND DEMAND MODELLING

Transfer traffic is one of the most difficult segments of the market to forecast on a disaggregated basis. Data on the demand side is non existent in much of Europe except for surveys at specific airports. In contrast, the US has an overall 10% ticket sales sample. Transfer flows can also be very ephemeral in nature. It is necessary therefore to devise a model based around knowledge of the supply side to imply patterns of passenger demand.

There are a number of reasons why the distribution of connecting flows may alter over time. These include:

Changes to airline service provision (eg launch of new routes or frequencies)
Changes to airline schedules (eg creation of a new or different wave system)
Changes to MCTs (eg through provision of a new terminal facility or baggage system)
Changes to airline commercial strategies (eg pricing incentives or alliances)

This is particularly crucial when aiming to assess the revenue implications of investments in new infrastructure or services. One example of recent interest involved estimating the impact on transfer passengers of possible changes in service at London Heathrow or Gatwick, relative to the other major European airports. These fall into several different categories (MCT changes such as from a possible

fifth terminal at Heathrow; creation of some form of wave system; operation of additional flights due to enhanced runway capacity).

The principle is that the composition of the existing transfer traffic over London by carrier and route group is known from the CAA surveys. No comparable data is available for the other European airports however. We also know the existing level of service in the different hub markets at Heathrow and Gatwick compared to the rival hubs (eg Frankfurt, Paris CDG, Amsterdam). This was achieved by inputting the published schedules to a computer database and then writing some special programs to interrogate this in terms of connecting services for selected connection windows (eg MCT up to 2 hours short-haul, MCT up to 4 hours long-haul). Some estimates of airline yields in the different markets enable a monetary value to be put on the resulting traffic.

The assumption is that the existing London transfer traffic is a reflection of the existing availability of connecting services. By improving the level of service at eg Heathrow relative to the other airports we could then imply a benefit in terms of transfer traffic. This is only at a snapshot in time but provides a measure of the benefit of the new facilities - in practice Heathrow may be running to stand-still as other hubs improve faster but the incremental gain will be similar.

One of the major benefits of the proposed fifth terminal at Heathrow (T5) would be to enable British Airways to combine all its existing T1 and T4 operations in one building. This would hence reduce the high 75 minute MCT that currently exists for interchange between T1 and T4 to a figure of around 45 minutes. The impact of this on one of the (unidentified) transfer market groups in the analysis is outlined below.

The base traffic is 697,000 transfers in the year (each of these passengers makes both an arrival and departure at Heathrow). This is achieved on 543 connecting pairs of flights on an average day: 18.1% of the total on-line connecting service in this market (BA v KL v AF v LH etc). The improved MCTs from T5 increase BA's service with an unchanged schedule to 676 connecting flight pairs. This is 21.5% of the new (larger) total on-line connecting service. We therefore expect BA's traffic to rise by a factor of 21.5/18.1 ie to 831,000 passengers an increase of 134,000. Further gains come from passengers switching within Heathrow as the BA-BA connection becomes a better option than their current one (some of these may already be using BA on one leg of the journey). This brings an extra 74,000 passengers. A 'same terminal' benefit is also included based on experience of existing connections available within the same terminal (eg Paris-Intercontinental which is already within T4) against those involving a change of terminals (eg Brussels-Intercontinental which requires T1-T4 interchange) net of MCT factors. An additional 45,000 passengers are anticipated here. This gives an overall gain in transfer passengers of 253,000 in this market group (+36%). The same process is then repeated across each transfer market sector. The fact that Heathrow is better located geographically in some markets than others is reflected in the current base transfer flows from the CAA data. For example, although there are many theoretical Europe-Europe connections via Heathrow, these generate very few passengers due to the circuitous routings involved.

Applying the appropriate yields gives the estimated revenue to the airline from these extra 253,000 transfer passengers (which then has to be adjusted down slightly as some were already using British Airways on one leg of the journey). The balancing loss comes partly from other carriers at Heathrow but mainly from the foreign hub rivals such as KLM and Air France. Other scenarios can then also be tested, such as placing the Star Alliance together in T1 at an enlarged Heathrow.

To assess schedule changes or additional flights, a mock new schedule needs to be created (with assumptions about how any additional capacity will be used). This then replaces the existing schedule in the competition analysis with the rival hubs.

Although this is a fairly simplistic model it could be developed further - for example, to consider different price levels between the airlines or to give different weightings to faster and slower connections. Complexity does not necessarily guarantee a more reliable outcome however! Further ideas are discussed by Bootsma (1997), working for KLM, who suggests methods for estimating the relative size of city-pair origin & destination (O+D) markets. This can be done either by breaking down published sector flows into the underlying city pair markets or grossing up one airline's O+D data to the total market. An accurate Quality Service Index (QSI) model is shown to be crucial in accomplishing this. This can then be used to estimate the impact of a new schedule on the true O+D flows.

SOME IMPLICATIONS FOR FUTURE DEVELOPMENT

Range of connections and capacity constraints

There are limited ways in which individual airlines and airports can improve their competitiveness as hubs. The most obvious comes from developing a wider range of destinations or increased frequencies. This is only feasible if the airport has spare capacity - which may be possible at Amsterdam or Brussels but not so easy at Heathrow or Frankfurt. Short-haul feeder routes are being squeezed out at Heathrow while Schiphol continues to build its network. It is therefore likely that the smaller hubs will narrow the gap compared to their rivals as the airports with runway capacity constraints can only increase passenger throughput by using larger aircraft, which does nothing to expand the range of services.

Paris CDG has a strong local demand, is well located geographically and new runway infrastructure is planned. After many years of under-performing, Air France is at last realising the potential of this facility and is well placed to become one of the dominant European carriers in the years ahead.

At Heathrow the scope for change is more limited; grandfather rights to slots have been uniformly distributed and one runway is used for take-off and one for landing (for reasons of noise abatement) which makes it impossible to build up a wave pattern of arrivals and departures. The proposed Terminal 5 would benefit British Airways as outlined in the previous section. BA has tried to overcome the lack of a symmetric timetable and the need to depend on random connections by moving to double daily frequencies on many key long-haul routes. This much improves the chance that one of the flights will make a reasonable connection in any given market. The real solution is mixed mode runway operations which would allow airlines to swap arrival and departure slots to create a wave pattern. The capacity gains are however marginal and hence unlikely to offset the environmental concerns accompanying such a change.

To complement Heathrow, British Airways is also undertaking a major expansion at Gatwick where despite the limited capacity (only one runway) waves of flights (perhaps better described as ripples!) are operated to offset the problems of low frequencies that exist there. A similar pattern to Amsterdam sees three sets of arrival and departure waves per day with most short-haul aircraft based in Europe overnight. Amsterdam itself is now actually facing slot restrictions for the first time, although it is environmental pressures rather than capacity shortfalls that are the problem here (Jones, 1998).

Where major capacity enhancements are under way, this could provide the opening for one or more other airports (eg Milan Malpensa, Munich, Berlin-Brandenburg) to promote itself to major hub status in the future. A number of smaller airports could also become regional hubs, relieving pressure on the congested airports and facilitating journeys which may be cumbersome by surface transport but possess insufficient demand for dedicated air services. Examples include the BA Eurohub at Birmingham and Regional Airlines operation at Clermont Ferrand.

Networks of hubs

In the US all the major carriers have built up networks of hubs to cover the main traffic flows in the region. In Europe, national boundaries have tended to obstruct this type of arrangement and airlines have ended up dominating several airports in close proximity in their home country. For example, British Airways at Heathrow, Gatwick, Manchester and Birmingham; Lufthansa at Frankfurt, Dusseldorf and Munich. This is less efficient from a competition viewpoint and these operations are often defensive in nature (ie to block another carrier from getting in rather than being viable operations in their own right). However the emphasis may be changing through the creation of alliances which can reach additional markets. For example, Swissair has built links with Sabena and Austrian to extend its influence into northern and eastern Europe plus TAP to the west, giving a very efficient geographic spread.

Low cost carriers

Hubs offer the major airlines one of the stronger defences against low cost new entrants. Contrary to popular opinion, most of the heavily dominated hubs in the US have been left alone by the low cost carriers. For example, Denver has been avoided by Southwest despite lying in the middle of its home territory. Northwest has a virtually clear run at Minneapolis and Detroit. The new entrants tend to focus on either dense local markets, often using a secondary airport (eg Love Field at Dallas, Midway at Chicago) and/or the busier non-hubs eg Kansas City, Omaha.

The scope for new entrants in Europe is more limited: shortages of capacity coupled with high airport charges make opportunities more limited. It is also rare to find the abandoned inner city airports that have been used so successfully in the US. At London, for example low cost airlines have been obliged to use Luton or Stansted which pushes up surface access costs and travel times. Although British Airways is losing some market share in the London originating traffic - not just to low cost carriers but also to growth by British Midland and Virgin Atlantic, it has been able to counteract this with an increase in hub traffic. For the major airlines their strength lies in their networks.

High speed rail services

The growth of the high speed rail network in Europe is casting a shadow over a number of short-haul air services. Unlike point to point traffic, transfer passengers do not want to go to city centres however and their goal is a hub airport. With few exceptions therefore it will remain faster to travel by air feeders than rail and because airlines retain control over the marketing of these services they can be priced and promoted more attractively. Lufthansa finds it impossible to remove the air services that parallel its 'airport express' trains because these passengers would be more likely to switch to alternative hubs such as Amsterdam than take the train to Frankfurt. Where rail services can have a complementary role however is to bring people in from relatively nearby cities (up to about 300 km) where air services are being forced out of the congested hubs. It is ironic that Heathrow is the airport that could probably benefit most from rail feeders but has the least planned provision of links to the long distance rail network.

CONCLUSION

Hubs will continue to offer major geographic and mathematical advantages to airlines operating in a competitive European environment. All major carriers are becoming more commercially orientated and seeking ways to attract traffic from beyond their own national frontiers. The need to have a sizeable network and frequencies however mean that it is the largest airlines and airports that tend to dominate this traffic. Airports such as Manchester, Madrid or Milan are much less important as hubs than they are

for local traffic. Similarly, airlines such as Virgin, Air Liberte, TAP or Olympic are not serious contenders for passengers requiring a connecting journey.

There is vigorous competition between the major hubs for this traffic. Heathrow suffers from poor schedules, congestion and an awkward multi-terminal layout which counterbalance its unrivalled range of intercontinental services. In contrast KLM and Swissair have been adept at maximising the potential of their smaller scale operations in Amsterdam and Zurich while Sabena has been quietly building a useful intra-European hub in Brussels. Air France - for many years the sleeping giant amongst European carriers has finally woken up and probably has some of the best prospects for the future,. with an excellent geographical location, a strong traffic base and good airport facilities. There is therefore a tendency for the competitive position to equalise between the major airports. Capacity constraints may offer opportunities to less congested locations to develop as hubs. Few cities can support long-haul services or an extensive European network on the basis of local demand alone. It is hence necessary to make a strong pitch for the passengers making a myriad of other journeys - for this is the most footloose traffic of all.

REFERENCES

AEA (1995) **Medium Term Forecast of European Scheduled Passenger Traffic**. Association of European Airlines, Brussels.

Beechener, J. (1996) Short term problems fade with new capacity plans. **Jane's Airport Review**, Vol.8 No.5 pp. 9-11.

Blacklock, M. (1990) Hubbing: European Style. **Airports International**, September 1990 pp. 22-26.

Bootsma, P. (1997) **Airline Flight Schedule Development**. Thesis: University of Twente, Enschede.

Butterworth-Hayes, P. (1993) Schiphol targets prime hub position. **Jane's Airport Review**, Vol.5 No.4 pp. 17-23.

CAA (1997) **Passengers at Birmingham, Gatwick, Heathrow, London City, Luton, Manchester and Stansted Airports in 1996**. CAP 677, Civil Aviation Authority, London.

Dennis, N. (1994) Airline Hub Operations in Europe. **Journal of Transport Geography**, Vol.2 No.4 pp. 219-233.

IATA (1997) **World Air Transport Statistics Number 41**. International Air Transport Association, Geneva.

IATA (1995) **European Air Transport Forecast 1980-2010**. International Air Transport Association, Geneva.

Jane's Airport Review (1997) Munich wins new hub business. Vol. 9 No.10 p. 14.

Jones, L. (1998) Restrictions put KLM all out at sea. **Airline Business**, January 1998, pp. 22-23.

Small, N. (1995) Airline Deregulation, Hubbing and the Implications of Superior Accessibility for Metropolitan Economic Development. **PTRC 23rd European Transport Forum,** Seminar J pp. 52a.