An Assessment of the Capacity and Congestion Levels at European Airports

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Abstract

This paper examines the current capacity of the EU's airport infrastructure and the main factors determining that capacity. The nature and role of airport services are detailed. The determination of capacity is examined with discussion of the influence which air traffic control factors, demand characteristics, environmental conditions and engineering design will have on capacity. The methods used to assess delay are detailed along with extensive data sketching the current state of Europe's system of large airports and the extent of infrastructure congestion. The options available to policy makers to improve the management and organisation of capacity are set out and critically discussed.

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Key Words: *Airport Infrastructure; Airport capacity; Congestion*

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1 Introduction

An airport represents a multi-service networked industry with significant monopoly control in the provision of many of its suite of services. In the first section of the paper, the nature of airport services are examined, since the 'bundling' of services at airports is of particular significance in a European context, particularly in relation to pricing/costing compared with the US.

The main aim of this paper is to examine the current capacity of the EU's airport infrastructure and the key factors determining that capacity. The increasing levels of congestion experienced in the 1990s, particularly at the largest airports, indicates that there is insufficient capacity. The nature and causes of delays at airports are examined and the ways of alleviating or reducing delays are outlined. The second section of the paper examines and reports on these factors. Data were gathered from a variety of sources in order to present as comprehensive a view as possible of the current EU and ECAC air traffic distribution patterns and delay and/or congestion distributions. These data are presented in this section also.

Airport infrastructure capacity constraints is crucially important in determining the long term development of the air transport sector. While the airline industry has been liberalised extensively through the implementation of the 'Third Package' of measures (which came into effect between 1993 and 1997), control over the industry continues to be exercised indirectly or directly by governments through their control of airport capacity allocation. Airport pricing policy is of great significance in affecting economically efficient allocations of existing capacity and in signalling where and when expansion of capacity is necessary and justified. The pricing policy will among other things influence the average size of aircraft at airports, the relative importance and emphasis on short- versus medium- or long-haul services and, the distribution of all EU traffic across the airports system. These factors in turn have important implications for airline network structures - a key competitive tool for carriers in a deregulated market. These issues are explored and discussed in third and fourth sections of the paper.

In the final section of the paper the implications of these issues for interoperability in the EU's transport system are briefly outlined.

2 Assessing the capacity of airport infrastructure

2.I. The nature of Airport Services

2.1.1. Functions and ownership of civil airports:

The basic functions of an airport are to provide access for aircraft to the national airspace, to permit easy interchange between aircraft and to facilitate the consolidation of traffic. In order to perform these functions, the airport must have several basic infrastructure elements present[1] such as runway, taxiways, aprons ('airside infrastructure') and airport ground resources for passengers or cargo. The ground resource elements as well as airside infrastructure capacity dictate the airport's air traffic capacity.

Traditionally, European and US airports have been in public ownership by local, regional or national governments or some combination of government tiers. Approximately 160 airports received scheduled international air services in the EU in 1991. This number has been expanding recently with the growth in services to regional airports encouraged by air transport liberalisation. The largest EU airports are owned by a combination of city, regional and national governments, with the exception of the London airports, The London airports are privately owned and operated by BAA plc. In the US, the airports that are used by scheduled air carriers are virtually all publicly owned facilities run by an agency on behalf of the state or local government. There are a small number of publicly owned airports which are managed and run by private companies who receive a management fee for their services. No US airports have been privatised to date.

The EU has taken substantial steps towards liberalising the air transport sector, particularly with the provisions in the so-called 'Third Package' of liberalisation measures. One of the cornerstones of these regulations is that there be free entry to international markets, and since April 1997, domestic markets for all EU registered carriers. As Hardaway (1991) noted, access to airport gates and terminals is critical in permitting effective competition to take place and "Denial of access serves as an absolute barrier to entry". The constraints on existing airport capacity have been identified in several studies as one of the main elements which will determine the extent to which competition actually develops in the liberalised EU market (Balfour (1995), Comite des Sages (1994), Doganis (1995), AEA (1996)).

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[1] In the US Document "Policy Regarding Airport Rates and Charges" [Federal Register: June 21, 1996 (Volume 61, Number 121)] [Notices], the following distinction between aeronautical and non aeronautical uses is made: "The [US] Department [of Transportation] considers the aeronautical use of an airport to be any activity that involves, makes possible, is required for the safety of, or is otherwise directly related to, the operation of aircraft. Aeronautical use includes services provided by air carriers related directly and substantially to the movement of passengers, baggage, mail and cargo on the airport. Persons, whether individuals or businesses, engaged in aeronautical uses involving the operation of aircraft, or providing flight support directly related to the operation of aircraft, are considered to be aeronautical users. Conversely, the Department considers that the operation by U.S. or foreign air carriers of facilities such as a reservations center, headquarters office, or flight kitchen on an airport does not constitute an aeronautical use......Such facilities need not be located on an airport. A carrier's decision to locate such facilities is based on the negotiation of a lease or sale of property. Accordingly, the Department relies on the normal forces of competition for non aeronautical commercial or industrial property to assure that fees for such property are not excessive."

It can be argued that the larger European and US airports have a monopoly position in relation to terminating or originating traffic (i.e. hinterland traffic) but face competition for connecting or transferring traffics from other airports. In many large cities, there are two or more airports supporting air transportation and thus competing for the hinterland traffic as well as transferring traffics. The economic rationale for public ownership and operation is usually that some type of market failure exists and government regulation or direct involvement is required. The main types of market failure and other arguments for public ownership of airports (adapted from Button (1993) and Kahn (1988)) are as follows:

- The containment of monopoly power
- The control of excessive competition
- The regulation of externalities
- The provision of public goods
- The provision of high costs infrastructure
- The integration of transport into wider economic policies
- The improvement in transport co-ordination
- The importance of the facility nationally
- The facilities may be natural monopolies
- Competition simply does not work well.

It can be argued that many of these factors continue to be relevant and substantive in relation to continued public ownership and provision of airports. The key points of concern are (i) whether these issues are relevant to all of the services provided at airports, or if it is the case that users would benefit and efficiency would be improved if some airport services were competitively provided and (ii) for services which remain in public ownership, what forms of economic regulation will optimise efficiency and capital investment ?

Concerns in the US about privatisation have highlighted two main issues:
1. That privatised airports may not be able to fund long term maintenance and capacity expansion programmes
2. The issue of access (for certain carriers as well as for general aviation users) may be problematic under a privatised system of operation, particularly if capacity constraints exist or are likely to exist in the future.

An extensive study undertaken by the World Bank in 1995 (Juan, 1995) suggested that, on the basis of relatively small scale private sector participation in airport ownership so far, the available data indicates that both the quality of service and investment commitments have significantly improved. This is the situation in which the private sector has a significant participation in management and ownership. The effect of airport privatisation on airport pricing policies is difficult to measure, but the following general patterns are noted:

(i) airside charges are not lower, nor have they increased substantially than under the previous public ownership, but the charges pricing mechanisms have become more complex
(ii) airside charges are subject to price-cap economic regulation
(iii) there has been intense development of non-aeronautical commercial airport revenues at relatively high prices. We note that non-aeronautical users of airport facilities have alternatives in terms of locational choice and property fees[2].

2.1.2. The nature and range of airport services

Figure 1 gives a schematic representation of the categories of airport services typically found at European and US airports. The services are grouped according to (a) whether the airport service is an

[2] At present, there are few constraints on a private developer building car parks or hotels on lands adjacent to a large number of European airports and competing with the airport authority in the provision of these services. If air-side capacity is required however, constraints exist because of the airport authority's ownership of most of the land tracts adjacent to the runways and taxiways.

'aeronautical use' or non-aeronautical use (b) whether there is general public access or access only for those travelling by air (c) whether or not there is direct airside access. For airside facilities, it is argued that duplication of runway, taxiway and apron facilities is not advisable for the following reasons:

i) These infrastructural items require substantial capital investments and should generate fees sufficient only to cover replacement costs.
ii) These facilities have significant planning requirements in terms of zoning of adjacent lands, and surface transport access.
iii) These facilities have merit good characteristics and have non-economic potential benefits or insurance aspects. For reasons of defence or growth and development, it may be necessary to provide excess capacity or facilities of a higher technical standard than are actually required to meet current demand with current technology.

Groundside facilities can be provided in a number of ways (a) through continued public ownership by a single airport company (b) through franchised arrangements with public or private management/operator companies (c) through mixed public/private ownership by multiple companies (d) through privately owned terminal companies, which have airside access (see Juan, (1995) for lengthy discussion of these options). From an economic standpoint, the main issue is whether competition in the provision of these services is necessary, feasible and if it can be justified in terms of keeping rates and costs low <u>and</u> producing a reasonable standard of service quality. While the costs and benefits of each alternative approach need to be assessed for particular facilities, it is clear that European airports offer an increasing range of services and facilities to their different customer groups. Retail franchising and duty free sales for example are very lucrative areas for the airports and have allowed for investment and expansion of the airports' suite of services and facilities. The airports have maintained a dominant or monopoly position for this suite of services and facilities. In many instances, landing fees have been kept low because cross-subsidisation has taken place.

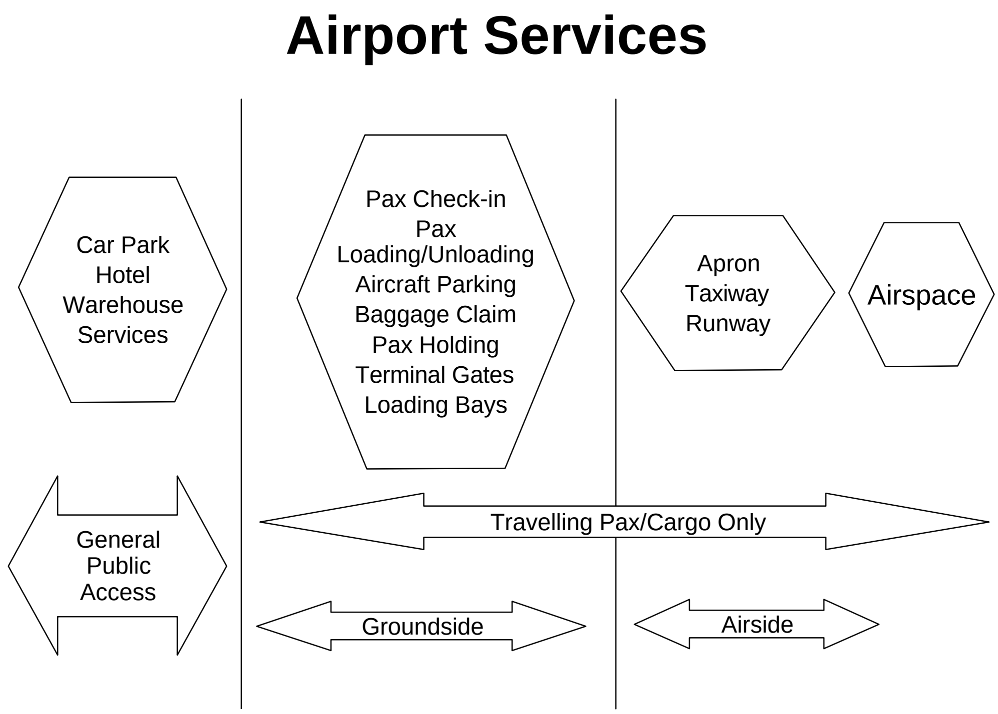


Figure 1: Natures of Airport Services

Many companies doing business at an airport pay both rental for the space which they occupy and a gross receipts fee based on their turnover at the airport. In computing carrier fees, some airports may take these concessionaire revenues fees into account. There are two methods used for the computation of air carrier fees, the residual method and the compensatory method. With the former, the airport deducts all revenue earned from non-airline sources from its total annual budget. The airlines then pay the residual. With the latter approach, the airport is divided into various cost centres and the airlines pay their fees based on the measures of airport services or facilities which they use (for example, parking, terminals etc.) [ATAA, (1995)]. If competition is permitted in the provision of terminal and groundside services, then this cross-subsidisation is unlikely to continue. With competition in groundside services, revenues for infrastructure use can be collected either by billing carriers separately for each service or by imposing collection requirements on a single agent.

The provision of basic airside infrastructure requires significant capital investment as well as having substantial planning requirements. In addition, the merit good characteristics and insurance aspects provide strong argument for continued public sector ownership and involvement. However in relation to the other types of airport services, a wide range of possibilities exist for raising the level of private sector involvement and imposing competitive or efficiency conditions on the production of services. The World Bank report (Juan, 1995) gives examples of a variety of circumstances and contexts. Generally speaking, the US airports offer a narrower range of services and facilities to airlines and passengers and have exercised greater flexibility in permitting private sector development and use of publicly owned airport lands.

2.2. Airport Infrastructure and the determinants of Airport Capacity

2.2.1. Defining airport capacity

Airport capacity analyses serves two main functions: (a) to objectively measure the capabilities of the components of the airport system to handle forecast aircraft movements and passenger flows and (b) to estimate the extent of delays in the system as demand varies (Ashford and Wright, 1992).

'Capacity' refers to the ability of a component in the airport system to handle aircraft and is usually expressed in terms of operations per hour (arrivals or departures). This hourly capacity is the maximum number of operations that can be handled in a one hour period under specific operating conditions, most notably

- Ceiling and visibility
- Air traffic control
- Aircraft mix
- Nature of operations

Capacity is therefore a measure of supply. In order to determine the capacity, the operating conditions must be specified.

The preferred measure of capacity is the 'ultimate or saturation' capacity which gives the maximum number of aircraft that can be handled during a certain period under conditions of continuous demand (Ashford and Wright, 1992). Runway capacity is usually the controlling element of the airport's system capacity and will be the main focus of discussions in this section of the paper. The main factors influencing runway capacity are

- Air Traffic Control
- Demand Characteristics
- Environmental Conditions
- Design and Layout of the Runway System

We will examine each of these factors in some detail.

Air Traffic Control

EUROCONTROL specifies minimum vertical, horizontal and lateral separations of aircraft in the interests of safety. These minima in turn depend on

- Aircraft size
- Availability of radar
- Sequencing of Operations
- Runway Occupancy Time

Capacity can be significantly increased by inserting departures between pairs of arrivals, since the minimum separations of both operations limit the total hourly capacity of a runway (Ashford and Wright, 1992). Arrivals on final approach are typically given absolute priority over departures where the latter are permitted when suitable gaps occur in the flow of arrivals.

Separation minima are the dominant ATC factor affecting capacity. Other ATC factors include

- Length of the common path from ILS (Instrument Landing System) gate to the threshold
- Sequencing strategy used by controllers for aircraft travelling at different speeds (e.g. first come first served versus speed-class sequencing)
- Probability of violation of the separation rules
- Technology and the degree of sophistication of the ATC system

Demand Characteristics

The runway capacity will depend on aircraft size, speed, manoeuvrability and braking capability as well as human factors such as pilot skills. Aircraft size impacts on (a) approach and touchdown speeds (b) wing-tip vortices. Slower speeds reduce the runway capacity; the generation of wing-tip vortices by larger aircraft creates maneuverability problems for smaller aircraft and therefore requires greater separation between larger and smaller aircraft for reasons of safety. Quite often, practical separations are longer than the regulated minima in order to allow for a mix of fast and slow, large and small aircraft.

The runway occupancy time required by arriving aircraft will vary depending on speed, braking capability and ground maneuverability. This will influence the availability of suitable slots for departing aircraft. Furthermore the mix of arrival and departure operations will affect the runway capacity.

Environmental Factors

Visibility, runway surface conditions, winds and noise abatement requirements are the most important environmental factors influencing runway capacity (Ashford and Wright, 1992). As visibility conditions worsen, longer separations are required for reasons of safety. When visibility falls below certain thresholds, instrument flight rules (IFR) are required which passes control of spacing to the air traffic controller from the pilot. Wet or slippery conditions may force longer runway occupancy times as braking for example may take longer. Crosswinds or tail winds may require the imposition of restrictions on the use of multiple runways. Noise abatement regulations affect capacity by limiting or restricting the use of one or more runways at particular times of the day.

Design Factors

Airport layout and design of the runway and taxiway system are important influences on the runway capacity. The key factors which must be taken into account in this category are

- The number, spacing, length and orientation of the runways
- The number, locations and design of exit taxiways
- The design of ramp entrances.

The relationship between each of these factors and runway capacity is discussed in detail in Ashford and Wright (1992).

2.2.2. Measuring capacity and delays

The two main sources of data used in this paper for the analysis of European airport delays and indications of congestion come from (i) the Association of European Airlines (AEA) and (ii) The Centre for Delay Analysis (CODA) at EUROCONTROL (the European Organisation for the Safety of Air Navigation). The data collected and reported by both of these agencies are described and outlined below. A brief summary of the main trends reported in the CODA and AEA reports for the most recent period is then presented. The implications for the long term development of EU air transport are outlined in the next section.

(i) AEA monitoring of airline punctuality

The AEA has conducted a survey among its members at a sample (19) of the larger EU airports since 1986, aimed at monitoring on a monthly basis the extent and reasons for delays on intra-European departures. The data are obtained from between 10 and 13 reporting airlines. The AEA use IATA's standard delay codes and categories in collating their results and annually present two summary figures in their Yearbook. Further details on the survey were sought from the AEA but were not forthcoming. The AEA report that these data are highly sensitive commercially and confidentiality clauses constrain them from making more information publicly available. IATA detail very precisely the situations giving rise to delays in airline departures and conduct their own survey among 16 airlines annually. Their analysis is discussed below in conjunction with the EUROCONTROL data. The standard delay codes used by both IATA and the AEA are included in Appendix 1 and fall into 11 main categories. These are:

- Internal airline problems or schedule discrepancies
- Passenger and baggage
- Cargo and mail
- Aircraft and ramp handling
- Technical and aircraft equipment
- Damage to aircraft and EDP automated equipment failure
- Flight operations and crewing
- Weather
- Airport and government authorities (including air traffic control)
- Reactionary
- Miscellaneous (e.g. industrial action)

Departure delays in the AEA and IATA surveys are based on real recorded delays compared with the CODA measure of delay which is based on the difference between the scheduled off block time and the calculated off block time, taking into account slot time and estimated taxi time.

The AEA survey showed relatively high levels of delay in the late 1980s, with improvements generally in the early 1990s, up until 1994. Since summer of 1994, there has been a gradual rise in departure delays as measured by the percentage of flights delayed by 15 minutes or more. Figure 2 is taken from the most recent AEA report and shows the Percentage of European Departure Delays by the Main Reason for the Delay. In 1997, there was a 4% increase in average delay per aircraft movement for all reasons compared with 1996. In 1997, 54% of all flights were delayed for any of the above causes, compared with 59% of all flights in 1996; the average delay per movement was 11 minutes in 1997.

The graph indicates that the majority of delays were related to airport and air traffic control difficulties, which accounted for roughly 60% of all delays in 1995 & 1996. Figure 2 shows the monthly trend in European departure delays. For 1996, it can be noted that the distribution of delays shows a less obvious seasonal pattern than in previous years (there was a more significant seasonal pattern in 1995).

In 1996, air traffic flow management over Europe was centralised within Eurocontrol, which the AEA report resulted in a wider distribution of delay. This helped to alleviate delays in the worst affected sectors but introduced delays in sectors, which had previously operated, with minimal delay. The European air traffic control system remains fragmented with 49 European ATC centres, 31 national systems, 18 hardware suppliers, 22 operating systems and 30 programming languages under the ECAC organisational umbrella (AEA, Yearbook 1997).

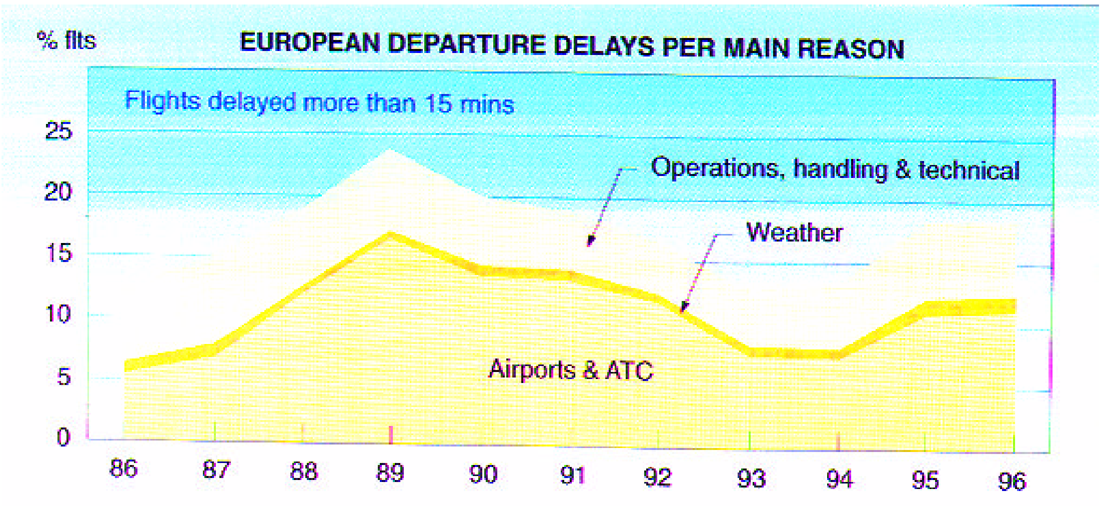


Figure 2: European Departure Delays by Main Reason
(Source: Association of European Airlines Yearbook, 1997)

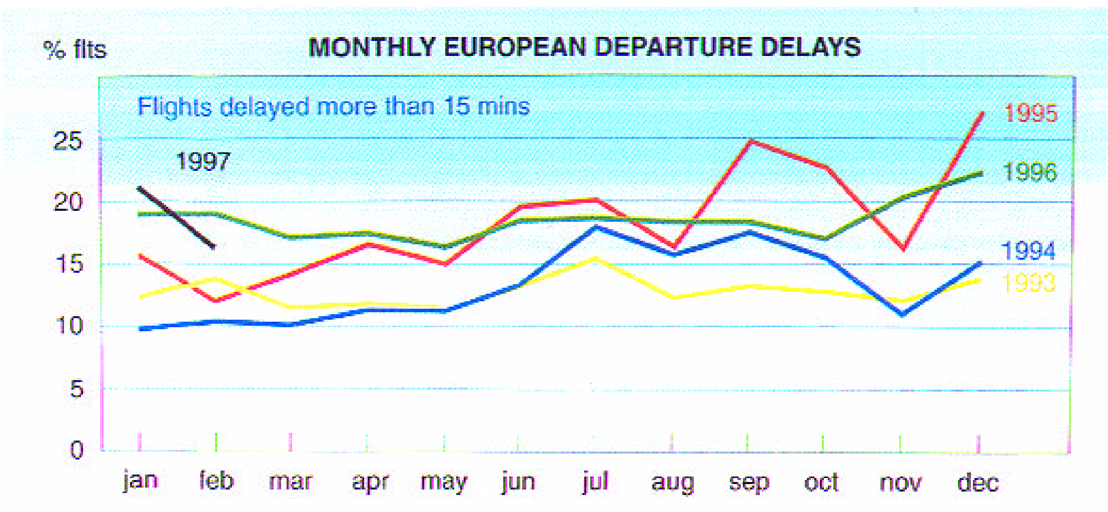


Figure 3: Monthly European Departure Delays, 1993-97
(Source: Association of European Airlines Yearbook, 1997)

In monitoring the charges for ATC services, the AEA demonstrate that both enroute charges and ground handling charges are the two main infrastructure costs which have increased most significantly on European routes since the implementation of the Third Package in January 1993. On average, landing charges have remained unchanged since 1993 with ground handling increasing by 6.2% and enroute charges increasing by 6.4% between 1993 and 1995. These costs vary significantly across the ECAC states as demonstrated in Figure 4 which shows the enroute costs in US dollars to overfly European states for a standard aircraft type and distance of 850kms.

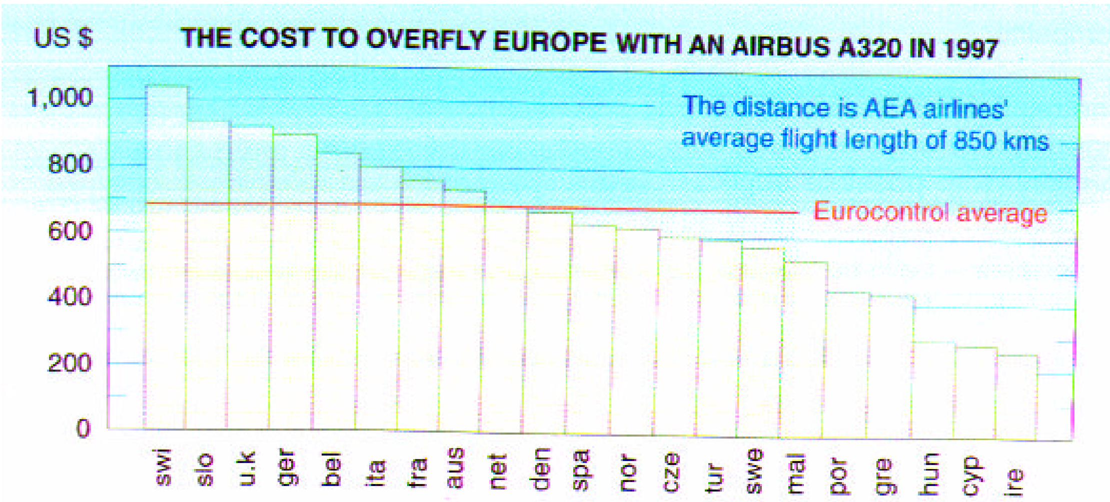


Figure 4: Costs to Overfly Europe in 1997
Source: Association of European Airlines Yearbook, 1997 and Eurocontrol

Aircraft and passenger handling delays have increased in significance in the most recent period, reflecting internal airline procedures as well as airport ground facilities and terminal conditions.

(ii) EUROCONTROL Centre for Delay Analysis (CODA) analysis of delays in European air transport.

In 1997, the Centre for Delay Analysis at EUROCONTROL began producing monthly delay reports using data collated from several sources, the main three being (a) AEA data (b) Air Traffic Flow Management data reported by the Central Flow Management Units within EUROCONTROL and (c) data supplied by the International Air Transport Association (IATA), which is based on 16 reporting airlines. The Centre produces its own ‘CODA Delay Indicator’, which gives an overview of the overall delay experience. The CODA analysis provided much more detailed breakdowns of the causes of delays and gives route specific analysis of average delays in minutes based on CFMU data. The main trends reported in the most recent CODA reports are outlined below and pertain to 1996 and 1997. First quarter results for 1998 were also available and have been included where relevant. The data obtained from the AEA are presented in CODA reports in far more detail than they appear in the AEA’s own Yearbook publication, but are only available since the beginning of 1997.

ECAC traffic grew by 6% in 1997 over 1996 traffic levels. Despite this growth, CODA claim that the amount of delay caused by the imposition of air traffic flow management measures of the CFMUs has remained relatively unchanged since 1996. The number of flights delayed by more than 15 minutes decreased between 1996 and 1997, with longer delays of greater than 30 minutes decreasing by 15% between 1996 and 1997, amongst flights subject to ATFM restrictions. The ATFM restrictions were put in place to protect congested airports, which faced problems associated with lack of capacity, parking difficulties, low visibility procedures etc. Airports particularly affected by these restrictions include London Heathrow, Athens, Barcelona, Milan and Amsterdam (CODA, 1998). The CODA report presents data for ECAC airports with more than 30,000 movements (departures and arrivals separately) annually and gives the following statistics for each of these airports:

- Total number of flights
- Total number of delayed flights
- Total delay in minutes
- Number of flights delayed 60 minutes or more
- Average delay per delayed flight
- Average delay per movement

These data are presented in full in Appendix 2. Summary statistics for 10 worst departure and ten worst destination airports are presented in Table 1. The *departure* airports with the worst average delay per movement in 1997 were Athens, Madrid, Palma, Nice, Dusseldorf and Geneva. For all of these airports more than 25% of flights were delayed and the average delay per movement exceeded 4.9 minutes. For the ECAC area as a whole, the percentage of delayed flights was 15% in 1997, with an average delay per movement of 2.9 minutes.

The *destination or arrival airports* with the worst average delay per movement were Athens, Milan/Linate, Barcelona, Madrid/Barajas, London/Heathrow and Paris/Charles de Gaulle. A significant proportion of the delays at these airports was due to ATFM restrictions at Milan, Barcelona, Madrid and London Heathrow airports.

The data were combined with the Airports Council International (ACI) traffic data and correlations with growth rates are also presented. The ACI data cover the years 1995, 1996 and 1997 and give breakdowns of traffic for 38 European countries, 341 European cities and 359 European cities in 1997. Traffic statistics cover aircraft movements (distinguished by passenger, combination and all-cargo air transport aircraft as well as detailing general aviation movements), passenger volumes (distinguished by domestic and international terminal passengers and transit passengers) and cargo (differentiated by domestic and international cargo, and by mail and all other freight). Tables 2 and 3 present recent traffic statistics for the busiest *city* in each European state, for the period 1995-1997. This is in line with US analysis by the FAA using its ‘hub’ classification (DOT/FAA, 1996), which analyses air traffic patterns for cities or metropolitan areas as single entities. Of the 341 European cities examined, 8 are served by two airports, 3 by three airports and London is served by five airports.

Tables 2 and 3 demonstrate the international nature of European traffic; Moscow, Stockholm, Madrid and Rome are distinctive by their high share of domestic traffic (less than 60% of total traffic is international). The percentage of transit traffic is generally quite low. The tables give two measures of average passenger per aircraft movement: the correct comparison uses average passengers per air transport movement rather than per total movements (which includes general aviation), but in many instances data on air transport movements alone were not available. The main trend noted in the table is the significantly lower number of passengers per movement in the former Soviet Union/Eastern European states.

Average passengers per movement are highest at the main hub in the UK, Germany, France and Italy, which tend to have the most congested airports. Rates are also high in the Southern European tourism oriented cities of Larnaca (Cyprus), Malta, Madrid and Istanbul. We note that growth rates in passenger volumes has generally been higher than growth rates in aircraft movements. The highest growth rates have been experienced in the former Soviet Union/Eastern European states. Significant declines in traffic were also most significant among these states. More modest growth rates are recorded for Paris, Frankfurt and Athens.

Tables 4 and 5 present recent traffic statistics for the top 40 European passenger airports in 1997. London (Heathrow and Gatwick), Frankfurt, Paris (Charles de Gaulle and Orly) and Amsterdam were the six busiest airports in greater Europe in 1997, with the top 4 dominating in both passenger throughput and aircraft movements. Over 80% of passenger traffic is international for these four airports, while for the group ranked from sixth to eighth serve as important domestic airports (i.e. Paris/Orly, Rome/Fiumicino and Madrid/Barajas). The busier airports generally tend to have higher average passenger numbers per movement. London’s Heathrow and Gatwick airports have substantially higher rates again compared with the other top ranked airports. Heathrow's rate has increased significantly in the last two years reflecting the constraints, which this facility faces.

The ACI data and the CODA data were combined in order to compute correlations between traffic and delay characteristics. The correlations computed are recorded in Table 6. The table highlights the fact that traffic *levels* have the greatest association with overall delay (i.e. departure plus arrival delays); the R-squared between traffic level and delay is 0.82. There is no statistical association between traffic growth rates and average delay per movement. The correlation between total delay and average passenger/movement is 0.37. So the congested airports which experience the greatest delays can allow increases in their passenger throughput by encouraging the utilisation of larger aircraft.

Table 1
Summary Statistics For 10 Worst Departure And Ten Worst Destination Airports

Most Penalised Destination Airports (with more than 30,000 flights)							
Ranked by Average Delay per Movement							
Airport	**Total Flights (TTF)**	**Delayed Flights (TDF)**	**% Delayed flights (PDF)**	**Total Delay (TDM)**	**Flights Delayed 60 min**	**Avg. Delay (ADD)**	**Avg. Delay per Movement**
Athens	67790	19336	28.52	561808	1566	29.06	8.29
Milan/Linate	91829	32857	35.78	655815	841	19.96	7.14
Barcelona	107139	33608	31.37	680490	745	20.25	6.35
Madrid/Barajas	131659	45197	34.33	791670	837	17.52	6.01
London/Heathrow	218132	65221	29.9	1308785	2459	20.07	6
Paris/Charles-De-Gaulle	200538	53899	26.88	1100202	1554	20.41	5.49
Paris/Orly	122318	33996	27.79	615610	676	18.11	5.03
New York	30418	7830	25.74	151412	123	19.34	4.98
Nice	63932	15017	23.49	296555	274	19.75	4.64
Tenerife Sur/Reina Sofia	27055	5987	22.13	120140	88	20.07	4.44
Most Penalised Departure Airports (with more than 30,000 flights)							
Ranked by Average Delay per Movement							
Airport	**Total Flights (TTF)**	**Delayed Flights (TDF)**	**% Delayed flights (PDF)**	**Total Delay (TDM)**	**Flights Delayed 60 min**	**Avg. Delay (ADD)**	**Avg. Delay per Movement**
Athens	68102	27064	39.74	802053	2333	29.64	11.78
Madrid/Barajas	132350	43493	32.86	897386	1500	20.63	6.78
Palma De Mallorca	74123	18758	25.31	391171	378	20.85	5.28
Nice	64014	16276	25.43	316151	325	19.42	4.94
Dusseldorf	91386	25778	28.21	448948	315	17.42	4.91
Geneva	62592	15846	25.32	294571	357	18.59	4.71
Lyon/Sartolas	50394	12164	24.14	226206	244	18.6	4.49
Marseille/Provence	46751	10854	23.22	207165	220	19.09	4.43
Barcelona	106866	23460	21.951	471672	673	20.11	4.41
Brussels	134942	33831	25.07	590159	497	17.44	4.37

CODA also present detailed data on average delays per movement for routes/city pairs with 3,000 or more flights per annum. These data are reproduced in Appendix 2. City pairs with either London or Paris as the destination airport dominate the list of the worst affected routes. These cities are critically important hubs in the European air traffic system as Table 7 demonstrates. These data from Eurostat show the volumes of air traffic between EU countries in 1994 and the dominance of London and Paris can be appreciated.

Table 2A
Recent Traffic Statistics for Busiest City in Each European State

Country	City	No. Airports	Total Air Transport Movements			Total Passengers		
			1995	1996	1997	1995	1996	1997
AUSTRIA	VIENNA	1	143236	154272	155933	8546233	9140643	9738292
BELGIUM	BRUSSELS	1	221765	241518	254720	12600617	13520869	15935226
BULGARIA	SOFIA	1	23742	22890	22266	1212740	1095762	1084900
CROATIA	ZAGREB	1	21338	23840	25312	902925	1008646	1080697
CYPRUS	LARNACA	1	34752	34399	35304	3777177	3648399	3797236
CZECH REPUBLIC	PRAGUE	1	68623	73824	77334	3211460	3798859	4359962
DENMARK	COPENHAGEN	1	237371	265805	279312	14678879	15860778	16837116
ESTONIA	TALLINN	1	11381	13781	17246	366919	431929	503427
FINLAND	HELSINKI	2	113154	121538	136462	7140849	7689316	8471288
FRANCE	PARIS	2	558058	605931	632561	55009348	59089020	60349696
GERMANY	FRANKFURT/ MAIN	1	372587	380012	387510	38179544	38761176	40262692
GREECE	ATHENS	1	121785	123003	139741	10480786	10411690	11090035
HUNGARY	BUDAPEST	1	44760	50702	55065	2909330	3314020	3619074
IRELAND	DUBLIN	1	110568	121673	134325	8024894	9091296	10333202
ITALY	ROME	2	219550	248383	259118	21857748	23815110	25845492
LATVIA	RIGA	1	14342	14958	15395	504094	505754	535235
LITHUANIA	VILNIUS	1	9656	9968	11339	355638	370537	410879
LUXEMBOURG	LUXEMBOURG	1	36555	37628	40329	1235580	1262576	1413145
MACEDONIA	SKOPJE	1	9768	6918	7278	583053	422598	440988
MALTA	MALTA	1	27321	26766	27742	2589010	2518528	2704638
MONACO	MONACO	1				109209	117776	131038
NETHERLANDS	AMSTERDAM	1	290689	321779	349476	25355008	27794872	31569976
NORWAY	OSLO	2	152389			10552803		
POLAND	WARSAW	1	44530	50282	55597	2735469	3090321	3547143
PORTUGAL	LISBON	1	69868	73148	76780	6476564	6580115	6817050
ROMANIA	BUCHAREST	2	38816	24122	26660	2089839	1468989	1470659
RUSSIAN FEDERATION	MOSCOW	3	69957	182510	198930	4362372	12922999	14355797
SLOVAK REPUBLIC	BRATISLAVA	1	8412	8929	8879	213774	273083	300766
SLOVENIA	LJUBLJANA	1	17600	17939	14723	638268	668532	713696
SPAIN	MADRID	2	219318	242955	252669	19956511	21856931	23601989
SWEDEN	STOCKHOLM	2	231847	245349	267421	14362412	15052551	16111129
SWITZERLAND	ZURICH	1	209034	224432	241465	15340449	16226041	18268522
TURKEY	ISTANBUL	1	131579	148930	158337	12074379	13506137	14801819
UKRAINE	KIEV	1	30728	28656	30660	1307699	1280310	1375337
UNITED KINGDOM	LONDON	5	716953	772042	815428	83304550	88401218	94934438
YUGOSLAVIA	BELGRADE	1	16636	18048	20658	976476	1191247	1379567
Average			132819	141055	149485	10945072	11560795	12449782

Source: Airports Council International, Geneva, 1998
Note: Blanks indicate data not available

Table 2B
Recent Traffic Statistics for Busiest City in Each European State

Country	City	No. Airports	Total Freight			Percentage Int'l Pax			Percentage Transit Pax	
			1995	1996	1997	1995	1996	1997	1995	1997
AUSTRIA	VIENNA	1	98588	101620	113734	93.76	93.80	94.60	2.04	1.46
BELGIUM	BRUSSELS	1	441262	464036	530718	99.22	98.79	99.24	0.77	0.74
BULGARIA	SOFIA	1	11650	10795	10498	91.94	92.31	92.66	0.00	0.04
CROATIA	ZAGREB	1	8183	7575	7331	62.35	65.84	65.56	0.53	1.07
CYPRUS	LARNACA	1	29506	28666	29321	95.51	95.69	96.74	4.49	3.26
CZECH REPUBLIC	PRAGUE	1	30304	19941	24603	97.42	95.77	92.14	1.37	6.47
DENMARK	COPENHAGEN	1		337965	387699	79.24	80.05	82.23	2.43	1.37
ESTONIA	TALLINN	1	2488	3997	5590	99.20	98.98	98.81	0.00	0.19
FINLAND	HELSINKI	2	91314	97218	99236	65.33	65.16	63.63	8.70	9.36
FRANCE	PARIS	2	1220255	1241346	1309404	66.49	66.44	67.95	0.79	0.37
GERMANY	FRANKFURT/ MAIN	1	1461284	1497245	1514267	79.25	80.02	80.52	1.84	1.44
GREECE	ATHENS	1	104111	84340	119927	63.92	63.66	61.55	2.26	0.00
HUNGARY	BUDAPEST	1	23221	23354	27175	100.00	100.00	100.00	0.00	0.00
IRELAND	DUBLIN	1	66607	74150	92000	94.07	94.11	94.32	0.52	0.95
ITALY	ROME	2	298457	308179	298443	57.39	55.31	54.54	1.88	1.48
LATVIA	RIGA	1	3918	3912	4281	97.32	98.23	99.23	2.68	0.75
LITHUANIA	VILNIUS	1	9253	6724	5845	100.00	99.91	99.80	0.00	0.09
LUXEMBOURG	LUXEMBOURG	1	286965	281183	340331	97.92	99.16	99.28	2.08	0.72
MACEDONIA	SKOPJE	1	9922	2951	4868	99.63	99.31	97.76	0.32	2.24
MALTA	MALTA	1	11613	11468		98.15	97.02	96.79	1.85	3.21
MONACO	MONACO	1								
NETHERLANDS	AMSTERDAM	1	1019315	1124652	1207282	97.45	97.46	97.66	1.97	1.74
NORWAY	OSLO	2	71722						0.70	
POLAND	WARSAW	1	34899	41047	51028	88.98	88.03	88.44		
PORTUGAL	LISBON	1	99231	100725	110631	77.07	77.58	78.16	3.60	2.72
ROMANIA	BUCHAREST	2	31650	19699	13414	70.23	95.60	96.11	5.25	3.84
RUSSIAN FEDERATION	MOSCOW	3	27521	120973	131136	6.92	60.62	58.77	0.59	1.27
SLOVAK REPUBLIC	BRATISLAVA	1	2809	3121	2210	79.89	84.74	87.54	12.68	4.92
SLOVENIA	LJUBLJANA	1	6418	5042	5898	99.95	99.81	98.62	0.00	1.29
SPAIN	MADRID	2	253637	267703	282410	47.63	46.77	46.68	1.43	2.03
SWEDEN	STOCKHOLM	2	130143	145004	146083	53.77	55.48	57.31	1.75	1.52
SWITZERLAND	ZURICH	1	344044	340091	355301	91.00	91.14	91.67	2.75	2.18
TURKEY	ISTANBUL	1	139281	140313	178714	67.26	68.53	66.40	1.24	1.31
UKRAINE	KIEV	1	16492	17105	12417	64.54	67.86	94.01	0.72	1.08
UNITED KINGDOM	LONDON	5	1488200	1570657	1713883	87.29	86.78	87.13	0.67	0.60
YUGOSLAVIA	BELGRADE	1	5214	6757	8164	67.02	76.22	74.82	0.00	0.00
Average			231749	243130	268936	76.03	78.78	79.46	1.89	1.66

Source: Airports Council International, Geneva, 1998
Note: Blanks indicate data not available

Table 3A
Selected Statistics for Busiest City in Each European State

Country	City	Avg Pax per Pax/Combi Movement			Avg Pax per Total Movements		
		1995	1996	1997	1995	1996	1997
AUSTRIA	VIENNA	60.60	60.12	63.76	59.67	59.25	62.45
BELGIUM	BRUSSELS	62.66	61.79	69.75	56.82	55.98	62.56
BULGARIA	SOFIA	54.36	51.21	52.52	51.08	47.87	48.72
CROATIA	ZAGREB	42.32	42.31	42.70	42.32	42.31	42.70
CYPRUS	LARNACA	109.50		107.70	108.69	106.06	107.56
CZECH REPUBLIC	PRAGUE				46.80	51.46	56.38
DENMARK	COPENHAGEN	65.52	62.97	63.66	61.84	59.67	60.28
ESTONIA	TALLINN	32.36	31.50	32.42	32.24	31.34	29.19
FINLAND	HELSINKI				63.11	63.27	62.08
FRANCE	PARIS	103.24	102.11	100.36	98.57	97.52	95.41
GERMANY	FRANKFURT/ MAIN	108.32			102.47	102.00	103.90
GREECE	ATHENS				86.06	84.65	79.36
HUNGARY	BUDAPEST				65.00	65.36	65.72
IRELAND	DUBLIN	79.79			72.58	74.72	76.93
ITALY	ROME	105.06			99.56	95.88	99.74
LATVIA	RIGA	35.25	33.88	34.78	35.15	33.81	34.77
LITHUANIA	VILNIUS	38.85	38.44	36.66	36.83	37.17	36.24
LUXEMBOURG	LUXEMBOURG	39.90	39.26	41.68	33.80	33.55	35.04
MACEDONIA	SKOPJE	64.48	63.01	61.61	59.69	61.09	60.59
MALTA	MALTA	97.17	95.38	99.21	94.76	94.09	97.49
MONACO	MONACO						
NETHERLANDS	AMSTERDAM	90.80	90.00	93.83	87.22	86.38	90.34
NORWAY	OSLO	71.83			69.25		
POLAND	WARSAW	61.43	61.46	63.80	61.43	61.46	63.80
PORTUGAL	LISBON	94.20	90.88	89.59	92.70	89.96	88.79
ROMANIA	BUCHAREST				53.84	60.90	55.16
RUSSIAN FEDERATION	MOSCOW	65.66	72.08	78.28	62.36	70.81	72.17
SLOVAK REPUBLIC	BRATISLAVA	31.09			25.41	30.58	33.87
SLOVENIA	LJUBLJANA	38.22	39.86	54.39	36.27	37.27	48.47
SPAIN	MADRID				90.99	89.96	93.41
SWEDEN	STOCKHOLM	63.68	63.70	62.12	61.95	61.35	60.25
SWITZERLAND	ZURICH	73.45	72.33	75.68	73.39	72.30	75.66
TURKEY	ISTANBUL				91.77	90.69	93.48
UKRAINE	KIEV	44.24	47.25	47.11	42.56	44.68	44.86
UNITED KINGDOM	LONDON	123.10	117.94	119.87	116.19	114.50	116.42
YUGOSLAVIA	BELGRADE	59.97	66.60	66.98	58.70	66.00	66.78
Average		53.25	39.00	43.29	64.75	63.16	64.46

Source: Airports Council International, Geneva, 1998
Note: Blanks indicate data not available

Table 3B:
Selected Statistics for Busiest City in Each European State

Country	City	Traffic Growth - Pax			Traffic Growth - Movements		
		1995/96	1996/97	1995/97	1995/96	1996/97	1995/97
AUSTRIA	VIENNA	6.96	6.54	13.95	7.70	1.08	8.86
BELGIUM	BRUSSELS	7.30	17.86	26.46	8.91	5.47	14.86
BULGARIA	SOFIA	-9.65	-0.99	-10.54	-3.59	-2.73	-6.22
CROATIA	ZAGREB	11.71	7.14	19.69	11.73	6.17	18.62
CYPRUS	LARNACA	-3.41	4.08	0.53	-1.02	2.63	1.59
CZECH REPUBLIC	PRAGUE	18.29	14.77	35.76	7.58	4.75	12.69
DENMARK	COPENHAGEN	8.05	6.16	14.70	11.98	5.08	17.67
ESTONIA	TALLINN	17.72	16.55	37.20	21.09	25.14	51.53
FINLAND	HELSINKI	7.68	10.17	18.63	7.41	12.28	20.60
FRANCE	PARIS	7.42	2.13	9.71	8.58	4.39	13.35
GERMANY	FRANKFURT/ MAIN	1.52	3.87	5.46	1.99	1.97	4.01
GREECE	ATHENS	-0.65	6.52	5.81	1.00	13.61	14.74
HUNGARY	BUDAPEST	13.91	9.20	24.40	13.28	8.61	23.02
IRELAND	DUBLIN	13.29	13.66	28.76	10.04	10.40	21.49
ITALY	ROME	8.96	8.53	18.24	13.13	4.32	18.02
LATVIA	RIGA	0.32	5.83	6.18	4.30	2.92	7.34
LITHUANIA	VILNIUS	4.19	10.89	15.53	3.23	13.75	17.43
LUXEMBOURG	LUXEMBOURG	2.18	11.93	14.37	2.94	7.18	10.32
MACEDONIA	SKOPJE	-27.52	4.35	-24.37	-29.18	5.20	-25.49
MALTA	MALTA	-2.72	7.39	4.47	-2.03	3.65	1.54
MONACO	MONACO	7.84	11.26	19.99			
NETHERLANDS	AMSTERDAM	9.62	13.58	24.51	10.70	8.61	20.22
NORWAY	OSLO						
POLAND	WARSAW	12.97	14.78	29.67	12.92	10.57	24.85
PORTUGAL	LISBON	1.60	3.60	5.26	4.69	4.97	9.89
ROMANIA	BUCHAREST	-29.71	0.11	-29.63	-37.86	10.52	-31.32
RUSSIAN FEDERATION	MOSCOW	196.24	11.09	229.08	160.89	9.00	184.36
SLOVAK REPUBLIC	BRATISLAVA	27.74	10.14	40.69	6.15	-0.56	5.55
SLOVENIA	LJUBLJANA	4.74	6.76	11.82	1.93	-17.93	-16.35
SPAIN	MADRID	9.52	7.98	18.27	10.78	4.00	15.21
SWEDEN	STOCKHOLM	4.81	7.03	12.18	5.82	9.00	15.34
SWITZERLAND	ZURICH	5.77	12.59	19.09	7.37	7.59	15.51
TURKEY	ISTANBUL	11.86	9.59	22.59	13.19	6.32	20.34
UKRAINE	KIEV	-2.09	7.42	5.17	-6.74	6.99	-0.22
UNITED KINGDOM	LONDON	6.12	7.39	13.96	7.68	5.62	13.74
YUGOSLAVIA	BELGRADE	21.99	15.81	41.28	8.49	14.46	24.18
Average		10.40	8.49	20.25	8.47	5.97	15.20

Source: Airports Council International, Geneva, 1998
Note: Blanks indicate data not available

Table 4A:
Recent Traffic Statistics for Top 40 European Airports

Rank by 1997 Movements	Rank by 1997 Pax Volume	**Country**	**City**	**Airport**	**Airport Code**	**Total Air Transport Movements '000**			**Total Passengers '000**		
						1995	**1996**	**1997**	**1995**	**1996**	**1997**
1	1	UK	LONDON	HEATHROW	LHR	418.8	426.9	429.2	54452.6	56037.8	58142.8
3	2	GERMANY	FRANKFURT/ MAIN	RHEIM/MAIN	FRA	372.6	380.0	387.5	38179.5	38761.2	40262.7
2	3	FRANCE	PARIS	CHARLES DE GAULLE	CDG	325.3	360.6	395.5	28355.5	31724.0	35293.4
4	4	NETH.	AMSTERDAM	SCHIPHOL	AMS	290.7	321.8	349.5	25355.0	27794.9	31570.0
13	5	UK	LONDON	GATWICK	LGW	192.0	211.0	229.3	22549.3	24337.4	26961.5
12	6	FRANCE	PARIS	ORLY	ORY	232.7	245.4	237.1	26653.9	27365.0	25056.3
11	7	ITALY	ROME	FIUMICINO	FCO	209.2	236.5	245.7	21091.4	23035.8	25001.0
9	8	SPAIN	MADRID	BARAJAS	MAD	219.0	242.8	252.4	19956.1	21856.7	23601.7
7	9	SWITZ.	ZURICH	ZURICH	ZRH	209.0	224.4	241.5	15340.4	16226.0	18268.5
8	10	GERMANY	MUNICH	MUNICH	MUC	201.9	211.7	246.4	14867.9	15686.1	17894.7
5	11	DENMARK	COPENHAGEN	COPENHAGEN	CPH	237.4	265.8	279.3	14678.9	15860.8	16837.1
26	12	SPAIN	PALMA DE MALLORCA	PALMA DE MALLORCA	PMI	119.9	127.3	142.8	14728.1	15377.4	16557.6
20	13	UK	MANCHESTER	MANCHESTER	MAN	148.9	143.7	148.5	14982.7	14670.4	15950.6
6	14	BELGIUM	BRUSSELS	BRUSSELS NATIONAL	BRU	221.8	241.5	254.7	12600.6	13520.9	15935.2
18	15	GERMANY	DUSSELDORF	DUSSELDORF	DUS	166.5	161.7	168.8	15146.5	14422.1	15532.1
10	16	SWEDEN	STOCKHOLM	ARLANDA	ARN	215.7	227.9	246.2	13540.4	14221.7	15197.7
14	17	SPAIN	BARCELONA	BARCELONA	BCN	152.8	177.7	208.0	11727.6	13434.7	15065.7
16	18	TURKEY	ISTANBUL	ATATURK	IST	131.6	148.9	158.3	12074.4	13506.1	14801.8
17	19	ITALY	MILAN	LINATE	LIN	132.6	156.9	165.7	10827.1	12563.4	14271.1
27	20	GREECE	ATHENS	ATHINAI	ATH	121.8	123.0	139.7	10480.8	10411.7	11090.0
22	21	IRELAND	DUBLIN	DUBLIN	DUB	110.6	121.7	134.3	8024.9	9091.3	10333.2
19	22	AUSTRIA	VIENNA	VIENNA INTL	VIE	143.2	154.3	155.9	8546.2	9140.6	9738.3
31	23	RUSSIAN FED.	MOSCOW	SHERMETYEVO	SVO		116.3	117.6		8572.5	9384.1
29	24	GERMANY	BERLIN	TEGEL	TXL	112.5	117.2	117.5	8271.8	8374.0	8731.6
21	25	GERMANY	HAMBURG	HAMBURG-F HLSBUTTEL	HAM	118.6	119.9	124.7	8201.5	8194.9	8648.8
25	26	FINLAND	HELSINKI	HELSINKI VANTAA	HEL	113.0	121.5	136.4	7140.7	7689.2	8471.2
49	27	SPAIN	GRAN CANARIA	GRAN CANARIA	LPA	76.8	76.3	78.9	7877.3	7890.7	8160.5
85	28	SPAIN	TENERIFE SUR	TENERIFE SUR	TFS	52.1	51.8	52.8	7398.5	7293.8	7580.8
15	29	FRANCE	NICE	NICE-COTE D'AZUR	NCE	122.6	141.5	173.7	6142.9	6604.0	7373.0
56	30	SPAIN	MALAGA	MALAGA	AGP	55.7	59.5	65.1	6311.5	6652.6	7270.2
28	31	GERMANY	STUTTGART	STUTTGART	STR	85.3	96.2	95.3	5158.5	6515.2	6910.3
46	32	PORTUGAL	LISBON	LISBON	LIS	69.9	73.1	76.8	6476.6	6580.1	6817.1
86	33	TURKEY	ANTALYA	ANTALYA	AYT	39.8	44.9	49.0	4727.7	5592.9	6687.6
23	34	SWITZ.	GENEVA	AEROPORT INTL DE GENEVE	GVA	99.2	102.1	100.6	6207.8	6118.3	6117.8
40	35	UK	GLASGOW	GLASGOW	GLA	74.9	75.6	80.1	5528.6	5591.9	6115.8
37	36	UK	BIRMINGHAM	BIRMINGHAM INTL	BHX	75.0	77.4	80.5	5333.4	5472.0	6030.2
30	37	FRANCE	MARSEILLE	MARSEILLE PROVENCE	MRS	72.4	79.4	86.9	5106.6	5401.4	5473.6
35	38	UK	LONDON	STANSTED	STN	66.1	77.5	84.4	3920.3	4865.1	5426.7
24	39	GERMANY	COLOGNE	COLOGNE BONN	CGN	111.4	120.2	136.2	4740.1	5227.0	5308.7
38	40	FRANCE	LYON	SATOLAS	LYS	75.5	85.3	94.1	4432.6	4967.1	4944.5

Table 4B:
Recent Traffic Statistics for Top 40 European Airports

Rank by 1997 Pax. Volume	Country	Airport	Airport Code	**Total Freight '000**			**Percentage Int'l Pax**			**Percentage Transit Pax**	
				1995	**1996**	**1997**	**1995**	**1996**	**1997**	**1995**	**1997**
1	UK	HEATHROW	LHR	1125.6	1140.8	1260.1	85.96	86.12	86.96	0.63	0.57
2	GERMANY	RHEIM/MAIN	FRA	1461.3	1497.2	1514.3	79.25	80.02	80.52	1.84	1.44
3	FRANCE	CHARLES DE GAULLE	CDG	929.0	979.0	1072.2	90.05	90.36	89.39	1.27	0.54
4	NETH.	SCHIPHOL	AMS	1019.3	1124.7	1207.3	97.45	97.46	97.66	1.97	1.74
5	UK	GATWICK	LGW	245.9	294.0	287.4	91.36	90.52	90.44	0.73	0.61
6	FRANCE	ORLY	ORY	291.2	262.3	237.2	41.43	38.70	37.74	0.28	0.13
7	ITALY	FIUMICINO	FCO	291.3	300.1	288.2	56.11	54.15	53.25	1.82	1.47
8	SPAIN	BARAJAS	MAD	253.6	267.7	282.4	47.63	46.77	46.68	1.43	2.03
9	SWITZERL AND	ZURICH	ZRH	344.0	340.1	355.3	91.00	91.14	91.67	2.75	2.18
10	GERMANY	MUNICH	MUC	100.2	110.9	123.5	59.88	61.63	61.83	1.66	1.50
11	DENMARK	COPENHAGEN	CPH		338.0	387.7	79.24	80.05	82.23	2.43	1.37
12	SPAIN	PALMA DE MALLORCA	PMI	19.1	21.1	24.9	74.48	73.73	74.23	0.61	0.65
13	UK	MANCHESTER	MAN	54.7	83.8	99.0	80.66	82.46	83.67	2.98	1.46
14	BELGIUM	BRUSSELS NATIONAL	BRU	441.3	464.0	530.7	99.22	98.79	99.24	0.77	0.74
15	GERMANY	DUSSELDORF	DUS	62.1	62.9	71.4	72.95	73.41	73.90	0.89	0.80
16	SWEDEN	ARLANDA	ARN	130.1	145.0	146.1	56.96	58.65	60.68	1.86	1.61
17	SPAIN	BARCELONA	BCN	74.6	86.0	85.4	38.91	39.87	41.56	3.53	3.34
18	TURKEY	ATATURK	IST	139.3	140.3	178.7	67.26	68.53	66.40	1.24	1.31
19	ITALY	LINATE	LIN	79.0	78.1	75.6	56.79	54.90	53.80	1.09	0.06
20	GREECE	ATHINAI	ATH	104.1	84.3	119.9	63.92	63.66	61.55	2.26	0.00
21	IRELAND	DUBLIN	DUB	66.6	74.2	92.0	94.07	94.11	94.32	0.52	0.95
22	AUSTRIA	VIENNA INTL	VIE	98.6	101.6	113.7	93.76	93.80	94.60	2.04	1.46
23	RUSSIAN FED.	SHERMETYEVO	SVO		77.8	79.3		76.74	76.07		1.73
24	GERMANY	TEGEL	TXL	33.4	36.3	37.1	38.67	41.24	41.37	1.03	1.25
25	GERMANY	HAMBURG F LSBUTTEL	HAM	59.6	57.3	53.8	57.76	58.20	57.59	1.11	1.19
26	FINLAND	HELSINKI VANTAA	HEL	91.3	97.2	99.2	65.33	65.16	63.63	8.70	9.36
27	SPAIN	GRAN CANARIA	LPA	37.6	40.6	43.8	66.06	66.12	67.14	3.23	2.87
28	SPAIN	TENERIFE SUR	TFS	11.1	12.0	11.6	81.37	81.97	83.22	2.26	1.88
29	FRANCE	NICE-COTE D'AZUR	NCE	26.7	26.9	27.4	36.76	36.18	39.60	1.22	0.91
30	SPAIN	MALAGA	AGP	7.5	7.4	8.4	72.57	71.85	71.94	0.98	1.09
31	GERMANY	STUTTGART	STR	31.3	35.6	34.1	60.78	65.04	64.81	1.46	2.39
32	PORTUGAL	LISBON	LIS	99.2	100.7	110.6	77.07	77.58	78.16	3.60	2.72
33	TURKEY	ANTALYA	AYT	3.8	3.7	3.3	87.43	88.60	89.21		
34	SWITZ.	AEROPORT INTL DE GENEVE	GVA	78.1	72.8	73.6	82.70	82.71	82.82	3.17	2.00
35	UNITED KINGDOM	GLASGOW	GLA	17.0	15.7	14.8	50.54	47.84	46.90	1.92	1.70
36	UNITED KINGDOM	BIRMINGHAM INTL	BHX	22.6	21.0	21.4	79.79	80.17	80.37	2.53	2.01
37	FRANCE	MARSEILLE PROVENCE	MRS	61.0	64.3	58.6	27.87	27.87	28.09	4.55	2.51
38	UNITED KINGDOM	STANSTED	STN	102.3	116.9	141.8	78.47	77.34	77.52	0.77	1.11
39	GERMANY	COLOGNE BONN	CGN	308.1	344.2	398.5	50.22	53.24	51.53	1.55	1.37
40	FRANCE	SATOLAS	LYS	32.5	35.0	38.2	49.09	50.12	51.27	3.19	2.54

Table 5A:
Selected Statistics for Top 40 European Airports

Country	City	Airport	Airport Code	Avg Pax per Pax/Combi Movement			Avg Pax per Total Movements		
				1995	1996	1997	1995	1996	1997
UK	LONDON	HEATHROW	LHR	131.13	132.42	136.61	130.02	131.28	135.47
GERMANY	FRANKFURT/ MAIN	RHEIM/MAIN	FRA	108.32			102.47	102.00	103.90
FRANCE	PARIS	CHARLES DE GAULLE	CDG	93.63	94.73	96.46	87.16	87.98	89.24
NETH.	AMSTERDAM	SCHIPHOL	AMS	90.80	90.00	93.83	87.22	86.38	90.34
UK	LONDON	GATWICK	LGW	120.65	118.29	119.85	117.44	115.33	117.57
FRANCE	PARIS	ORLY	ORY	115.91	112.25	106.43	114.52	111.53	105.69
ITALY	ROME	FIUMICINO	FCO	105.01			100.80	97.40	101.74
SPAIN	MADRID	BARAJAS	MAD				91.11	90.02	93.50
SWITZ.	ZURICH	ZURICH	ZRH	73.45	72.33	75.68	73.39	72.30	75.66
GERMANY	MUNICH	MUNICH	MUC	74.64	75.20	73.71	73.64	74.09	72.61
DENMARK	COPENHAGEN	COPENHAGEN	CPH	65.52	62.97	63.66	61.84	59.67	60.28
SPAIN	PALMA DE MALLORCA	PALMA DE MALLORCA	PMI				122.79	120.83	115.93
UK	MANCHESTER	MANCHESTER	MAN				100.62	102.11	107.41
BELGIUM	BRUSSELS	BRUSSELS NATIONAL	BRU	62.66	61.79	69.75	56.82	55.98	62.56
GERMANY	DUSSELDORF	DUSSELDORF	DUS	91.74	89.99	92.45	90.98	89.18	92.00
SWEDEN	STOCKHOLM	ARLANDA	ARN	64.66	64.98	63.81	62.76	62.41	61.72
SPAIN	BARCELONA	BARCELONA	BCN				76.73	75.61	72.43
TURKEY	ISTANBUL	ATATURK	IST				91.77	90.69	93.48
ITALY	MILAN	LINATE	LIN	82.48	80.49	86.48	81.65	80.07	86.11
GREECE	ATHENS	ATHINAI	ATH				86.06	84.65	79.36
IRELAND	DUBLIN	DUBLIN	DUB	79.79			72.58	74.72	76.93
AUSTRIA	VIENNA	VIENNA INTL	VIE	60.60	60.12	63.76	59.67	59.25	62.45
RUSSIAN FED.	MOSCOW	SHERMETYEVO	SVO		75.14	81.07		73.68	79.77
GERMANY	BERLIN	TEGEL	TXL	74.38	72.02	75.07	73.51	71.42	74.31
GERMANY	HAMBURG	HAMBURG-FHLSBUTTEL	HAM	70.04	69.23	70.28	69.13	68.35	69.33
FINLAND	HELSINKI	HELSINKI VANTAA	HEL				63.18	63.27	62.12
SPAIN	GRAN CANARIA	GRAN CANARIA	LPA				102.59	103.47	103.47
SPAIN	TENERIFE SUR	TENERIFE SUR	TFS				142.13	140.74	143.45
FRANCE	NICE	NICE-COTE D'AZUR	NCE	50.97	47.44	43.15	50.12	46.67	42.46
SPAIN	MALAGA	MALAGA	AGP				113.40	111.88	111.61
GERMANY	STUTTGART	STUTTGART	STR	62.00	69.64	74.73	60.49	67.71	72.53
PORTUGAL	LISBON	LISBON	LIS	94.20	90.88	89.59	92.70	89.96	88.79
TURKEY	ANTALYA	ANTALYA	AYT				118.67	124.60	136.43
SWITZ.	GENEVA	AEROPORT INTL DE GENEVE	GVA	63.27	60.74	62.22	62.60	59.90	60.83
UK	GLASGOW	GLASGOW	GLA	75.76	75.48	77.63	73.85	73.92	76.38
UK	BIRMINGHAM	BIRMINGHAM INTL	BHX	72.37	71.90	75.81	71.08	70.66	74.89
FRANCE	MARSEILLE	MARSEILLE PROVENCE	MRS	78.15			70.52	67.99	62.96
UK	LONDON	STANSTED	STN	69.44	71.67	73.76	59.34	62.76	64.28
GERMANY	COLOGNE	COLOGNE BONN	CGN	58.12	58.97	52.92	42.56	43.48	38.98
FRANCE	LYON	SATOLAS	LYS	64.38	64.47	58.49	58.71	58.22	52.53

Table 5B:
Selected Statistics for Top 40 European Airports

Country	City	Airport	Airport Code	Traffic Growth - Pax			Traffic Growth - Movements			Percentage All-Cargo Movements		
				1995/96	1996/97	1995/97	1995/96	1996/97	1995/97	1995	1996	1997
UK	LONDON	HEATHROW	LHR	2.91	3.76	6.78	1.92	0.54	2.48	0.84	0.86	0.83
GERMANY	FRANKFURT/ MAIN	RHEIM/MAIN	FRA	1.52	3.87	5.46	1.99	1.97	4.01	5.40	0.00	0.00
FRANCE	PARIS	CHARLES DE GAULLE	CDG	11.88	11.25	24.47	10.84	9.68	21.57	6.91	7.13	7.48
NETH.	AMSTERDAM	SCHIPHOL	AMS	9.62	13.58	24.51	10.70	8.61	20.22	3.94	4.02	3.73
UK	LONDON	GATWICK	LGW	7.93	10.78	19.57	9.90	8.67	19.43	2.66	2.50	1.90
FRANCE	PARIS	ORLY	ORY	2.67	-8.44	-5.99	5.42	-3.37	1.86	1.20	0.64	0.69
ITALY	ROME	FIUMICINO	FCO	9.22	8.53	18.54	13.03	3.90	17.44	4.01	0.00	0.00
SPAIN	MADRID	BARAJAS	MAD	9.52	7.98	18.27	10.84	3.97	15.24	0.00	0.00	0.00
SWITZ.	ZURICH	ZURICH	ZRH	5.77	12.59	19.09	7.37	7.59	15.51	0.08	0.04	0.03
GERMANY	MUNICH	MUNICH	MUC	5.50	14.08	20.36	4.87	16.40	22.06	1.34	1.48	1.48
DENMARK	COPENHAGEN	COPENHAGEN	CPH	8.05	6.16	14.70	11.98	5.08	17.67	5.61	5.24	5.31
SPAIN	PALMA DE MALLORCA	PALMA DE MALLORCA	PMI	4.41	7.67	12.42	6.10	12.23	19.08	0.00	0.00	0.00
UK	MANCHESTER	MANCHESTER	MAN	-2.08	8.73	6.46	-3.51	3.37	-0.26	0.00	0.00	0.00
BELGIUM	BRUSSELS	BRUSSELS NATIONAL	BRU	7.30	17.86	26.46	8.91	5.47	14.86	9.31	9.40	10.30
GERMANY	DUSSELDORF	DUSSELDORF	DUS	-4.78	7.70	2.55	-2.86	4.39	1.41	0.82	0.90	0.48
SWEDEN	STOCKHOLM	ARLANDA	ARN	5.03	6.86	12.24	5.63	8.06	14.14	2.93	3.96	3.28
SPAIN	BARCELONA	BARCELONA	BCN	14.56	12.14	28.46	16.25	17.07	36.10	0.00	0.00	0.00
TURKEY	ISTANBUL	ATATURK	IST	11.86	9.59	22.59	13.19	6.32	20.34	0.00	0.00	0.00
ITALY	MILAN	LINATE	LIN	16.04	13.59	31.81	18.32	5.64	24.99	1.01	0.51	0.43
GREECE	ATHENS	ATHINAI	ATH	-0.65	6.52	5.81	1.00	13.61	14.74	0.00	0.00	0.00
IRELAND	DUBLIN	DUBLIN	DUB	13.29	13.66	28.76	10.04	10.40	21.49	9.04	0.00	0.00
AUSTRIA	VIENNA	VIENNA INTL	VIE	6.96	6.54	13.95	7.70	1.08	8.86	1.54	1.45	2.05
RUSSIAN FED.	MOSCOW	SHERMETYEVO	SVO		9.47			1.11			1.93	1.60
GERMANY	BERLIN	TEGEL	TXL	1.23	4.27	5.56	4.20	0.21	4.43	1.16	0.83	1.01
GERMANY	HAMBURG	HAMBURG-F LSBUTTEL	HAM	-0.08	5.54	5.45	1.06	4.04	5.14	1.30	1.27	1.35
FINLAND	HELSINKI	HELSINKI VANTAA	HEL	7.68	10.17	18.63	7.53	12.20	20.65	0.00	0.00	0.00
SPAIN	GRAN CANARIA	GRAN CANARIA	LPA	0.17	3.42	3.60	-0.67	3.41	2.71	0.00	0.00	0.00
SPAIN	TENERIFE SUR	TENERIFE SUR	TFS	-1.41	3.93	2.46	-0.44	1.97	1.52	0.00	0.00	0.00
FRANCE	NICE	NICE-COTE D'AZUR	NCE	7.51	11.64	20.02	15.44	22.74	41.68	1.68	1.61	1.61
SPAIN	MALAGA	MALAGA	AGP	5.40	9.28	15.19	6.84	9.55	17.04	0.00	0.00	0.00
GERMANY	STUTTGART	STUTTGART	STR	26.30	6.06	33.96	12.82	-0.98	11.71	2.44	2.76	2.94
PORTUGAL	LISBON	LISBON	LIS	1.60	3.60	5.26	4.69	4.97	9.89	1.60	1.01	0.90
TURKEY	ANTALYA	ANTALYA	AYT	18.30	19.57	41.46	12.67	9.20	23.04	0.00	0.00	0.00
SWITZ.	GENEVA	AEROPORT INTL DE GENEVE	GVA	-1.44	-0.00	-1.45	3.00	-1.53	1.42	1.06	1.39	2.24
UK	GLASGOW	GLASGOW	GLA	1.14	9.37	10.62	1.05	5.84	6.95	2.53	2.06	1.60
UK	BIRMINGHA M	BIRMINGHA M INTL	BHX	2.60	10.20	13.07	3.22	3.98	7.32	1.79	1.73	1.22
FRANCE	MARSEILLE	MARSEILLE PROVENCE	MRS	5.77	1.34	7.19	9.71	9.42	20.05	9.77	0.00	0.00
UK	LONDON	STANSTED	STN	24.10	11.54	38.43	17.32	8.91	27.78	14.55	12.42	12.85
GERMANY	COLOGNE	COLOGNE BONN	CGN	10.27	1.56	11.99	7.95	13.28	22.29	26.76	26.26	26.34
FRANCE	LYON	SATOLAS	LYS	12.06	-0.45	11.55	13.01	10.32	24.66	8.81	9.70	10.18

Table 6
Simple Correlations Between Variables Using Combined ACI And CODA Air Traffic Statistics

	%Change in Pax Volume 95-97	Avg Pax per Movement, 1997	Total delay per Movement, 1997	Total delay in Minutes, 1997	Avg % delayed flights	% Change in Movements, 95-97	% Change in Movements, 95-96	%Change in Movements 96-97	Total Pax, 1997	Total Air Transport Movements, 1997	Total Flights	Total Delayed Flights	Total Delayed Movements
%Change in Pax Volume 95-97	1.000												
Avg Pax per Movement, 1997	-0.060	1.000											
Total delay per Movement, 1997	-0.160	0.050	1.000										
Total delay in Minutes, 1997	-0.013	0.370	0.205	1.000									
Avg % delayed flights	-0.103	0.160	0.385	0.735	1.000								
% Change in Movements, 95-97	0.154	-0.373	-0.188	-0.323	-0.138	1.000							
% Change in Movements, 95-96	0.145	-0.360	-0.185	-0.084	-0.161	0.964	1.000						
%Change in Movements 96-97	0.614	-0.143	-0.160	-0.098	0.020	0.392	0.253	1.000					
Total Pax, 1997	-0.111	0.593	-0.057	0.820	0.330	-0.149	-0.144	-0.205	1.000				
Total Air Transport Movements, 1997	-0.056	0.350	-0.099	0.305	0.366	-0.004	-0.015	-0.116	0.932	1.000			
Total Flights	-0.019	0.375	0.024	0.863	0.392	0.008	0.007	-0.125	0.928	0.986	1.000		
Total Delayed Flights	0.001	0.406	0.147	0.951	0.635	-0.076	-0.082	-0.073	0.853	0.840	0.856	1.000	
Total Delayed Movements	0.001	0.407	0.171	0.960	0.643	-0.084	-0.090	-0.043	0.847	0.828	0.840	0.856	1.000

Table 7:
Passenger Transport, 1994: Air Traffic between EU Countries (Million passengers)

	Reporting Country (From:)														
To:	B	D	DK	E	F	GR	I	IRL	L	NL	P	UK	A	FIN	S	EU15
B		0.91	0.26	1.69	0.91	0.48	0.86	0.13	0.04	0.26	0.33	1.75	0.16	0.10	0.22	8.10
D	0.91		1.01	**12.50**	3.12	**4.83**	3.08	0.36	0.15	1.59	1.38	**6.16**	1.68	0.47	0.60	37.84
DK	0.23	0.99		0.56	0.53	0.52	0.38	0.02	0.02	0.34	0.09	1.18	0.16	0.30	1.63	6.98
E	1.70	**12.61**	0.74		2.97	0.22	2.74	0.51	0.22	1.94	0.69	**17.31**	0.63	0.40	1.00	43.68
F	0.94	3.34	0.54	3.27		1.10	**3.65**	0.44	0.08	1.24	1.20	**7.45**	0.46	0.19	0.43	24.33
GR	0.47	**5.28**	0.59	0.19	1.04		1.26	0.07	0.04	1.01	0.02	**4.92**	0.75	0.23	0.74	16.61
I	0.83	3.02	0.37	2.72	**3.39**	1.30		0.14	0.05	0.90	0.35	**4.03**	0.35	0.08	0.16	17.69
IRL	0.11	0.36	0.08	0.52	0.44	0.08	0.14		0.00	0.16	0.11	**4.98**	0.03	0.00	0.01	7.02
L	0.04	0.16	0.02	0.21	0.11	0.04	0.05	0.02		0.05	0.06	0.16	0.00	0.00	0.00	0.92
NL	0.31	1.60	0.39	1.96	1.16	1.03	0.94	0.15	0.04		0.53	**4.03**	0.31	0.14	0.48	13.07
P	0.31	1.26	0.05	0.63	1.16	0.03	0.38	0.11	0.06	0.53		2.45	0.06	0.03	0.09	7.16
UK	1.88	**6.26**	1.28	**17.65**	**7.26**	**4.96**	**4.19**	**5.12**	0.16	**4.01**	2.69		1.14	0.42	1.12	58.14
A	0.16	1.71	0.17	0.64	0.44	0.77	0.37	0.03	0.01	0.31	0.08	1.14		0.05	0.13	6.01
FIN	0.10	0.47	0.30	0.40	0.19	0.23	0.08	0.00	0.00	0.14	0.03	0.42	0.05		0.73	3.14
S	0.22	0.51	1.26	0.78	0.34	0.42	1.09	0.06	0.00	0.43	0.08	0.64	0.10	0.73		6.66

Note: The 20 most important flows are highlighted with bold typeface.
Source: Eurostat (1997) EU Transport Statistics in Figures, 2nd Edition, Table 5.5

2.3 Options for improving management and organisation of existing Capacity

2.3.1. Pricing or Charging Policies

2.3.1.1. Optimal Pricing for Regulated Monopoly and public utilities:

The basic economic principles of marginal cost pricing suggest that welfare is maximised where prices are set equal to long run marginal cost. As with economies of scale, under economies of scope, price will be below average costs with this marginal cost pricing prescription. As Kahn (1988) points out, the traditional legal criteria of proper public utility rates have always borne a strong resemblance to the criteria of the competitive market in long run equilibrium. The principal benchmark for 'just and reasonable' rate levels has been the cost of producing including the necessary return on capital. The rule that individual rates not be unduly discriminatory has similarly been defined in terms of the respective costs of the various services. However, it is short run marginal cost to which price should be equated because it is the short run marginal cost which reflects the social opportunity cost of providing the additional unit that buyers are at any time trying to decide to buy. Marginal costs look to the future not the past since it is only future costs that can be saved if production is not undertaken. In the presence of competition, it is long run and not short run costs, which should set the floor. If capital costs are to be included in price, then it should be clear that those capital costs are those that will have to be covered over time in the future if service is to continue to be rendered.

The issue then arises as to whether all users should pay the price, which includes the capacity costs. Kahn argues that the off-peak users should not pay these costs since they do not impose these costs on society once their demand is sufficiently slight and inelastic that even at a zero cost, no congestion occurs at the time when they use the facility. The customers impose the necessity for expansion at the peak hours. If the same type of capacity serves all users, capacity costs should be levied only on utilisation at the peak. This peak responsibility pricing is not discriminatory between peak and off-peak users (that (discrimination) implies that the price differences are not based on cost differences), rather it reflects the fact that there is a genuine increase in the costs of supplying users at the peak compared with the off-peak. The proposal then is to reflect the cost difference in respective prices.
When infrastructure capacity or plant is built far in advance of total need (because for example of economies of scale), charging depreciation in equal instalments imposes a disproportionately heavy burden on customers in earlier years, when much of the capacity lies idle. This idle capacity is of benefit to future not present customers. Economic efficiency suggests concentrating capital charges in the later years.

Finally, in situations of economies of scale or scope, where price set equal to marginal cost will yield a loss, Ramsey prices eliminate the deficit while minimising the loss in welfare that results. Ramsey prices maximise social welfare but also require revenues to cover costs: the resulting prices achieve as great a level of social welfare as possible in the presence of realities that prevent the use of marginal cost prices.

The options for dealing with this infrastructural constraint are

- Expand capacity at existing airports
- Build new airports
- Utilise demand management techniques to better allocate capacity

Demand management techniques can be either administrative, where an executive body make decisions or involve pricing techniques, whereby operators make choices on the basis of their willingness to pay. Table 8 summarises the literature on runway congestion management techniques, under these two headings and presents the advantages and disadvantages associated with both sets of approaches.

Table 8: Advantages and Disadvantages of Approaches to Runway Congestion Management

Technique	Option	Advantages	Disadvantages
Administrative Techniques	Restrictions of aircraft operations (quotas and bans)	*Quotas*: · Simple method; attractive to airport authorities *Bans & quotas:* · Prompt & direct means · Can meet variety of objectives (efficiency; social; environmental; regional development) · Effective at controlling peak period traffic	· May not result in economically efficient allocation · Mix of categories may not be efficient or reasonable · May require constant monitoring and revision
	Allocation of access rights by airline scheduling committee	· Encourage certainty in airline route planning · Encourages continuity of scheduled service	· May be anti-competitive, biasing slots towards incumbents · Reduces contestability of industry · May make inefficient allocations · Less workable as gap between demand and supply increases
	Allocation of slots by lottery or partial allocation	· Unbiased allocation mechanism · May promote competition by allocation to new entrants	· Difficult to build schedule on random allocation · May not be sufficient to develop network schedules · May not be efficient allocation · May provide windfall gains to operators
Pricing or Market based Techniques	Peak period pricing	· Straight forward to administer · Access open to all potential operators based on willingness to pay · Helps remove or reorient low value operators to uncongested facilities - non-discriminatory · Revenue raised may be used for expansion	· May still require administrative strategy during peak period · Determination of appropriate MSC prices is impossible - prices determined based on demand suppression effect · Charges continually vary upwards based on increasing demand · Low cross-elasticity of demand between peak and off-peak: may be difficult to spread the peak period · Inequitable system favouring large higher revenue airlines
	Auctioning airport slots	· If prices is the sole means of allocation, will establish true market value of slots · Increase contestability of industry - open to all operators	· Bidders may lack adequate information on value of slots · Auction format may significantly influence success or failure of process · Long term implications of selling access rights to airport users need to be fully appreciated

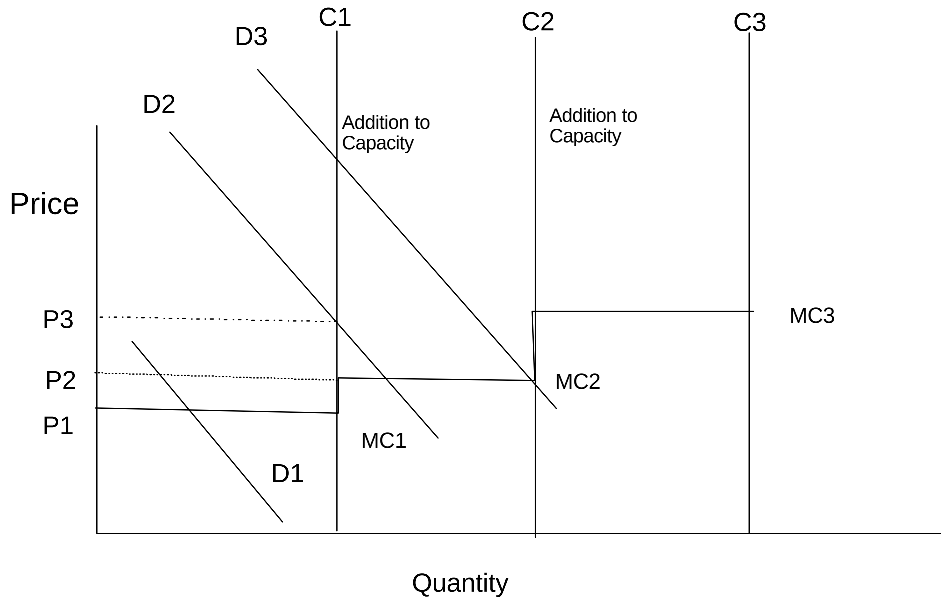
Sources: BTCE (1996); Hamzawi (1992); Doganis (1992); Swoveland (1980); Morrison (1987); Fawcett and Fawcett (1988); Brander, Cook and Rowcroft (1989); Mills (1990); Reed (1992); CAA UK (1993); Fisher (1989); Kearney and Favotto(1993); Balinski and Sand (1985).

2.4. Issues in expanding capacity

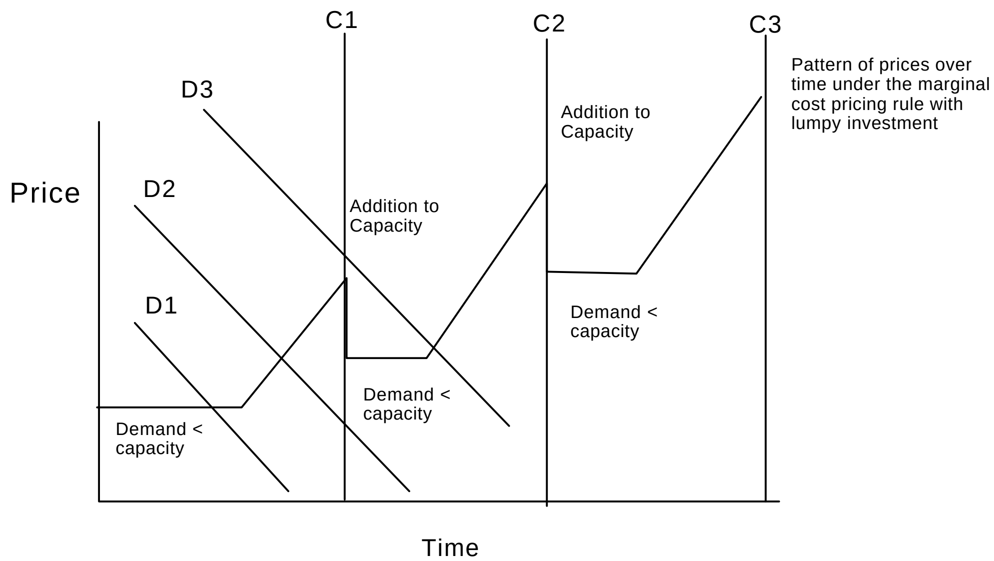
In the economics literature on the relationship between marginal cost pricing and investment, Vickrey (1971) suggested a pattern of pricing over time when investment is lumpy. This pattern is illustrated in Figure 5b. In the first part of the figure (a), demand is increasing over time. When demand grows from D_1 to D_2, in the short run, the marginal cost price rises from P_1 to P_2. As new capacity is added, and demand continues to grow, prices fall to P_3. The increase in price prior to the expansion of capacity rations the capacity at its initial supply level. The pattern continues over time as illustrated, with short-term increases in price when each successive level of capacity is reached. With additional capacity being added the price reduces to the level of the marginal cost. Vickrey's pricing pattern is somewhat different: as demand grows, price should rise for a period before the new capacity is available. The increase in price should be sufficient to curtail demand to the existing level of capacity. When the new capacity comes on stream, the price should drop sharply to the point where the new capacity is fully utilised. Once again the price should increase as demand grows so as to keep consumption within the limits of the available capacity.

Issues arise regarding who should pay the higher short run charges as demand increases and also which costs are fixed and which are variable in this scenario. Some of these issues were mentioned in the previous subsection. Small, Winston and Evans (1989) provide a detailed analysis of the application of such a pricing and investment policy to the management of road infrastructure, given different categories of road users, differing levels of deterioration in existing pavements, and differing levels of investment requirements for new and existing facilities. They also suggest a simplified policy application, given the likely public and government reaction to constantly changing prices.

Small et al suggest two sets of charges. The first are road wear charges and the second congestion charges. The road wear charges suggested would encourage firms to use less damaging vehicles and use roads most suited to heavy trucks. The charges would ideally be applied to all categories of heavy vehicle whether publicly or privately owned. The proposed congestion charges would replace replace traffic management measures and should be determined on the basis of their impact on specific sections as well as on competing sections.



(a)



(b)

Figure 5: Marginal Cost Pricing With Shifting Capacity And Increasing Demand

In relating these discussions to airports, airport charges and investment in infrastructure, we highlight the difficulties associated with implementing such a pricing and investment policy in airport facility management and point to several bottlenecks or constraints, which need further study and analysis.

For airports, which have the facility to expand capacity, the funding for this capacity and planning regulation are the key issues, which need to be addressed. The decision regarding the expansion of capacity is a public decision involving planners, residents and other interested groups. This process has become increasingly more involved as environmental regulations particularly have become a far more prominent issue in the public consultation process. The extent to which hearings and inquiries may delay, slow down or halt the process of expansion needs to be addressed from a policy point of view since the uncertainty about the form of the ultimate decision has significant cost and route planning implications for airport users.

The timing of investment decisions should be closely linked with an airport's pricing policy. The greater the degree of uncertainty in the timing of new capacity, the more difficult will be an appropriate pricing and management policy. The EU's framework for an airport charging policy (CEC, 1995) was slow to be negotiated and in draft form demanded transparency and non-discrimination in the application of charges to operators. The directive also allows for willingness-to-pay and Ramsey pricing mechanisms, which by their nature are discriminatory. Further, the directive permits the charges to be related to the airports overall costs or indeed to a regional system of airports' overall costs (these and other issues are discussed in detail in Reynolds-Feighan and Feighan (1997)). Unfortunately this 'bundling' of services creates problems when trying to relate charges for particular services to their costs: the pricing signals become obscured.

The airline industry in some parts of Europe has experienced the growth in new products initiated by low cost scheduled operators, who have been to the fore in driving change in the regions in which they operate. These low cost carriers have played and will play an important role in bringing about changes to the European air transport sector. The needs of these carriers must be considered by policy makers when planning infrastructure developments. The low cost carriers have tended to focus their operations on under-utilised secondary airports close to the key European metropolitan areas (for example, Ryanair the Irish carrier have focused its services around Paris-Beauvais, Brussels – Charleroi and London – Stansted and Luton airports). This will clearly impact on the interoperability of the air transport system.

It is important from a policy perspective to examine the management and traffic distribution in Europe from a system perspective and deal with issues of strategic infrastructure planning from this 'network' point of view. For airports which do not have the ability to expand, because of land constraints or planning regulations, the issue of long term rationing of their fixed capacity and the diversion of traffics needs to be addressed from this viewpoint. The issue of re-distributing traffic is contentious but critically linked to the role and level of investment funding for airports. The issue will need to be addressed in order to enable changes in the economic regulation of airlines to have their full effect. We are suggesting on one hand that individual services be costed as precisely as possible, but that these specific items be viewed as part of a network or system of facilities. For example, in allocating European airport runway slots, consideration would need to be given to pavement damage and congestion effects of particular categories of users at individual facilities. These charges then have to be considered in the context of their impacts on other airports in the network, and the possibilities for expansion.

There are legal constraints associated with introducing congestion taxes and then using the revenues to provide capacity elsewhere in the system (because it may not be possible to expand capacity at an existing congested facility). Analysis of traffic flow effects and the possible future air carrier network configurations will need to be explored in the theoretical literature so that the likely effects on traffic patterns and carrier networks may be analysed.

2.5. Implications for interoperability

It is clear from the data presented in earlier sections that while Europe may have sufficient airport infrastructure overall, that capacity is often in the wrong place, with congestion levels growing at the key hub centres. The expansion of capacity is not a straight forward process even if there is land available for further development at existing airports. Environmental regulations particularly and issues related to funding of investment can have a significant impact on the timing and final outcome in the expansion of infrastructure. Air transport has always been a component in multi-modal journeys for passengers and freight. Passengers need to get to and from airports as does freight so the issue of airport access is an integral part of airport planning and development.

The main factor that may prevent enhancement of the interoperability of the aviation sector is once again the infrastructure constraints and associated delays at airports. Most of the large airports in Europe now have or have planned substantial rail stations at the airports, with direct links to regional and metropolitan centres. Several airports have sought to integrate high speed rail interchanges at the airports. These kinds of developments will help to boost air traffic growth, which is forecast to continue growing at rates of 5-6% for passenger and freight services for the next 15 years.

One option is the development of secondary airports in Europe. We have already discussed developments at this category of airport by low cost operators. The larger airports will increasingly substitute long haul services for short haul services, since this will allow for increases in passenger numbers without an accompanying increase in movements. The problem is that all airports rely on the combination of locally originating and transfer passengers to support their air services. So the feasibility of separating out point-to-point traffic and concentrating it at secondary airports is questionable.

The evidence from the US suggests that deregulation allowed for significant growth in air traffic and carriers initially serviced the increased demand through interactive multiple hub network systems. Point-to-point operators at a certain stage can then enter certain markets where it is possible because of the increased volume to offer direct service. The viability of secondary airports in Europe will depend on the extent of traffic growth, the extent of competition from other surface transport modes and the characteristics of the traffic, particularly the extent of high yield business traffic. These airports will need to offer a certain threshold level of service on routes served since passengers will choose more frequent service (at primary airports) over less frequent service.

The planning and funding of infrastructure for Europe's network of airports, which are increasingly becoming multi-modal hubs, requires careful collection and collation of data monitoring traffic characteristics and pricing information. Data for the EU air transport sector is not routinely made avaiable and is not consistent in what it records. In planning for the enhancement of each mode of transport in order to improve its interoperability, the collection of detailed accurate and comprehensive information on the sector must be prioritised.

3 Conclusions

This paper has focused on the capacity of the European air transport sector and the measurement of factors influencing its supply of services. In the first section of the paper, it was argued that the airport is in fact a multi-service network of activities, many of which are not specifically related to aeronautical uses. This has implications for the pricing or costing of the aeronautical activities, since the issue of cross-subsidisation or cross-crediting of revenues is an important one in Europe. We argued that airport infrastructure services, such as runway use, passenger terminal use etc, should be costed separately in order to allow the pricing mechanism to correctly signal when expansion or rationing is required.

The next section of the paper dealt with the definition and measurement of airport capacity. 'Capacity' refers to the ability of a component in the airport system to handle aircraft and is usually expressed in terms of operations per hour (arrivals or departures). This hourly capacity is the maximum number of operations that can be handled in a one-hour period under specific operating conditions, in particular, ceiling and visibility, air traffic control, the aircraft mix and the nature of operations. Capacity is therefore a measure of supply. Each of these factors was examined in turn in a general manner.

The issue of airport delays was then focused and comprehensive data were presented illustrating the current distribution of traffic in 'greater Europe' and the causes and levels of delay at the busier airports. It was shown that there were relatively high levels of delay in Europe during the late 1980s, with improvements up until 1994. There has been a gradual rise in delays at departure airports since then. In 1996, air traffic flow management over Europe was centralised within Eurocontrol, which the AEA report resulted in a wider distribution of delay. This helped to alleviate delays in the worst affected sectors but introduced delays in sectors, which had previously operated, with minimal delay. Data from EUROCONTROL's Centre for delay analysis became available for the first time in 1998 for the year 1997. These data were analysed in conjunction with the Airport Council International's traffic data in order to identify trends in the pattern of delays and the most penalised airports. It was concluded that traffic *levels* have the greatest association with overall delay (i.e. departure plus arrival delays). There is no statistical association between traffic growth rates and average delay per movement. The simple correlation between total delay and average passenger/movement is 0.37. So the congested airports which experience the greatest delays can allow increases in their passenger throughput by encouraging the utilisation of larger aircraft.

The options available to policy makers to improve the management and organisation of existing capacity were set out and critically discussed in the next section. Tables giving the advantages and disadvantages of different demand management policies and procedures were presented, thus summarising the extensive literature in this area. The general thrust of this paper has been to argue for better use of market-based management and investment strategies. These was elaborated in Section 2.4, where several issues arising in relation to the expansion of capacity were highlighted. It was suggested that an airport system-wide approach to traffic management and investment would need to be considered as several of Europe's larger and more congested airports would not be in a position to expand capacity and the appropriate pricing would seek to reallocate certain traffics. At the same time it was argued that it was important to cost or price specific services independently, since this would allow the pricing mechanism to signal optimal timing and location of new capacity.

In the final section of the paper, the implications of these approaches and problems for interoperability were sketched out. The key point made was that greater integration of different transport modes while enhancing users accessibility and route choice, would put further pressure on Europe's airport infrastructure. The section concluded that data collection and analysis needs to be prioritised in order for policy makers and airport managers to better manage the air transport component of Europe's transport networks.

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