EUROPEAN CONFERENCE OF MINISTERS OF TRANSPORT

ECONOMIC RESEARCH CENTRE

AIRPORTS AS MULTIMODAL INTERCHANGE NODES

ROUND TABLE

126

OECD

ECONOMIC RESEARCH CENTRE

REPORT OF THE
ONE HUNDRED AND TWENTY SIXTH ROUND TABLE
ON TRANSPORT ECONOMICS

held in Paris on 20th-21st March 2003
on the following topic:

AIRPORTS AS MULTIMODAL INTERCHANGE NODES

EUROPEAN CONFERENCE OF MINISTERS OF TRANSPORT

EUROPEAN CONFERENCE OF MINISTERS OF TRANSPORT (ECMT)

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Publié en français sous le titre :

LES AÉROPORTS: DES PLAQUES TOURNANTES MULTIMODALES

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THE EUROPEAN MARKET FOR AIRLINE TRANSPORTATION AND MULTIMODALISM

Kenneth BUTTON
School of Public Policy
George Mason University
Fairfax
United States

THE EUROPEAN MARKET FOR AIRLINE TRANSPORTATION AND MULTIMODALISM

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Fairfax, January 2003

1. INTRODUCTION

Air transportation has been growing rapidly over the past two decades and -- despite a significant slowing in demand during the period following the attacks in the US on the World Trade Center in New York and the Pentagon in Arlington -- is projected to grow in the foreseeable future. In economic terms, these predictions reflect the superior good nature of air travel as incomes rise. Additionally, increased amounts of leisure time, the continual growth in tourist travel and visits to family and friends, as well as the demands of modern industry for business travel, are seen as acting to continually foster demand for air passenger services. On the cargo side, just-in-time production, both in terms of limiting inventories of inputs and spare components and the easing of institutional constraints on trade, is leading to continually rising demands for air freight movements which are forecast to continue for at least two decades[1].

These forecasts are also founded on other, perhaps less solid assumptions about continuing trends in other causal factors. Institutionally, the liberalization of air transportation markets since the late 1970s has allowed the supplying airlines to offer more capacity and more innovative service networks at lower costs to customers (BAE Systems, 2000; Schipper *et al*., 2002). Again, forecasters see this pattern of regulatory reform continuing, most notably within the context of the emergence of more liberal bilateral and multilateral international air service agreements, with positive effects on air transportation use. While this may be a valid assumption in the long term, institutional changes and their timing are notoriously difficult to predict.

Combined with this, technology has continually been moving forward and leading to lower costs of air service provision[2]. Some of this has been of an incremental kind, e.g. in terms of more fuel-efficient engines and longer range versions of existing aircraft series, while others represent more significant structural changes, e.g. the advent of regional jet airliners and the potential for much larger jet aircraft, such as the Airbus 380. Major changes akin to the trend breaks of the past, notably the advent of the jet-engine commercial airliner and then wide-bodied aircraft, however, were probably also important in allowing the continuation of incremental changes. Early jet engines were much less efficient than their modern counterparts but overcame significant limitations of propeller-based technologies. However, such sea changes, as opposed to movements along a technology trend line, are rare and may well not occur in the near future.

There have also been technical changes in the infrastructure of air transportation, as new air traffic control and navigation systems have emerged and as these are gradually being integrated into the air transportation system, e.g. the European Single Skies initiative. Progress here, however, is and is likely to continue to be patchy. It involves not only difficult technical issues of integrating new systems into an established structure but there is also a need for international co-ordination in so doing.

Perhaps of more importance, many of the forecasts implicitly assume that airport capacity will be available at more or less the same level as it has been in the recent past. Airports provide the vital terrestrial nodes to the air service links. As such, they effectively can act as a constraint on the growth of air traffic networks. But the issue goes beyond the narrow one of the ability to handle aircraft.

Airports are, for the vast majority of travellers, multimodal interchange points -- the exception being transit traffic (and even here, some would say switching from a large intercontinental aircraft to a local turbo-pro carrier may be seen as a modal switch). Equally, increasing freight transporters are using air transportation for part of their carriage and, again, airports are serving as modal interchange points. Indeed, many of the earliest scheduled air services were for the movement of mail between road/rail links in the mail network.

The demand for airport services has inevitably increased in the previous environment of long-term economic growth and a secular decline in air transportation costs. This is true in terms of both air-side movements, involving the take-off and landing of aircraft and their movement about the airport, and the land-side movements, involving people accessing and leaving the airport and their movements within it. But this has been within a context of limited investment in new airport capacity and relatively little enlargement to the capacity of existing facilities[3]. There is no indication that this will change in the future and this is now in a situation where in many parts of the world, and particularly in western Europe, airport capacity is becoming heavily congested.

The vast majority of trips or freight movements involving air travel also involve the use of a variety of other transportation modes. There is the need to access the airport to initiate the air transportation component of a movement, and the need to move from the airport at the end of a flight to the final destination[4]. In that sense, all airports are multimodal interchange modes. But there are complexities to this. In some cases, for example, the movement to/from the airport is essentially one of access and egress from the air transportation network -- air travel being the primary mode. In other cases, there may be more than one primary mode -- for example, local transportation to an airport, a flight, an intercity rail journey and local transportation to the destination. Here, the initial airport links local and trunk-haul movements, whilst the second airport links two trunk-haul movements. This general picture applies to freight as well as passenger movements (Muller, 1999).

The object here is not to look at airports as purely air transportation infrastructure but rather to place them more fully within their context as intermodal nodes in a larger multimodal transportation network. As with any form of interchange point in a network, modal changes impose financial, environmental, safety and security challenges which differ from those of a single-mode node. The challenge is to develop policies and structures whereby the largely financial benefits of interchange to travellers and freight shippers (essentially stemming from transhipment and consolidation) outweigh the more diverse costs of interchange activities, which often impinge on those outside of the transportation activity.

Overall, the paper considers in economic terms the optimal level of interchange which should take place in this wider context. This is done within a general framework, and for specific features of the passenger and freight markets. It illustrates and also contrasts this with some examples of developments which are taking place at a number of airports in Europe and elsewhere. In doing this, the paper is not concerned so much with airport systems, as with the optimal use of individual airports. Prior to considering these features, basic introductions are offered to both the economics of hub-and-spoke operations and to trends in the European air transportation market.

2. THE BASIC ECONOMICS OF HUB-AND-SPOKE NETWORKS

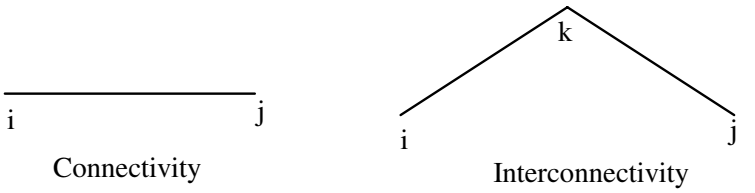
Few would dispute that airline services are provided within a network-based context. But there are several potential forms of network which could be and are used. Much of the current air transportation system in unregulated markets is based on the idea of hub-and-spoke operations (Button, 2002a). These have grown out of a variety of structures which had previously been imposed under various regulatory regimes in different parts of the world. There are now some indications that this hub-and-spoke structure may itself be less robust than once thought by economists, for instance, as the number of point-to-point services has grown in western Europe and North America. Nevertheless, it still dominates many of the major air transportation markets. In a multimodal context, which includes surface movements to and from airports, the importance of this structure is even more evident.

2.1. Connectivity *vs.* interconnectivity

For any node to serve as a multimodal node there must exist some form of hub-and-spoke system. The analysis here is couched largely in terms of a single mode, an air transportation system, but it is intrinsically the same if the network involves a number of interacting modes offering hub-and-spoke services. Indeed, in economic modelling, following Lancaster's work (1966), most analyses consider modal attributes (speed, cost, reliability, safety, security, comfort, etc.) as opposed to transportation modes *per se*. This is seen in the development of abstract mode analysis by Quandt and Baumol (1966) and the work of the Nobel Laureate, MacFadden (2001) on random utility models.

Hub-and-spoke operations have been widely used throughout history. Trading posts were the first commercial manifestations. The postal and telephone services provide the classic modern examples. In the postal case, large consignments of letters destined for a single city are collected together at a single sorting office and subsequently dispatched for final delivery in smaller consignments. They involve bringing together traffic and then, usually after some sorting, dispersing it to various destinations; the alternative being for each movement to be directly from one location to another. For it to be worthwhile to develop a network of any configuration other than simply providing single-link services, there must exist some form of network economy. The discussion here is largely about a network involving interconnectivity. Connectivity exists, as seen in the left diagram in Figure 1, when there exists a connection between two points or nodes (i and j). Interconnectivity involves at least three nodes, as in the right diagram. In this case, k is a nodal hub.

Figure 1. **Connectivity and interconnectivity**



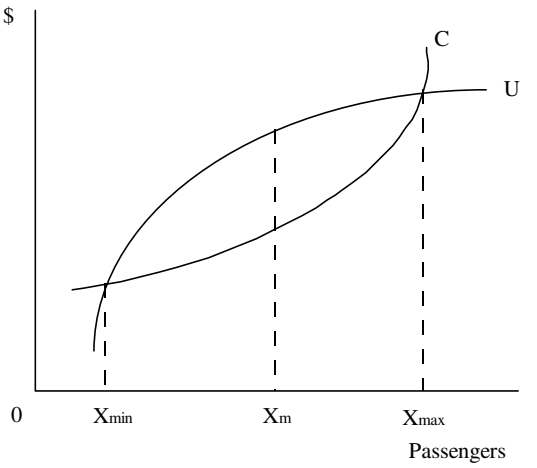
2.2. Optimal levels of hubbing

The relevant economies which favour movements between i and j going via k, rather than being direct, may be on the cost side but they may also reflect the possibility of earning higher revenues on the demand side for commercial undertakings offering transportation services[5]. On the cost side, there may simply be traditional economies of scale linked to having larger operations and the ability to spread fixed costs over a larger number of customers. These are often somewhat different in form to those found in non-network-based industries. They often involve economies of scope and density as well as pure scale. Simply, economies of scope exist if the unit cost of providing a number of services in combination is lower than providing each individually. Economies of density exist when unit costs fall with higher utilisation levels[6].

In terms of user benefits, larger networks can offer the advantage of access to a much larger range of destinations and generally with this goes greater service frequency. Additionally, any individual user helps ensure that this range of options is available to others -- a positive network externality. This means, for example, that in terms of an individual user of an air transportation network, by paying the fully attributable cost of using the service, that user helps to ensure that the service is also available for other potential users, as well as himself, to benefit from their support of the network.

There are limits to these benefits, and costs rise after some point. The main reason for this is that the costs borne by air travellers extend beyond simply those of the fares being paid for the opportunities which larger networks may offer. In Figure 2, it is assumed that the costs, C, to airlines of providing networks of services rise with the size of the network (proxied by passenger numbers) but at a decreasing rate (i.e. some scale/scope/density benefits are implied but these diminish with the size of the network). For the user, there are increased benefits associated with larger networks (U) but the rate of increase declines with the size of the network -- basically, once the important nodes have been embraced, other nodes generate less utility. To obtain any passengers there must be a minimum size of network (Xmin), which may be greater than unity but, after Xmax, the additional traffic the airline gains from adding links is less than the additional costs, and further expansion will not be justified.

Figure 2. **Optimal networks**



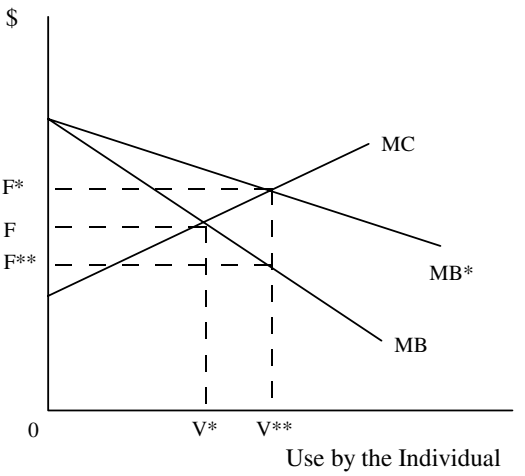
From the perspective of passengers, however, the optimum network is that involving Xm passengers, where there is a maximum deviation between the financial costs they must pay to cover airline costs and the network benefits to be enjoyed. Passengers, however, will continue to seek flights up to Xmax, since their marginal benefit exceeds the costs they will be charged. In this sense there is a divergence between the social and individual optima.

2.3. The user externalities approach to optimal hubbing

Another way of looking at this, or more strictly, an alternative means of explaining optimal hubbing, is to treat the issue as a simple case of positive and negative externalities (Figure 3).

Here, an individual's demand (marginal benefit) for an airline service is shown as MB, with the marginal costs involved of MC. For simplicity, it is assumed that there are no negative externalities arising due to congestion or adverse environmental effects. The flights made by the individual help sustain the network for other potential users so that the marginal social benefit curve -- where society is deemed to embrace only other air travellers -- is to the right of the MB curve at MB*. It is assumed for simplicity that, in drawing this, the larger the number of flights taken by the individual, the greater the social benefit. If no allowance is made for this external effect then the fare is set at F and the volume of service used is V*. Allowing for the externality pushes the optimum volume of service out to V** and the fare up to F*. There is no incentive for the traveller to move out to V*, however, because he does not recognise these benefits. One policy solution is to subsidise fares down to F** which would achieve the optimal volume of traffic. Another approach would be to adopt a form of price differentiation which allows costs to be recovered by airlines at an output of V* by extracting consumer surplus from intra-marginal users of the network.

Figure 3. **The case of a positive externality**

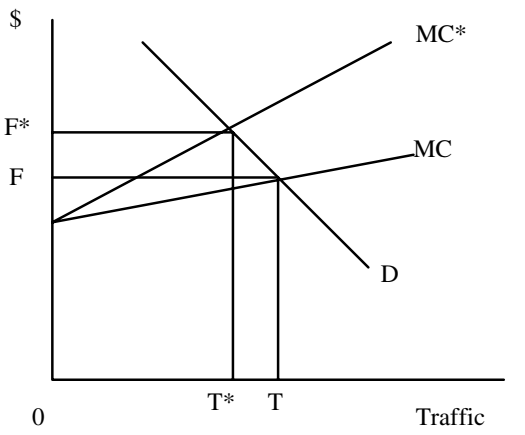


In addition to the positive externalities which may be associated with larger networks, there are issues of possible congestion which can arise on links and at hubs. There is an optimum level of congestion which arises simply because there is interaction between those using elements of the network, and without this the facility would be underused in an economic sense. The bigger concern is that of excess congestion when a facility is overused and the benefits which are being derived from it are not maximised. This normally stems from inappropriate pricing of the facilities involved (an issue regularly debated by policymakers).

Figure 4 provides the standard explanation of how this problem can arise and indicates how it may be handled. The marginal cost of a flight, as seen by the air traveller, is represented as the MC curve -- this embodies the cost to the airline of providing the seat, which is passed on in the fare, and the time costs of the trip to the traveller. With a demand curve of D for the service, the volume of traffic will be T. This, however, ignores the congestion which each traveller imposes on other travellers (the so-called "club good" problems), in terms of aircraft using runways and the congestion on planes. If congestion is allowed for, then the marginal cost of a trip goes up to MC* and the optimal level of traffic falls to T*. A degree of congestion remains, the difference between the MC* and D curve at traffic flow T*, but this reflects the optimal level of interaction. This optimal outcome can be achieved by a pricing policy which pushes up the costs to travellers to F*, or the same result could come by limiting travel through other means (e.g. slot controls) to T*.

The extent to which congestion is an issue depends, to some degree, on how much of it is already internalised within the fares paid by passengers and cargo shippers. Unlike non-club-good externalities, such as those associated with noise or air pollution, the inefficiency costs of congestion are borne by the users of air services and those who provide those services. In situations where there is only one carrier monopolising an airport, there is thus an incentive for that carrier to make efficient use of facilities and to allow for congestion costs when setting fares and establishing services (Button, 2002b; Brueckner, 2002). In other cases, a variety of measures, ranging from simple "grandfathering" of slots to incumbent airlines to slot auctions, are used or are in the process of consideration.

Figure 4. **Congestion costs**

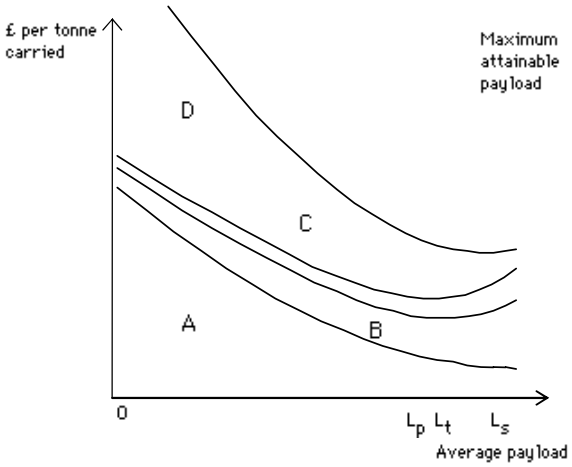


2.4. Environmental considerations

Environmental costs add a further element to the discussion. These are external to all transportation activities and are inflicted on non-beneficiaries of the transportation provision[7]. One way of illustrating this would be simply to add these costs to the congestion costs inherent in Figure 4. But they are somewhat distinct. Congestion is a club effect which imposes external costs on other users, while environmental costs are user-on-non-user externalities. They may well signal different things. If there is congestion then this implies that, from the user's perspective, scarce transportation services are not being allocated efficiently, but it can also mean that more transportation infrastructure and services should be provided. Negative environmental externalities certainly suggest that the existing system is not being used in a socially optimal way, but can also show that less transportation infrastructure and fewer services would be socially optimal. It is helpful, therefore, to treat them separately and in a way which reflects some of the diverse interests of those involved in transportation.

Economies of scope and density lead to air movements being consolidated via a hub-and-spoke system, and the degree of this consolidation can be broadly reflected in the average payload of an aircraft. Greater consolidation inevitably increases the average payload. Figure 5 shows line-haul costs of an air service falling with consolidation until the maximum physical or legal average payload is reached. If only aircraft flight costs were to be considered this would represent the optimal payload, but there are also the resource costs involved with consolidation itself. This incorporates the provision of the hub airport itself as well as airport services -- air traffic ground control, baggage handling, administration, etc. These terminal costs are likely to rise with the level of consolidation. Consequently, the airline, when hubbing and looking at its costs, will seek an average payload of L_t.

Figure 5. **Consolidation costs (represented cumulatively)**



So far, we have only looked at the terminal and movement costs confronting the airline. However, customers also have personal costs which vary with hubbing levels. The greater the amount of consolidation and the higher the final average payload, the fewer the number of flights (or banks of flights) which will be offered by the airline. Sparser frequencies push up the generalised waiting time costs for travellers. Thus the time costs to users of increased consolidation rise with the average payload, suggesting that, overall, the combined optimal level of hubbing for airlines and passengers is L_p. There is a clear distinction, therefore, between the direct costs influencing the airlines' optimum and those affecting the final customer. Additionally, there are wider environmental costs. Generally, increased hubbing and higher payloads will reduce these costs, because fewer flights are needed to transport the same number of passengers[8]. Hence, from the overall societal point of view, the optimal level of consolidation in Figure 5 is when all costs are minimised, that is, at point L_s.

While one can isolate these different positions, in practice there are immense problems in putting values on the various elements. From a political economy perspective, there is also the problem of capture of parts of the decisionmaking process by one of the parties, which pushes the actual level of hubbing (as indicated by load factor in this case) to levels away from L_s.

2.5. Multimodal considerations

This discussion of hubbing in an abstract mode framework simply treats each mode of transportation as a collection of attributes (speed, cost, environmental damage, reliability, etc.)[9]. The extent to which links to/from airport modes will involve multimodal activities depends upon the relative demands for these attributes by passengers and shippers and the extent to which the different modes provide substitutable or complementary bundles of attributes.

If airport users are seeking similar packages of attributes when interlining at an airport (e.g. when speed, reliability and flexibility are important but low cost is less relevant), then they will favour providers for the air movement (full service air carriers) and for the surface movement (rental car or high-speed rail) which dominate in offering these features. If low costs are a key concern and flexibility and frequent service are less important, then charter or no-frill carriers will be favoured for

the air link and local buses for the surface link. The types of multimodal infrastructure and services provided will, therefore, vary between airports depending on the types of user and their demands for different attributes[10].

In theory, any combination of modes may offer services to and from an airport and provide various combinations of interlining possibilities. In practice, it seems unlikely that some combinations will be viable. The linking of shipping and airfreight services at an airport seems, for example, to have limited possibilities because of the differing types of freight carried by the modes and the different types of container technology involved in their transportation[11].

The abstract mode approach, in its original theoretical formulation, assumed that there were no transfer costs involved in changing modes at a node (or, more strictly, they could be directly attributable to a single mode). This is unrealistic. The degree to which various modes co-ordinate their services (e.g. in terms of scheduling) affects their relative attractiveness. There is also the degree to which the various modal terminals within an airport are physically separated. In general, air-to-air interlining poses lower transfer costs because gates are close together, and when changing between planes of a single carrier, the "banking" structure of schedules minimises waiting times. Modal change may also pose ticketing problems if there is no common issuing agent and there is the question of the responsibility of various modes if delays on earlier legs of a trip prevent catching a service on a later leg.

These types of problem are perhaps less acute for freight movements, where forwarders act as intermediaries and the actual item being moved is much less sensitive to routings, timings, etc., than are passengers. The growth of Internet booking and the demise of the traditional travel agent in many parts of the world, in contrast, can add to the costs of modal change for passengers (National Commission to Ensure Consumer Information and Choice in the Airline Industry, 2002).

3. TRENDS IN EUROPEAN AIR TRANSPORTATION

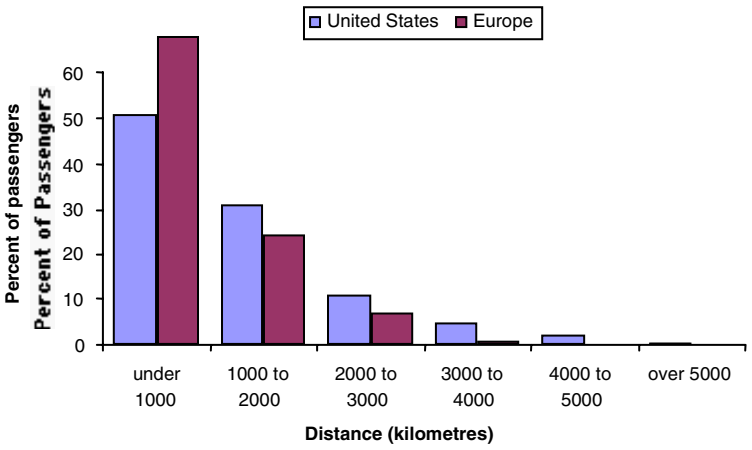
Economic abstractions can provide a useful modelling framework to help in the understanding of the role of airports in a transportation network, and of the considerations which need to be taken into account in creating an optimal amount of hubbing. However, they offer limited guidance as to multimodal considerations in specific contexts, or to the peculiar roles of the various non-air modes. In abstract mode modelling, this may not be seen as relevant. But, in the more practical world, decisions by both public and private sector agents have to deal with a rather narrow range of attribute bundles (e.g. those constituting aircraft, trains, cars and buses) and set them within a broader political and institutional environment. It is thus helpful to look at some of the actual trends which are emerging regarding passenger and freight air transportation and the role of airports in the widest sense within these trends.

3.1. Market trends

The European air transportation sector is part of a global transportation network which currently carries about 1 600 million passengers a year, is responsible for 3.9 million jobs, has a turnover of some $260 billion, engages 18 000 aircraft, and serves a 15 million kilometre network involving 10 000 airports. Air cargo traffic is over 130 billion revenue tonne-kilometres[12]. It is the dominant form of passenger transportation over long distances but still serves the needs of many middle-distance travellers. The average route length of passenger air services in Europe is 720 kms, but is 1 220 kms in the US, where the major centres of economic activity are more dispersed (Figure 6). It is also the dominant form of freight transportation over long distances in value terms.

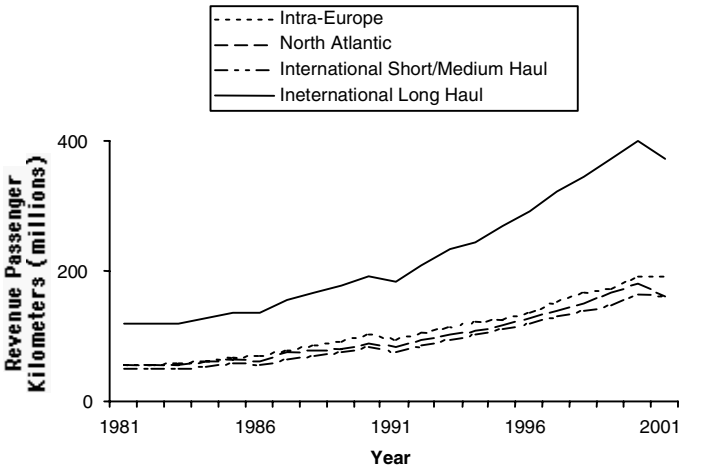
To facilitate improved efficiency in air transportation supply, there has been a trend towards greater market liberalisation over the past twenty years. Most air transportation markets were heavily regulated from their inception, with controls over fares, service levels and suppliers. The US broke with this in 1977 by liberalising its domestic cargo markets and, a year later, by deregulating its domestic passenger market. The EU has developed multilateral free markets between themselves. These were phased in as three "packages" from 1988 which now leave the internal market for airline services essentially free from economic regulation. Further, many bilateral agreements between EU countries and those outside, governing the terms on which air services are traded, have been liberalised (Button *et al.,* 1998).

Figure 6. **Passenger numbers by distance of service**



Assessing the exact implications of these changes over a relatively short time period, when there are on-going trade-cycle effects, technical changes and other policy developments taking place, is not easy (European Commission, 1998a). At best, one can say that, partly as the result of these more liberal market conditions, Association of European Airlines (AEA) members saw a steady growth in their traffic in Europe during the 1990s which produced a doubling of passenger-kilometres travelled. By 2000, the market was 32 times larger than in 1960. No all-European-based markets have grown at the same rate, instead they have varied according to fluctuations in demand patterns and the extent to which saturation levels are being approached, but they also vary according to the extent to which residual restrictive regulations remain (Figure 7).

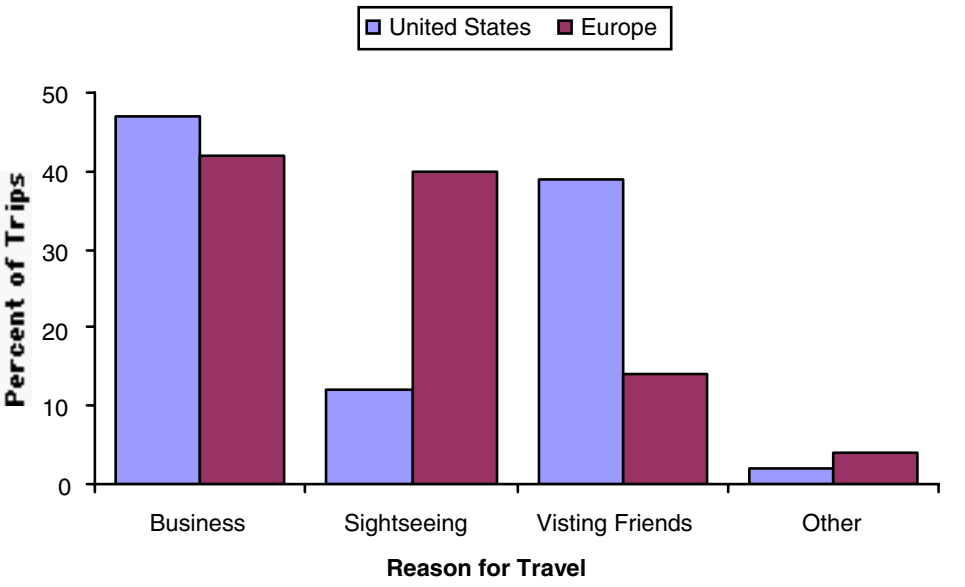
Figure 7. **Long-term trends in European-based passenger markets**



Source: Association of European Airlines (2002).

There is a variety of reasons why people make use of air transportation. In Europe, while about 40 per cent of air trips are for business purposes, nearly as many are for sightseeing and recreational activities (Figure 8). Basically, European airlines serve an important role in moving people to tourist destinations (Papatheodorou, 2002), accounting for 80 per cent of tourist movements to some parts of the Mediterranean region. A large part of the European tourist market has traditionally been served by non-scheduled operations. Charter operations cover about 44 per cent of the intra-European revenue passenger-kilometres and carry about 27 per cent of the passengers -- the difference being due to the non-scheduled services providing carriage on the longer north-south routes. Specialist charter carriers carry many of the passengers but scheduled carriers such as Finnair, Lufthansa and Turkish Airlines are also significant players.

Figure 8. **Motivations for travel in the US and Europe**



Sources: Institute of Air Transport, Gallop/ATA Survey.

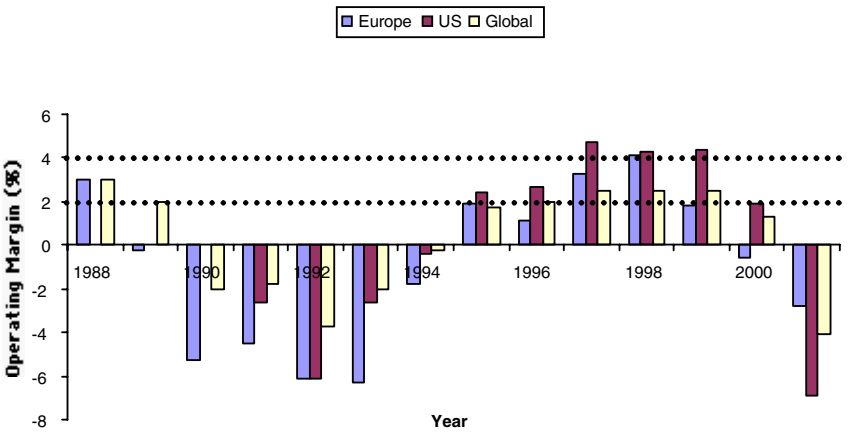
3.2. Finance

The profitability of the traditional European airlines has varied across carriers and across the business cycle. After running a deficit for several years in the early 1990s, most airlines managed to make profits in 1995. However, financial performances varied, with only British Airways, Finnair and KLM achieving universally favourable results over the entire period between 1990 and 1994. The later years of the 1990s saw profits across the main carriers on international routes exceeding $2.25 billion for 1997 and 1998. Higher fuel prices combined with enhanced competition in the late 1990s squeezed profits, resulting in aggregate losses in 1999. The result was that operating margins fell (Figure 9). The onset of recession in the US in 2000 and the events of September 2001 pushed operating margins into the red and financial recovery has been weak. The situation is not unique to a single market. Figure 9 also shows details of the net operating margins of major US and EU passenger airlines and globally.

3.3. Airports

The bulk of major airports in Europe are heavily congested. This has impacted on the quality of air service offered. AEA surveys show relatively high levels of departure delay in the late 1980s, with improvements generally in the early 1990s up to 1994. After 1994, there has was a gradual rise in departure delays, as measured by the percentage of flights delayed by 15 minutes or more. The problems became particularly acute in 1999 but even after extensive efforts to improve the situation, 2000 was still the second worse year on record. The downturn in traffic from 2001 eased the situation.

Figure 9. **Operating margins after interest as percentage of operating revenue**



Note: US data refer to airlines which are members of the Air Transport Association and the European data to airlines which are members of the Association of European Airlines. The global data is from Boeing Commercial Airplanes.

4. SEGMENTATION OF EUROPEAN AIR TRANSPORTATION

The ongoing changes on both the demand and supply sides are leading to restructuring of airline networks, and with this have come changes in the role of airports as nodes. Developments in air transportation, in turn, have knock-on effects for other modes linked to them via airports. The market for intra-European air services was traditionally integrated, in that scheduled services provided a full menu of service types (and often have significant interests in air cargo transportation), with charter carriers catering for a large volume of seasonal leisure travel. However, the market for passenger air transportation in Europe would now seem to be becoming much more segmented. To some extent this also seems to be a trend in cargo opertations. In the past, a considerable amount of cargo was carried in belly-holds but increasingly the role of specialised carriage is growing.

4.1. Full-service carriers

The full-service European carriers (essentially the "flag carriers") have traditionally provided network services through their domestic hubs. These airliness provide a range of services (business/leisure, domestic/intra-Europe/Intercontinental, home market/sixth freedom, etc.). They normally have a monopoly of the major national hubs although not to the same extent as the US hub carriers, where an airline may control 90 per cent of slots at a hub. In the past, the international bilateral agreements effectively prevented a carrier from obtaining more than 50 per cent of slots in Europe, and this has been slow to change.

Full service carriers make use of hub-and-spoke style operations to maximise economies of scope and density, but are limited in what they can do because of the relatively short hauls in Europe. They have significant infrastructures to handle sales, marketing and distribution across a highly complex network. Much of their revenue has come from the business market, largely because their hubs are at the major centres of commerce, their services are frequent and because their service networks, usually involving strategic alliances, offer on-line global connections. They also provide services tailored to the perceived needs of the business traveller, such as lounges, differentiated cabins and flexible ticketing.

The slow path of regulatory change in Europe from the late 1980s, combined with the continuing needs of the wider international air service agreement structure, has limited change after deregulation. The constraints of heavily congested airports and air traffic control also dampen the forces for any dynamic change in the hub structure. This legacy effect, coupled with the reality of present constraints, has produced a two-tier structure of hub service providers -- those based at a major hub and those at a smaller hub. The major hubs and their related carriers are: Heathrow (British Airways), Frankfurt (Lufthansa), Charles deGaulle (Air France) and Schiphol (KLM). In aggregate, they account for some 55 per cent of the scheduled capacity. Each is also a major intercontinental hub as well as an intra-European hub. Smaller airports often have links to these major hubs through the activities of alliance partners or subsidiary carriers.

The various forms of network economy which become particularly predominant in the longer-haul markets are leading to consolidation among the full service airlines in terms of alliances. The difficulties of full merger may in some cases be the driving force behind such alliances, but in other cases there are sound economic and managerial arguments for avoiding many of the problems which are often encountered in full mergers. These alliances are based around the four largest carriers (Lufthansa, Air France, British Airways and KLM) and their global alliance partners.

4.2. Non-scheduled services

The passenger charter market in Europe is large -- some 62 million passengers in 1999 covering 120 billion revenue-passenger miles. Their main function has been to provide leisure-based services, normally as part of an inclusive tour, for traffic from the north of Europe to resorts in the south. They grew up as a means of circumventing restrictive international, bilateral air service agreements. They operate from secondary airports, provide no form of interlining and often operate at what would be off-peak times for scheduled airlines. They generally have more seats than comparable aircraft and fewer cabin crew. Their services are combined in inclusive tours which normally involve transportation from and back to the destination airport. In that sense, inclusive tours provide a multimodal package through an airport for at least part of the travel.

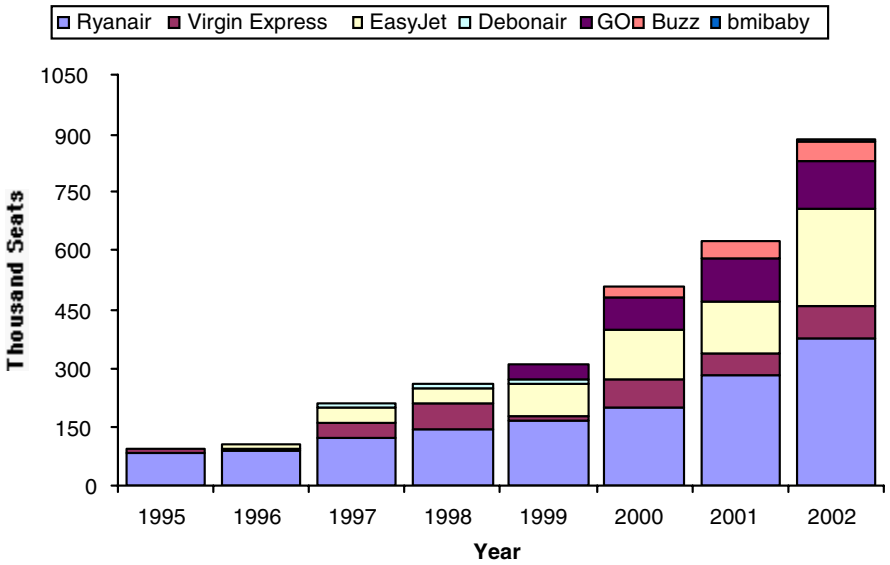
4.3. No-frills services

An important change in Europe has been the growth of no-frills carriers (low-cost carriers in US jargon) since the mid-1990s (Cranfield University Air Transport Group, 2002). These airlines differ amongst themselves but all offer mainly a single-class, point-to-point service rather than a hub-and-spoke network of services. They also make extensive use of on-line booking and many service regional airfields rather than major airports. The number of carriers is growing (a further seven were added in 2001-02 to the six operating in 2000). The market share of no-frills carriers is relatively small -- some 5.2 per cent of the scheduled seat-kilometres in the intra-EEA market in 2000. But the share is growing, with the six main carriers increasing the seats offered by 48.3 per cent between the summer of 2001 to the summer of 2002 (Figure 10), whilst the overall growth in services was 116 per cent in 2002.

4.4. Regional airlines

In addition to the no-frills carriers there are numerous regional airlines in Europe that often offer essential no-frills services. These are growing rapidly in number -- the membership of the European Regions Airline Association has risen from 48 carriers in 1991 to 78 airlines in 2001. These airlines serve a variety of functions at the local level, for example, smaller short-haul markets and providing feed to larger carriers. They may be seen as complementary to the full service airlines they are often linked to.

Figure 10. **Growth of no-frills carriers**



4.5. Premium-only services

There are very few air services that are exclusively aimed at the business traveller. Most business travel is accommodated in a separate cabin on a multi-class aircraft. There have been attempts to develop such services in recent years (e.g. Lufthansa provides a single-class service from Germany to the US and Ciao has been developing short-haul, business-oriented services out of Italy) on the basis that business travellers are willing to pay a premium for high-quality service.

4.6. Implications of segmentation for airports

These emerging trends in the segregation of the air transportation market have implications for airports and, *ipso facto*, in their roles as multimodal nodes.

The growth of no-frill and regional carriers has led to a greater use of secondary and local airports in Europe. Whilst the primary no-frill markets have been between the UK and Ireland and between the British Isles (from airports such as Stansted, Luton, Manchester, Newcastle, Glasgow and Dublin) and continental Europe, this is changing as they are expanding services on continental Europe. Ryanair is developing Frankfurt-Hahn and Charleroi as hubs and EasyJet is developing Geneva. The trend at the major airports has been towards a continued pressure for additional slots but in some cases there has been a contraction in the destinations being served (Table 1). This may be because pressure on capacity has led to airlines focusing on their most profitable routes. But it may also be seen in part as a reflection of the fact that some secondary airports (Luton and Stansted in the London context) are acting as focal points for destinations more suited to no-frill styles of service.

The changing pattern of air service supply which seems to be both a function of new business strategies and a reaction to constraints confronting the traditional full-service carriers is also leading to changes in the composition of the European aircraft fleet. While there is certainly no concensus between the main manufacturers about the long-term demands for larger aircraft, there is more agreement that the trend is towards smaller aircraft for intra-European services if market trends continue (Figure 11). This implies more point-to-point services and reflects the anticipated growth in the use of smaller, regional airports. In terms of passengers accessing and leaving these airports, this would seem to imply that high-capacity modes such as rail would be at a disadvantage.

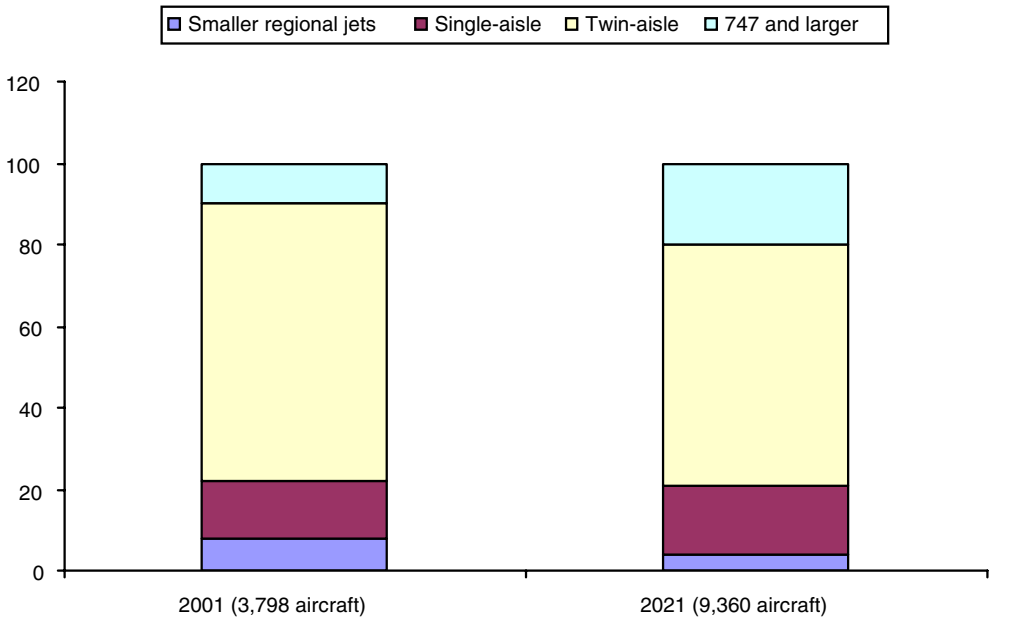
Table 1. **Number of destinations served from major European airports, 1990-2002**

Year	Schiphol	Charles de Gaulle	Frankfurt/ Main	London Heathrow	London Gatwick
1990	201	210	254	170	227
1991	198	210	250	142	212
1992	204	217	262	149	210
1993	210	219	271	147	212
1994	227	229	285	150	213
1996	231	254	317	165	209
1997	240	251	292	178	200
1998	239	251	291	179	198
1999	234	241	289	175	191
2000	238	250	292	180	189
2001	215	246	296	170	186
2002	205	220	296	140	191

Note: Includes all unique destinations served by direct flights and two-leg flights.

Source: Parkinson and Sentance (2002).

Figure 11. **Forecast delivery of aircraft (percentage of fleet) to the European fleet**



Source: Boeing Commercial Airplanes (2002a).

The growth of no-frills services at some secondary airports has clear implications for local surface transportation. Many of the airports are located a considerable distance from the final destination city (e.g. Frankfurt/Hahn is about 100 kilometres from Frankfurt). In a very small number of cases there are limited local train services but, in general, access and egress is by road transportation. This can lead to congestion on routes that do not have the capacity to cope with the additional traffic flows, cause road damage on pavements not originally designed for such flows and impose an environmental burden on areas that were previously relatively quiet.

The growth of these secondary airports, however, can also reduce surface transportation elsewhere when they take traffic originating near them rather than it having to go to more distant terminals. Further, since traffic congestion increases more than proportionately to traffic levels, the diversion can relieve some of the traffic problems around the major airports. There is a balance in this. The difficulty is that with all the distortions in the ways transportation infrastructure is priced -- specifically a lack of rational charges for road use and subsidies for rail and public transit modes -- it almost impossible to consider efficiency effects in a scientific manner.

5. TRENDS IN MULTIMODALISM POLICY

Much of the explicit discussion about multimodal transport has focused on freight movements. Many markets, such as the US, have developed very effective multimodal policies for freight movement based largely, although not exclusively, on the market (Muller, 1995; Transportation

Research Board, 2002). The distances involved and the nature of much of the cargo carried leads to natural synergies between local road services and trunk rail or water transportation. The result has been that since deregulation of road and rail freight transportation in the US during the 1980s multimodal transportation has been commercially viable in many markets. The integrated systems of FedEx, UPS, DHL, etc., provide extreme examples of this. Financial viability for multimodal freight transportation has proved problematic in Europe in part because of the geography of the region and also because of the significant efficiency differences between the road mode and complements such as rail and waterways. Multimodal passenger systems involving air transportation have perhaps been more successfully developed in Europe with rail links into cities and interacting air/high-speed rail systems.

There has been strong support for developing these types of multimodal transportation structures in Europe. In the case of air/rail much is now being made of moving from complementarity rather than competition between the modes. The approach now, however, is often one of justifying investment in new high-speed rail infrastructure, rather than congested airports. This is not the normal economic approach to complementarity, but rather one of planned substitution. Indeed, without any detailed analysis of individual cases and circumstances, there seems to be a religious belief in the EU that: "*We can no longer think of maintaining air links to destinations for where there is a competitive high-speed rail alternative* (European Commission, 2001)". If, in fact, rail can provide viable alternative links from airports without subsidies then there would be no need to evoke such faith: the user would simply elect to use it and policymakers would have no need to "think".

5.1. Airport access links

Major hub airports cater for a significant amount of interlining of air-passenger and airfreight movements. But they also accommodate major flows of originating and terminating traffic from their immediate hinterland. This traffic has to move to and from the airport. Automobiles, with their attendant problems of parking space and the need for dense highway networks, comprise much of this traffic in the US. This is much less the case in Europe where public transportation plays a very much larger role. Some of the major public transportation fixed-link facilities, connecting airports with adjacent urban centres, are included in Table 2. The mix in other parts of the world varies, although a common feature throughout is the importance of taxis as a mode for accessing and leaving airports.

All air transportation movements ultimately involve accessing and leaving air terminals. Air movements pose one set of problems but there are also mounting difficulties associated with ground movements. Accessing Europe's major airports is becoming increasingly difficult as surface traffic congestion grows. Similar problems exist at many airports in the US and Japan, and are increasing in less developed economies where surface transportation infrastructure is in general often poor. The emerging "edge city" pattern of urban land use[13] is compounding the problem as local traffic becomes entwined with traffic using the airport. The problems are often most acute for users travelling from central city sites who have to make radial trips out to air terminals along heavily used, cross-cutting commuter routes.

Table 2. **Some key rail links at selected European airports**

Airport	**Rail link**
Amsterdam	Regional, urban and inter-city rail links in place; potential for high-speed link
Cologne-Bonn	Inter-city link and urban rail links
Copenhagen	Regional and urban rail links planned; potential for high-speed link
Düsseldorf	Inter-city and urban links
Frankfurt	Inter-city and urban links; high-speed rail link planned
Geneva	Inter-city rail link
Hamburg	Metro connection planned; timing depends on funding
London/LHG	Urban rail link
London/LHR	Underground link and Heathrow Express in place
London/Stansted	Urban rail link
Manchester	Urban rail link
Milan/Malpensa	New high-speed link to city plus links to regional rail system
Munich	Urban rail link
Oslo	New high-speed link to city under construction
Paris/CDG	Regional and high-speed rail links in place
Paris/ORLY	Urban rail link
Vienna	City centre link; possible future inter-city connection
Zurich	Inter-city link

Most movements to and from airports are also by private car and the forecasts are that, even with the international trend towards policies involving traffic constraint, car ownership and use will grow. This has the added complication at the airport of multiple loading and unloading areas, parking provision and the movement of passengers to and from parks to terminals. Land transportation movements also pose severe environmental problems, inflicting noise and fumes on those living on access corridors. This is increasingly leading to public pressures to limit the construction of new road access links. The outward movement of suburbs towards formerly isolated airport locations adds to this debate.

Mass public transportation offers one possible method of more efficiently moving the forecast number of future air travellers. Some airports already have extensive public transportation access. In some cases airlines have also been proactive in attempting to ease the problem for their users by operating public transportation services. This has, for instance, been a policy of Lufthansa at Frankfurt, where the airline's "Airport Express" has provided train services to nearby urban areas.

In many cities there are plans to either introduce new public transportation systems to improve access or to upgrade existing ones (see again Table 2). Nevertheless, fixed track transportation involves considerable capital investments and in many cases, such as Heathrow, the forecasts suggest that new capacity will merely slow the increase in car traffic growth, not reverse it. The geographical configuration and historic pattern of land use in many European cities also pose serious planning problems that can often only be resolved by using expensive technologies such as tunnelling.

The idea of using innovative technologies to ease access problems has been particularly associated with Magnetic Levitation (Maglev) systems. Although to date the only operational Maglev system (tested and due for full operation in the Summer of 2003) involves linking Shanghai airport to

the city, the US has set aside funds to develop a trial system. This will involve either linking Baltimore/Washington to Baltimore Washington International Airport or Philadelphia to its airport. In the Netherlands, there has been consideration of linking Schiphol not only to Amsterdam but also to the much more distant Groningen (van Wee *et al*., 2003).

5.2. Airports as inter-urban modal interchange nodes

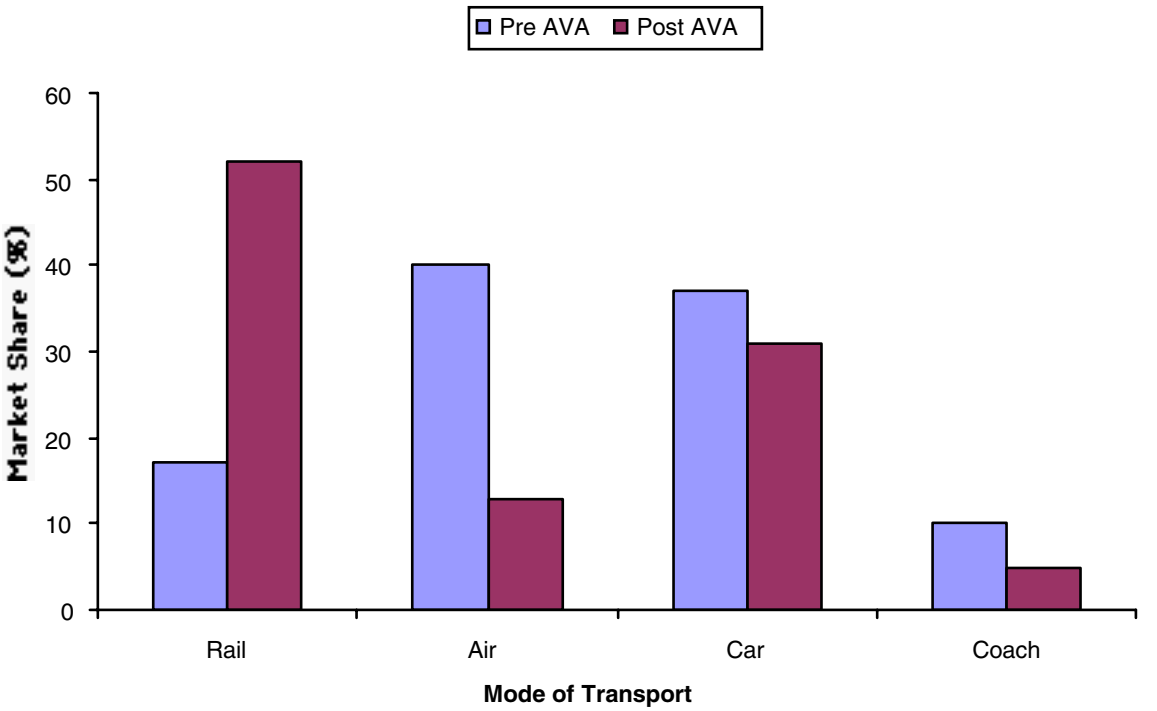
Fixed track public transportation is particularly attractive if it not only links an air terminal to its parent urban area but also ties it into a region's larger public transportation network. Tying in with the emerging Trans-European Rail Network adds to the potential attractiveness. Linking high-speed rail and air transportation in this way also takes away some of the strains imposed by slot congestion at airports. It allows airlines to use more of their capacity for medium- and long-haul services (Reynolds-Feighan and Button, 1999).

The openings of the Paris-Lyons TGV and the Channel Tunnel linking the UK to continental Europe are illustrative of this type of effect. A considerable part of the traffic making use of these links has been diverted from the air services. More recently in Spain, the mode split between Madrid and Seville has shifted significantly in favour of rail since the opening of the Alta Velocidad Española (AVE) (Figure 12). The demise of Sabena has also seen the withdrawal of air services between Brussels and Charles de Gaulle Airports and a dramatic rise in the use of Thalys high-speed rail services as a result. In other cases, most notably over longer distances where a number of intermediate stops are involved and where the origin and destination cities are less populous, high-speed rail services have proved relatively less attractive.

Outside the EU, the Swiss have already established a precedent by locating a mainline rail station under each major airport, and travellers' baggage may be checked in and delivered to any Swiss railway station. The development of the French TGV system and its *de facto* extensions through the Thalys system into the low countries involves joint rail/air terminals at Charles de Gaulle and Schiphol airports.

The idea that the EU airport network should be linked with the wider EU interurban transportation network formed one element of the Commission's approach to developing the trans-European transportation network. The guidelines for developing air transportation infrastructure priorities include not only the enhancement of existing airport capacity, the development of airport capacity and the enhancement of environmental compatibility but also the development of access to the airport and interconnections with other networks.

Figure 12. **Mode split Madrid-Seville pre- and post-Alta Velocidad Española**



Source: European Commission (2001).

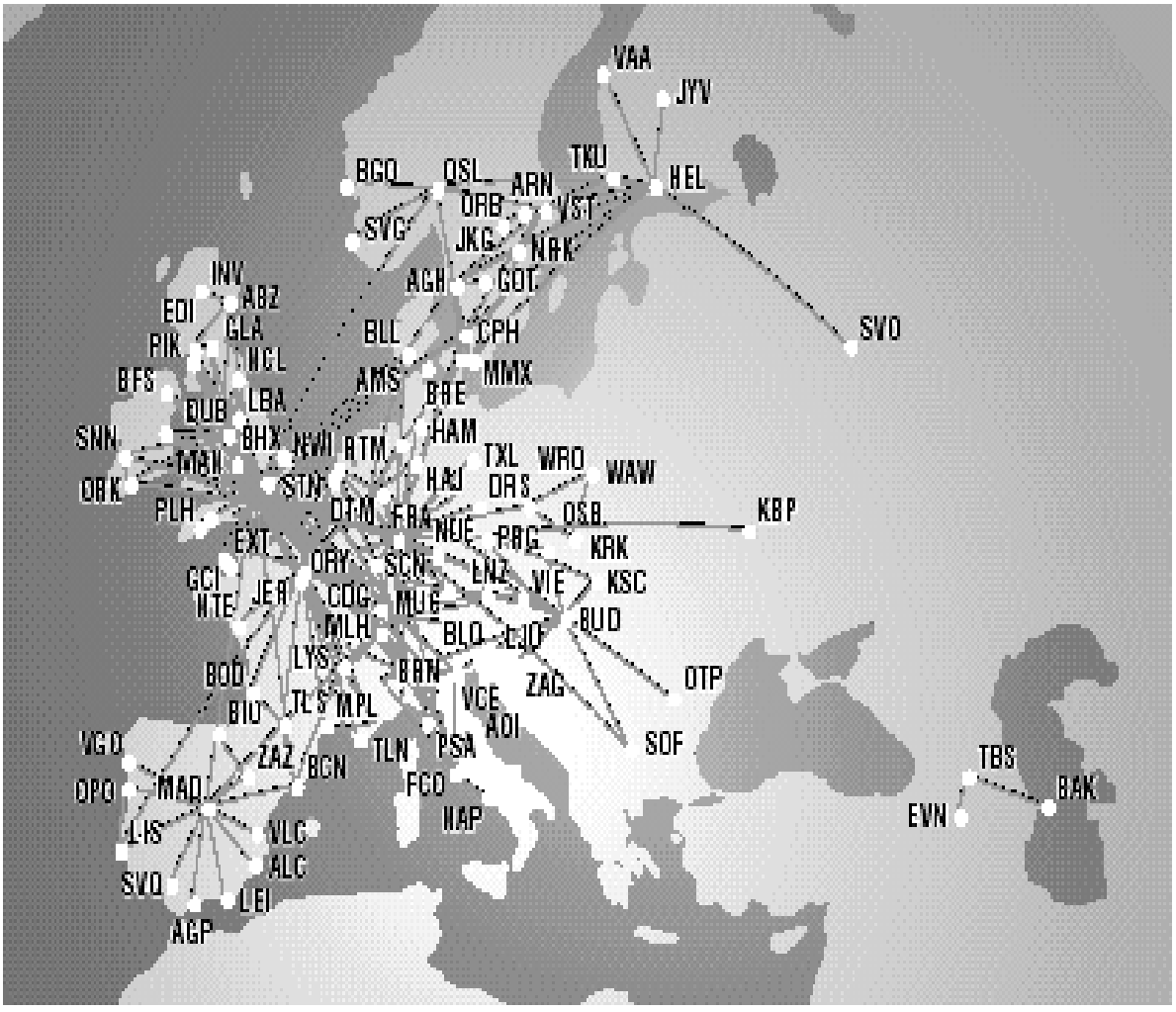
5.3. Air-trucking

The common objective of freight transportation is to get the right product to the right place at the right time so that the costs of holding inventories are minimised. Carrying and holding costs represent 25 to 30 per cent of the value of inventories in US firms in terms of the product, depreciation and interest costs involved. To keep inventories to a minimum and to allow flexibility in the system, trucking has been widely used to deliver and collect freight from airports. When there are technical difficulties, for example due to weather, it is also standard practice to deploy alternative modes to air transportation on a short-term, emergency basis to circumvent problems. In some markets, however, there is a clear possibility for subsituting an alternative mode for air transportation on a more permanent basis when economic conditions put pressure on the costs of air services. In some instances it is the airline which opts to use an alternative mode to meet customer needs. An example of this is "air trucking" or "truck flights", when an airline moves freight by road, with a flight number, rather than by 'plane. This is an option normally reserved for relatively short-haul movements, although there was an average of 3 900 frequencies per week of long operations in Europe in May 2002[14].

Within Europe and elsewhere, competition from surface modes has exerted a downward pressure on air freight growth. This, along with a relatively low overall economic growth rate, explains the below-average, long-term growth rate for air freight. Air trucking has been growing rapidly in Europe and similar things are happening elsewhere. Boeing (1998) estimated that air trucking has been expanding by about 15 per cent per annum since 1995 and that routes in Europe expanded from 38 in 1975 to 386 by 1995. There were 7 340 trips per week in Europe in 1997[15]. Air trucking also

provides regular scheduled freight services for higher valued exports from central and eastern Europe, where demand is too low or infrequent to justify dedicated freighter aircraft services. Figure 13 provides information on truck flights augmenting scheduled airline capacity in Europe.

Figure 13. **Truck flights augmenting scheduled airline capacity in Europe**



There is an inevitable concern that transportation users could be deceived when cargo is moved by road rather than by air. From an institutional perspective and, in particular, as a measure of consumer protection, efforts have been made to clearly define when air trucking is a legitimate option for an airline to adopt. In 1971, international airlines through IATA introduced and adopted IATA Resolution 507b, which clearly defined the circumstances under which trucking could be undertaken:

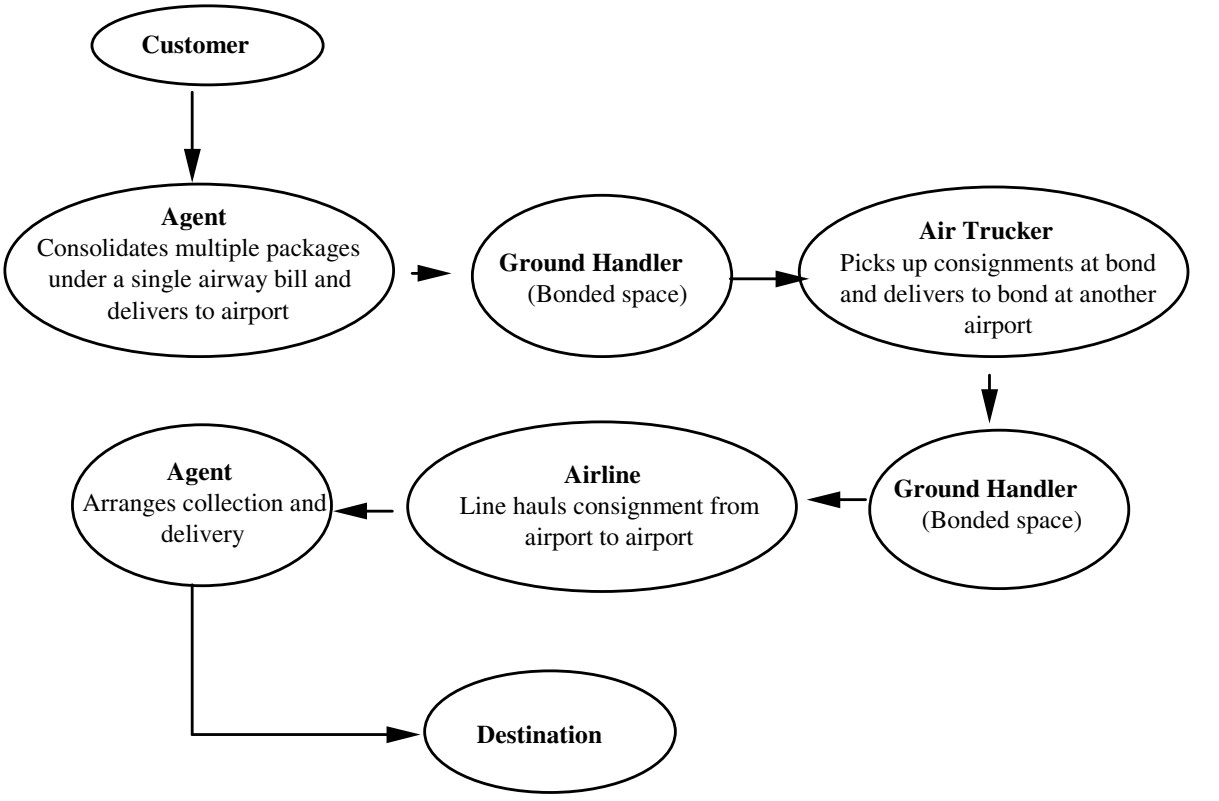
- Where there is a lack of available space on aircraft;
- Where consignments could not be handled on aircraft operated by an airline due to the size, weight or nature of the consignments (certain commodities may only be shipped in freighter or all-cargo aircraft) or because the carrier refuses carriage on some other grounds;

- Where the carriage by air will result in delayed transit times or in carriage not being accomplished within 12 hours of acceptance;

- Where carriage by air will result in missed connections.

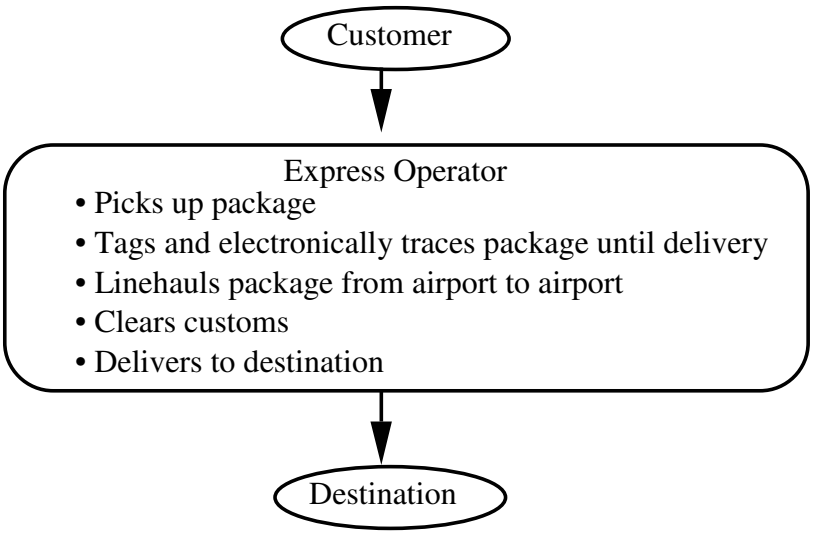
Today, the practice of air trucking is predominantly oriented towards moving intercontinental freight traffic to gateway airports. This process is described in Figure 14. It provides feeder service to the major hubs either where demand on the link is insufficient to justify air carriage or where local handling at the international airport makes truck/aircraft interchange more efficient.

Figure 14. **Air trucking in the freight logistics chain**



Air trucking is extensively used in the express operators' service chain, presented in Figure 15. There is much less outsourcing in this chain than with other forms of air trucking. The key advantages to customers of the express operators' service over traditional air freight services are the relatively short time which elapses between pick-up and delivery and the fact that a single company handles the package or freight from pick-up to delivery.

Figure 15. **Express operators' supply chain**



Customers can purchase different services based on speed and delivery requirements. The express operator will typically provide electronic tracking of packages, with customers having access to this tracking facility. Each package/consignment is separately tagged and tracked and will be cleared through customs. Customs services in most European countries now operate electronically so that consignments receive clearance en route to their destination airport. The customs authority can notify the operator of consignments that will require to be cleared on the ground and this information can be forwarded to the customer via the tracking system. Because each consignment requires separate documentation and customs clearance, charges are levied individually.

5.4. Telecommunications and airport use

Transportation is not simply about the movement of people and cargo, it is also about the movement of information. All airports, with their linkages to a variety of communications modes as well as handling people and goods, have always been major multimodal nodal points in the transportation of information. Without good flows of information, modern airports would quite simply not be able to function. In this sense the transportation of information into the airport becomes an input into the air service provision function. While important, this is not really what is understood as multimodal transportation.

Strict multimodal activities involve movement from A to B involving a combination of modes, inevitably through an intervening node. The amount of work on this aspect of multimodal transportation is comparatively limited -- most interest has been focused on whether telecommunications is a complement or substitute for car travel. The evidence on that is still far from conclusive but it is reasonable to say that new telecommunications opportunities have a complex relationship with travel. Many airports, or at least the various business lounges within them, offer access to the Internet. This means that information is transported to an airport on a plane (via a passenger) and then moved to its final destination by the electronic mode. There are reverse flows of information carried by the two modes. This type of multimodal activity is inevitably going to continue and to grow in importance.

5.5. The "mainport" concept

A much wider concept of a multimodal node is that of the "mainport". This involves the development of a much larger and integrated node in the transportation system which covers both freight and passenger activities. The mainport based around the seaport of Rotterdam and Schipol airport in the Netherlands is the most pronounced of these. While it is difficult to assess the overall economic efficiency of such combined infrastructure concepts, focusing terminal activities at one location may limit local environmental damage. Essentially, many of the effects can be internalised within the system.

The degree to which the mainport concept is transferable may be limited. Location is important and there must be sufficient traffic which can make viable use of a wide range of transportation modes to justify such a concentration at a single nodal point. In particular, there must be synergies between what may be seen as quite diverse transportation activities. For example, in terms of freight, the types of cargo carried by sea (low value, high bulk) make interlining with air transportation unlikely. Equally, there would seem to be few circumstances where either rail or trucking would enjoy significant economies of scale and scope by serving both a seaport and an airport. There are also questions about the economic benefits to a region of focusing on transit activities that may offer little value added to the local community.

5.6. Environmental factors

Transportation imposes a plethora of environmental costs. Unlike many other human activities, it is as much the diversity of adverse economic impacts that are a problem as the intensity of any specific effect. This diversity of local, regional and global implications makes it difficult to devise simple policy approaches: reducing one problem can often lead to an increase in the intensity of another. Air transportation is no different to other modes in this respect, although the details of the problem inevitably have specific elements (Snape and Metcalfe, 1991; Sommerville, 2003).

Any form of hubbing, be it single or multimodal, offers the potential for concentrating traffic into larger units and for reducing the per-unit environmental damage done in the trunk-haul element of a trip. But the cost of this is additional environmental damage around the hub. The introduction of multimodal nodes potentially affects both the trunk-haul elements of the environmental cost function and the terminal environmental cost function.

The trunk-haul element has the potential to contain environmental damage if it allows less intrusive modes to be used for some links. In the airport case, this may mean the use of less intrusive modes during some times of the day (e.g. truck or rail movements at night, thereby avoiding takeoff/landing effects). It seems unlikely, however, that there are significant reductions in terminals' environmental costs by having multimodal rather than simply air movements at an airport. Similar types of transhipment and consolidation are involved in both cases. Indeed, there may be greater environmental costs with multimodal activities if they require significantly larger land takes, which is often the case.

5.7. Safety

There are few aspects of safety which differ when an airport is viewed as a multimodal interchange point rather than as a single mode node. Most safety considerations relate to the links in a network rather than to nodes, with the exception of takeoffs and landings, and these are largely

decoupled from other modes. The main consideration at nodes is, therefore, the need for design and operational features which ensure appropriate separation of the various modes. At an airport, this may entail matters of segregating surface movements by ground transportation from those by aircraft -- a particular problem if large numbers of passengers are moved between aircraft and terminal building by bus, or between terminals. There are also design issues, to ensure that surface infrastructure features such as lighting or overhead power cables for rail do not interfere with the safe operation of aircraft.

5.8. Security

Air transportation has long posed a series of security problems. Traditionally these have involved high-jacking of aircraft or attacks on airports. The attacks in 2001 on the World Trade Center in New York and the Pentagon in Arlington, together with the failed attack on Washington, have inevitably led to more stringent security measures for all modes of transportation. With respect to air movements, these have in part been reflected in refinements to the International Civil Aviation Organisation's (ICAO) Annex 17 requirements, but have also led to unilateral actions on the part of many national governments (most notably the US). Whilst pirates and highwaymen have traditionally posed security problems during the actual movement part of any trip, considerable focus is now on security matters at nodal points in the network such as airports and seaports[16].

The design of many airports was not intended to meet current concerns. In Europe, where most airports until recently dealt primarily with international traffic, design was aimed largely at catering for a free flow of passengers and freight, constrained by customs and immigration requirements. Tighter security takes up space for equipment and for the holding of passengers and freight for inspection. Airports in countries (notably the US) which have traditionally seen relatively less international movements have even greater problems in integrating high security standards in facilities which were originally designed for the speedy processing of traffic.

The normal security structure allows for security inspections at the outset of movements and their termination (customs and immigration checks). Transit traffic is normally funnelled through the system in a secure "pipe" on the air side. It is essentially "bonded" as soon as it has entered the system. This has traditionally been particularly so with respect to international movements. Intermodal transportation poses additional costs within this structure, especially if one of the modes involves a number of different types of traffic (e.g. local and international)[17]. Some of the likely costs include the following[18]:

- The need to "bond" traffic through airports to avoid replication of security checks. This would require additional investment, considerable redesigning of facilities and ongoing operating costs. The segregation of traffics in Europe which came with the Schengen Agreement proved costly. Seamless security between different modes at an airport would seem likely to require even more resources;

- A possible need to conform to the highest common denominator. Since through traffic may involve movements in several jurisdictions, security standards must meet the most stringent of these to be accepted throughout;

- A need to separate passengers who are not interlining between modes from those who are. Most high-speed rail services which link with airports and many transit systems serving airports also carry large numbers of passengers who do not use the airport.

6. CONCLUSIONS

All airports inevitably generate a large number of multimodal movements. Airports need to be accessed by users and, with the exception of those involving air-to-air transfers, other modes are involved. Equally, passengers and freight have to be vacated from airports. A distinction, albeit in many ways an arbitrary one, can usefully be made between whether access or egress from the airport involves local transportation or another interurban mode. The former has been very much the traditional case and considerable resources have been expended to allow residents and visitors to an airport to have easy interconnections with the immediate vicinity. The issue of linking air services directly through airports to other medium and long-distance modes is a more recent phenomenon. It has partly been brought about by congestion of some of the main air service routes, but has also been influenced by environmental arguments. Capture of decisionmaking processes by railway interest groups may also have been influential.

It is relatively easy to develop models indicating in the abstract the optimal degree of hubbing that should take place at an airport. By feeding in the attributes of the various modes, it is then, once more in theory, relatively easy to determine the types of transportation that would optimally service each link in the network. Lack of full information, and in many cases of a clear objective function, limits this type of analysis in practice. What we do find is that, in quantitative terms, airports do act as major multimodal nodes in the larger transportation network. Further, this role is changing as the nature of the airline industry changes in response to a variety of market forces and as policy influences the comparative advantages of the various modes.

NOTES

1. There are many forecasts of air traffic available. Boeing Commercial Airplanes (2002a; b) is an oft-cited source. For the global market, its prediction is for an annual growth in passenger revenue kilometres of 4.9% per annum and 8% for air cargo.

2. Heppenheimer (1995) looks at this from an historical perspective.

3. This should also be seen in the much wider context of increasing congestion across much of the more extensive transportation infrastructure in Europe, especially in areas where there has traditionally been the most rapid economic growth.
4. The main concern here is with air transportation's relationship with non-airline movements. There has been a tendency to blur modal distinctions in studies by dividing up conventional modes into several categories (e.g. treating "high-speed rail" as distinct from "conventional" rail). Perhaps a much stronger case could be made for dividing up air transportation between short and long-distance services -- which, for example, would separate out various components of hub-and-spoke air networks. While this is useful at times, this paper does not focus on inter-aircraft changes but on movements involving aircraft and surface modes.

5. More detailed analysis of the economics of hub-and-spoke operations are found in Button and Stough (2000), while Economides (1996) offers a rigorous analysis of network economics more generally.

6. The technical distinction between economies of scale and economies of scope can be seen by reference to the equation below, where C denotes cost and Q is output. Economies of scope are assessed as:

$$S=\{[C(Q^1)+C(Q^2)] - C(Q^1+Q^2)\}/\{C(Q^1+Q^2)\}$$

   $C(Q^1)$ is the cost of producing Q^1 units of output 1 alone, $C(Q^2)$ is the cost of producing Q^2 of output 2 alone and $C(Q^1+Q^2)$ is the cost of producing Q^1 plus Q^2. Economies of scope exist if $S>0$. There are economies of scale if C/Q falls as Q expands.

7. The paper does not go into any detail about the environmental costs of transportation. There is a general political agreement that they should be internalised through the "polluter pays" principle (OECD, 1975), which the EU favours putting into operation, mainly through the pricing system for infrastructure use (European Commission, 1998b). For a discussion of some of the issues involved, see ECMT/OECD, 1994.

8. A network of three nodes (as in Figure 1), all linked, requires three services, but only two if one node is used as a hub and traffic is funnelled through it. If there are four nodes this requires six fully-connected services but only three through a hub; with five nodes it requires ten

fully-connected services or four through a hub; with six nodes, 15 direct services or five through a hub, and so on.

9. In modelling exercises these attributes are usually reduced to "generalised cost" or "generalised time" to allow for comparisons on a common scale.

10. The empirical evidence available indicates that the purpose of travel has a strong influence on the attributes being sought. This can, for example, be seen in the wide variation in the elasticities of demand for various modes according to trip purpose (Oum, 1992).

11. Although there were serious studies carried out in Brazil in the early 1980s on developing a multimodal facility at Rio, which would involve sailing maritime containers directly into an airport facility to be transhipped out as airfreight. The economic issue was whether the time saving and extra reliability this afforded was justified to move goods across the Andes. In some countries with poor surface transportation (e.g. Papua New Guinea), sea-air transhipment is also undertaken, although with a short trucking leg between.

12. For a discussion of the role of air transportation in Europe, see Comité des Sages for Air Transport (1995).

13. These are a growing phenomenon in the US and other parts of the world and represent the emergence of self-sufficient concentrations of population and employment close to traditional urban areas but distant from the urban core. This results in more complicated patterns of traffic movement than with the stylised single-core urban model.

14. Air trucking strictly involves the movement of air cargo by road under an air weigh bill (AWB).

15. As a point of comparison, in the US, air trucking frequencies now attain 16 000 a week and around 1 000 city-pairs are served.

16. This may be short-sighted. Whilst breeches in security are most likely at nodal points in air transportation, the track potentially poses a much weaker link for surface modes such as rail. Recent history may be producing a gut reaction to security priorities that do not reflect genuine long-term vulnerabilities.

17. There are institutional as well as technical issues involved. For example, international air security is, by agreement, set by ICAO standards.

18. This list is mainly intended to cover passenger traffic interlining rail and air. There are already bonding arrangements covering air to trucking that in many countries have always included a high level of security, although modifications have been made since 2001. The discussion does not include the potential security issues of automobile-to-air movements, which generate issues such as redesigning airports to ensure parked cars are a secure distance from terminals and runways, that vehicles dropping/collecting passengers are "clean", etc. This type of concern was high in the US after 2001 but has been seen as less of an issue in Europe.

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THE ROLE OF AIRPORTS IN THE TRANSPORT CHAIN

Sean D. BARRETT
Department of Economics
Trinity College
Dublin
Ireland

THE ROLE OF AIRPORTS IN THE TRANSPORT CHAIN

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Dublin, February 2003

INTRODUCTION : OVERLOOKING AIRPORTS IN THE TRANSPORT CHAIN

In recent years, economists have belatedly addressed the economics of airports. Previously, airports were somewhat neglected, as both a relatively minor part of government and a relatively unimportant part of the air transport journey. The public view of the glamour of air travel reflected on the airlines, management and flight crews alike, but not on airports. The heads of state airlines became national figures in the media as did their opponents in the private sector, from Sir Freddy Laker to Michael O'Leary of Ryanair, the author's former student and chief executive of the airline with the highest market capitalisation in Europe. By contrast, airport chief executives never attained such media profiles.

Airports have now become major commercial enterprises, instruments of regional and national economic growth in a globalised economy and, as the title chosen for this Round Table indicates, interface multimodal nodes.

Airports in the transport chain are multimodal interchange nodes between:

(a) Airlines and airports;
(b) Passengers, airlines and airports;
(c) Passenger ground transport, airlines and airports including private cars, taxis, car hire, bus and train; and
(d) Freight, airlines and airports.

1. THE AIRLINE/AIRPORT INTERFACE

In the past, the interface between airlines and their passengers involved matters such as a good working relationship between the airport and the airline, good facilitation arrangements at airports for both airlines and their passengers, all-weather operation of airports and ready availability of runway, stands and gates. For passengers, the considerations were matters such as prompt delivery of baggage to the arrivals hall, easy access to gates, good signage, quick delivery of baggage and short walking distances within the airport. As the airline business became more competitive, the interface between the airlines and airports began to change. The contrast between the airport service requirements of non-competing and competing airlines were stressed in public debate by the new competing airlines.

1.1. The airport/non-competing airlines interface

The airline/airport interface has changed radically in the years since airline deregulation. In the past, airlines did not engage in price competition. Market capacity and shares were determined in advance by the airlines. Government price surveillance was lax compared to what happened later under deregulation. Airlines achieved regulatory capture over governments in regard to both the exclusion of new market entrants and efficient price surveillance.

The defeat of the Open Skies proposals at the Chicago aviation conference of 1944, in favour of protectionism, set the economic climate for aviation for the following fifty years. International aviation markets were limited to one airline per country, licensed by the government in each country and typically the national airline owned by the government. Governments were supposed to regulate fares but, in fact, the airlines rapidly achieved regulatory capture over their supervisory government departments, many of which became, in the public mind, the downtown offices of national airlines. Capacity and market shares on each international route were determined in advance by the airlines and revenues were shared. Within countries, internal air services were confined to operators licensed in that jurisdiction.

In an air market without price competition and a ban on new entrants, airlines had both the resources and incentive to engage in non-price competition such as product differentiation, expensive advertising and public relations exercises. There were other adverse consequences from the non-competitive organisation of aviation. That monopolists and oligopolists charge too much was hardly news to economists or to consumers. That the monopolists and oligopolists can charge too much because they produce too little was less widely understood, and neither did we understand the consequences for the economy as a whole from the success of one sector opting out of normal market economics.

In the world of non-competing airlines, pricing was simply a matter of cost increase recovery rather than drilling down into the entire cost base of the airline. Since airports were part of the airline cost base, they operated also in a market with exemption from drilling down their cost base. Colluding airlines needed to serve the same airports because they shared markets and interchanged their tickets. It was a Noah's Ark system, in which every international air route involved two airlines, two airports and two governments.

The *de facto* control of busy airports passed to the airline scheduling committees, typically controlled by the host national airline. The scheduling committees, in turn, allocated slots at airports to airlines in order of seniority at the airport. This abdication of airport managers from managing their airports seems to me to be without parallel. It would be bizarre, for example, that, as a long-established customer of a shop, one could claim ownership rights over the shop owner in the running of the business. Slots at hub airports came to be seen as major assets in the balance sheets of airlines, despite the fact that the investment in airport capacity had been made by the airport rather than the airlines.

1.2. The airport/competing airline interface under deregulation

The impact of deregulation on air fares and market size was predictable both from the standpoint of economic theory and contrasting experience in monopolistic and competitive markets. In Adam Smith's Wealth of Nations, we read that monopolists charge too much, produce too little and greatly increase their incomes, whether in wages or profits, to above the levels in competitive markets.

During the years 1938-1978, the regulated US internal market for interstate air travel charged fares twice those in California, where the state government did not restrict new market entrants, such as San Francisco-Los Angeles. In Europe, the charter airlines serving sun destinations and operating outside the cartel arrangements regulating scheduled international air services between major cities, charged fares between 32 and 37 per cent of the scheduled airline fare for similar distances.

The most successful European deregulation has been on the Ireland/UK routes in 1986. Fares fell by more than half on the first day, from £208IR to £95.99IR on the Dublin-London route. Passenger numbers, static between 1978 and 1985 grew by 92 per cent in August of 1987, the first full year of deregulation, compared to August of 1985, the last full year of pre-deregulation policies.

By 1997, the Dublin-London route had 4 million passengers and was the second busiest international scheduled air route in the world after Tokyo-Taipei. The number of air passengers between Britain and Ireland was over 7.8 million compared to 6.4 million flying between Britain and France, 7.1 million between Britain and Germany and 5.2 million between Britain and Italy.

In 2002, the estimated passenger numbers carried by Easyjet (17 million) and Ryanair (16 million) in the British market is 84 per cent of the British Airways passenger number of 39 million. The productivity gains have also been impressive. The 15 million Ryanair passengers were handled in 2002 by 1 500 staff. This ratio of 10 000 passengers per staff member contrasts with an average of 752 in the Association of European Airlines. The gains in productivity have come from contracting out many functions, such as handling and maintenance, to specialist firms rather than performing them in-house; bringing pilots and cabin staff closer to maximum permitted flying hours; and eliminating sections of the cost base, such as in-flight service, business class, seat allocation, travel agents and the operation of multiple aircraft types.

1.3. The airport infrastructure requirements of deregulated airlines

The impacts of airline deregulation on airports may be examined under three headings; the pressure on costs at established airports and competitive pressures between airports.

As air fares fell after deregulation, the airport share of ticket prices rose. The very large efficiency gains of the new entrant airlines compared to the established airlines meant that the new airlines began to put pressure on their suppliers of services, such as airports. The new airlines began to dispute airport charges, just as they had previously disputed air fares.

Table 1 indicates the level of airport charges at thirteen traditional hub airports in Europe with an average of $5.91 per work load unit (WLU). The WLU is either one passenger or 100 kg of cargo. Table 2, prepared by the University of Westminster from data supplied by Ryanair, indexes charges at thirteen UK airports and ranked Dublin as the most expensive.

The cost data in Tables 1 and 2 indicate the type of benchmarking exercises which regulatory agencies perform in order to adjudicate on competing claims by both airports and airlines that charges at airports should be either increased, as advocated by airports, or reduced, as advocated by airlines.

Table 2 also indicates that the lesser airports in the UK have lower charges than at Gatwick, Birmingham and Manchester. The data for the eight provincial airports listed in the table after Stansted indicate that Ryanair has negotiated airport charges with at least a two-thirds discount on the Stansted charge.

Table 1. **European airports aeronautical revenues per WLU, (1998) US$**

Airport	Revenue US$
MAN	11.1
VIE	9.0
HAM	8.6
FRA	8.1
BAA	7.1
ADP	5.7
BRU	5.6
AMS	5.5
CPH	5.0
SEA	4.5
AENA	4.0
ADR	3.8
Air Rianta	3.4

Source : Warburg Dillon Read (1999).

Table 2. **Ryanair charges at Dublin and UK airports (January-June 2000) (Ryanair network average = 100)**

Dublin	204
Gatwick	179
Birmingham	155
Manchester	122
Luton	119
Stansted	102
Leeds/Bradford	36
Cardiff	31
Bournemouth	<30
Liverpool	<30
Bristol	<30
Prestwick	<30
Teeside	<30
Derry	<30

Source : University of Westminster.

This new process of agreeing airport charges replaces set scales of charges. The new airlines will seek out airports where there is significant overcapacity and seek to negotiate discounts. The airport operators will assess whether there is a net gain to them from increasing the volume of business. Spare capacity at airports may be the result of over-investment in the past, the use of airports as instruments of local and regional development by city and provincial governments and chambers of commerce, the conversion of former military airports to civilian use and increased private sector investment in airports.

Borgo and Bull Larsen (1998) point out that, historically, "*in the whole of the airline value chain the only participants not making attractive returns are the airlines themselves. To capture their right share of the value, the airlines must set about restructuring the value chain to improve their own position within it (59).*" Borgo and Bull Larsen state that between 1992 and 1997, airlines as a group earned 6 per cent return on capital compared to 17 per cent at privatised airports such as BAA, and 27 per cent return to the owners of CRS. Aircraft manufacturers and lessors, ground handlers and airline caterers were also far more profitable than the airlines they supplied with the various services. The process of new airlines, having hugely reduced their internal cost base and then tackling the costs of their external suppliers of services, is therefore entirely predictable, according to the analysis of Borgo and Bull Larsen.

The new airlines began to query the value of the airport product, just as they had themselves redefined the airline product by removing meals, free newspapers and drinks, reserved seats and business class. The new airlines did not require lounges and airbridge access to planes. They prefer simple, single-storey, low-cost terminals. The preference of the new airlines for low-cost facilities and low payments to the airports by airlines will increase pressures on airports to achieve higher productivity of labour and a better return on capital investment. The new airlines stress better airport management as the key to airport efficiency. This contrasts with the tradition of gold-plating of investment in airports not facing competing low-cost airlines. Traditional rate-of-return regulation of airports encouraged gold-plating, whereas the regulation of airports in a more competitive environment includes an RPI-X target, to keep any rise in airport charges below rises in prices as a whole, and limits on capital expenditure in order to control gold-plating. Airports therefore need measures of the efficiency of their labour force and their infrastructure, such as runways and terminals.

One such measure of infrastructure efficiency at airports is the throughput at check-in gates. The low-cost airlines require fewer check-in desks because check-in is speeded up by scrapping seat allocation, frequent-flyer points allocation, multi-journey tickets and interlining. The Ryanair throughput per check-in desk at Dublin is 130 000 passengers per year, compared to 48 000 per year for all other airlines. Ryanair handled 25 per cent of departing passengers but used only 11 per cent of the check-in desks.

The Dublin traffic of the other airlines includes a significant transatlantic traffic, traffic to third countries hubbing at Heathrow, Amsterdam and Paris and traffic transferring to and from eight routes within Ireland. This mix of traffics is likely to require far more check-in gates than the simple low-fare, point-to-point check-in required by low-cost airlines.

At Stansted, the passenger throughput per check-in is 110 000 for Ryanair and 70 000 for the other airlines, indicating that even where the traffic types are broadly similar the low-cost airline requires less infrastructure for check-in.

Hamzaee and Vasigh (2001) found that, in 1998, the average number of passenger departures per gate for ten major US airports was 194 000, with San Francisco exceeding that figure by 50 000. JFK was the lowest at 100 000, Detroit was 40 000 below the average and "the rest of the airports operated, more or less, at the average level."

In addition to lower charges at airports, the main requirement of the new airlines was for quicker turnaround times, as low as 25 minutes. The low-cost airlines required low-cost, single-storey terminals, with passengers arriving and departing at the same gate. Airbridges were seen as an unnecessary expense, to be eliminated from the cost base in the same manner as the low-cost airlines had eliminated what they regarded as excess costs within airline control, such as business class, in-flight service, newspapers, seat allocation and frequent-flyer points.

At Dublin, Ryanair submitted a proposal to the Government to build and operate its own low-cost terminal, having successfully argued that inter-terminal competition should be examined by the Government. The low-cost terminal was endorsed in January 2003 by the Chief Executive of Aer Lingus. In the era of non-competing airlines, Aer Lingus did not express public criticism of Irish airports, as both airline and airports were state companies.

The interface between airports and airlines may thus be seen as evolving through four phases:

1) Non-competing, usually state-owned, airlines and almost universally state-owned airports, with fares, market size and shares, and airport prices, investment and employment decided within the bureaucracy;

2) Competing airlines seeking, by public campaigns, to secure discounts in airport charges;

3) The establishment of airport regulation agencies to determine the level of prices charged at airports. The decisions of the regulator are typically contested by both airports and airlines, with competing claims of regulatory risk and regulatory capture. The regulatory risk case made by airports is that too strict a code of conduct by the regulator places the finances of airports at risk. The regulatory capture argument by airlines is that, as in other areas, airport regulation is sooner or later captured by the airport sector in the interests of airport owners and management, at the expense of the customers, passengers and their airlines;

4) The development of competition within and between airports as a complement to airport regulation. The abolition of ground-handling monopolies at airports has introduced price competition to this important component of the airline ticket price and reduced the dependence of the new airline on incumbent producers. It is also possible for airports to institute competitive tendering for airport ATC for fixed time periods, thus reducing the cost base of the airport. Competition between airports is examined below.

The interface between the deregulated airline and the airport may therefore be summarized as low-revenue yield per passenger for the airport, with a low-cost airport cost base per passenger, without many of the features of the airport product at the traditional airports. The potential gains for airports from the interface with low-cost airlines were the promise of volumes which the conventional airlines could not deliver and the prospects of extra revenues from the passengers of the low-cost airlines. Since low-cost airlines charge much lower air fares, their passengers have potentially more spending power at the airport. Since low-cost airlines had withdrawn the traditional free in-flight service, there was a potential for the new airports to sell food, refreshments, newspapers, journals, etc., to the passengers of low-cost airlines. Since the low-cost airlines tend to use airports which are more distant from city centres than the established airports, there is scope for the new entrant airports to sell

services such as car hire and bus and train tickets. When the new airlines bring their cost-cutting conduct to established airports, this generates pressures on the managers of established airports which were not a feature of the old, closed airline markets, without either price competition or new entrants. Unlike the established airlines, the new entrants also began to promote inter-airport competition.

2. PASSENGERS, AIRLINES AND AIRPORTS

2.1. Airports in competition -- the airport/airline/passenger interface

Airport competition has generated surprisingly successful results in the deregulated European aviation market. New services to previously little-used airports have been popular with passengers seeking low-cost point-to-point air service, through a combination of low-cost airlines and low-cost airports. After some initial hesitation, airport managers became willing to do deals with the new airlines which wanted low-cost airports with quick turnaround times. Passengers responded quickly to the new combination of low-cost airlines and low-cost airports. The advantages of the new airports, in addition to lower air fares, were less congestion at airports, less walking times between ground transport check-in desk and departure gate, quicker baggage collection times and, due to the smaller scale of operation, less chance of confusion and getting lost in a complex airport. The shorter time spent at the new airports could be offset against the longer distance and time required from the city centre to new airports compared to main airports. In some cases, the new airports served may have had a separate catchment area, thus saving some passengers long ground-transport, round-trip journeys to and from more distant airports.

In addition to the service benefits and fare savings generated by the combination of new airlines and new airports, the vitally crucial role played by the new airports should be stressed. The combination of a shortage of capacity at Europe's hub airports and the control of that capacity by incumbent airlines through the 'grandfather rights' slot allocation system, means that without new airports the new entrants would not have been able to achieve the scale of new market entry required to make deregulation a success.

2.2. Case studies in airport competition

(i) *London:* The largest international route in Europe, Dublin-London was a virtual Heathrow monopoly before deregulation in 1986. Under deregulation, half the 4.4 million passengers use Stansted, Luton, Gatwick and London City.

(ii) *Glasgow Prestwick*: Built for the transatlantic market, Glasgow Prestwick had 650 000 passengers in July 1976 and only 10 000 in 1993. Ryanair opened a Dublin service in 1994, in competition with the Aer Lingus monopoly on the route using Abbotsinch, and took 60 per cent of the market. Passengers contrasted the longer surface distance of 38 versus 8 miles with the fare reductions offered, combined with discounts on both rail and bus access to Prestwick from throughout Scotland. The total market grew by more than the Ryanair-Prestwick passenger numbers. Prestwick-Stansted, connecting lesser

airports at both ends of the London-Glasgow routes, has ten flights a day. In addition, there are services from Prestwick to Paris Beauvais, Brussels South, Frankfurt Hahn and Oslo Torp.

(iii) *Northwest England*: Barrett (2000) documents competition between Manchester, Liverpool and Leeds-Bradford in the 1990s. The competing airports are within a forty-mile radius of Manchester, which has steadily increased its market share to 67 per cent since entering the low-cost airline segment of the market in 1994, while Liverpool's share peaked at 41 per cent in 1993.

(iv) *Brussels South* has a market share of two-thirds of Irish traffic from Dublin and Shannon and 27 per cent of London-Brussels traffic.

(v) *Frankfurt Hahn/Stansted* has 22 per cent of Heathrow/Frankfurt traffic and is a hub for fourteen routes to seven European destinations, including five in Italy.

(vi) *Hamburg (Lubeck)* has a 27 per cent share of the London-Hamburg market.

(vii) *Stockholm Skavsta and Vasteras* have a 31 per cent market share of the London-Stockholm market.

(viii) *Oslo Torp* has 23 per cent of the London-Oslo market.

(ix) *Venice:* Stansted-Treviso has slightly under half of the London-Venice market.

(x) *Milan Orio al Serio* currently has 21 per cent of the London-Milan market.

(xi) *Rome Ciampino* has a 29 per cent share of the London-Rome market.

While airport competition is most frequently discussed in terms of reduced air fares, there are other dimensions which are important. Regional areas receiving direct service, for the first time cater for passengers who do not have to travel to busy hub airports, thus reducing surface transport and hub airport congestion. The newly-served airports allow twenty-five-minute turnaround times, thus increasing the productivity of planes and their crews compared to the slot-constrained hub airports. Examples of new service at secondary city airports include Bologna, Pisa, Turin, Genoa and Verona, reflecting Alitalia's emphasis on Rome and Milan, and Lyons and Toulouse, reflecting the focus on Paris by Air France.

2.3. Potential airport competition in Europe

Airport competition requires that there are available alternative airports and a willingness by both airlines and passengers to go into competition with the incumbent dominant airports. As the case studies above indicate, both airlines and passengers have been willing to transfer. Airport competition has potential to expand further, given the profitability of the low-fare airlines, their attractiveness, the attractiveness of the airports they serve and the supply of airport capacity.

Studies by Cranfield University Air Transport Group indicate that there is considerable scope for airport competition in Europe (Fewings, 1999). These studies found that in France, the UK and Germany, there were, respectively, 32, 34 and 28 airports within an hour's surface access of another airport. Further Cranfield studies showed that in 10 EU countries there were 131 airports within a

one-hour surface travel time and 369 within two hours. Table 3 summarises a Cranfield study of thirteen countries with 431 airports. The table shows that, for example, in Norway, there are 23 airports of 1 600 metre runways or over, that is 5.3 per million population. There are 28 airports with runways shorter than 1 600 metres, that is 6.5 per million population.

Table 3. **Level of airport and runway provision in Europe, 1998 -- Number of airports per million inhabitants according to runway length**

	Runway length	
	Over 1 600 m	**Under 1 600 m**
Austria	0.8	0.0
Denmark	1.9	0.4
Finland	4.1	0.0
France	1.0	0.1
Germany	0.3	0.1
Greece	2.5	1.2
Iceland	22.5	26.2
Ireland	1.1	2.5
Italy	0.6	0.1
Norway	5.3	6.5
Scotland	1.6	2.1
Sweden	4.3	0.7
UK*	0.7	0.3

*excluding Scotland
Source: Fewings (1998).

The large amount of relatively unused airport capacity in Europe reflects the previous concentration by non-competing airlines at hub airports, the high fares charged which dampened down demand, the supply of airports due to the civilianisation of military airports in recent years and the use of airports to promote regions and cities.

It might also be argued that if the above unused capacity in Europe's airport infrastructure were to significantly increase utilisation, a further wave of investment in airports would follow. This is examined in 2.4. below.

2.4. New airports investment in a competitive market

The influential Foster/Boyfield arguments against competitive airport privatisation in Britain secured the unitary privatisation of the British Airports Authority in 1987. The arguments are summarised in Table 4.

Table 4. **The Foster/Boyfield case against competitive airport privatisation, 1984**

1.	Planning controls and long lead times preclude new entrants.
2.	Product diversity.
3.	Small share of airport charges in airline costs makes airport competition difficult.
4.	Only a small number of airports can be viable given economies of scale in airport operation.
5.	Market provision of airports risks underinvestment.

Source: *Public Money* (1984), General Series 4.

Some of the Foster/Boyfield arguments were already being overtaken by events at the time they were made. Airport competition in Belfast began in the early 1980s when the City airport attached to the Shorts aircraft factory entered into competition with Belfast International. London City airport was constructed for £7 million, with a construction time of forty weeks. The economies-of-scale argument was also doubted. Manchester, with five million passengers in 1982-83, had profits of £7.3 million, while Gatwick, with 11 million passengers, had profits of only £0.775 million. Edinburgh had a loss of £1.3 million, with 1.2 million passengers, while East Midlands made a profit of £1.1 million on 900 000 passengers. Stansted had an income 14 times greater than the profitable airport at Gloucester-Cheltenham, but made a loss of £4.55 million.

It is difficult to accept the Foster argument that market provision of airports risks underinvestment. The ability of monopolists to earn economic rent derives from the restriction of output below output in a competitive market. In fact, the congestion at many of Europe's main airports at the time indicated that the monopolistic provision of airports had resulted in underinvestment.

Events since the introduction of greater competition in European aviation further weakened the Foster/Boyfield arguments against airport competition. As air fares fell, the airport share increased. Low-cost airlines sought reduced airport charges. Both the new airlines and their passengers transferred significant business to new airports. For example, the point-to-point passenger did not need the interline facility at expensive hub airports and transferred to low-cost airlines at low-cost airports. While the product diversity argument against airport competition maintained that a new airport could not hope to replicate the range of routes available at the existing hub airports, the actual experience of airport competition indicated that, typically, a quarter of passengers found the new airports an acceptable substitute, with as much as half the market on Dublin-London, Europe's busiest route, choosing airports other than Heathrow since deregulation.

Doganis (1992) expected airport *"financial performance should continue to outstrip that of its major customers, the airlines."* At the Global Airport Development Forum in Athens in 2002, Doganis advised airports to *"consider attracting low-cost carriers into the void left by failing airlines. Low-cost carriers are the future* (*Airports International*, Vol. 35, 1, p. 13)."

In 2001, Credit Suisse First Boston's Global Transportation Quarterly Review stated that airports are a low-risk investment with good growth prospects, predictable revenue streams and commercial revenue potential (*Jane's Airport Review*, July/August 2001). Ashford documents the progression of airports through commercialisation, corporatisation and privatisation. The private investor in both airports and airlines will continue to supplant the once-dominant state airlines and airports with a competitive edge to the airline/airport interface (*Airport 2000*, p. 45).

3. THE PASSENGER/AIRPORT/AIRLINE INTERFACE

A study of eighteen European airports found that passenger public transport use ranged from 1 per cent at Lelystad to 41 per cent at Munich (Navarre, 1996). The average was around 21 per cent, comprising 9 per cent for rail and 12 per cent for buses. Graham reports other public transport shares at Oslo (63 per cent), Zurich (59 per cent), Amsterdam (42 per cent), Paris CDG (20 per cent), Brussels (20 per cent) and Paris Orly (18 per cent). In 1998, the train and bus shares at the major UK airports, Gatwick, Heathrow and Manchester, were 30 per cent, 33 per cent and 10 per cent, respectively. At Stansted, the public transport share of passengers is about a third and the 2001 estimate for Heathrow is slightly higher (BAA, 2001). At Dublin airport, the public transport shares in 1995 were 17 per cent for passengers and 14 per cent for staff (DKM, 1999).

Research by the CAA, on modal choice of ground transport at the three major UK airports since 1972, shows a long-term decline in the share of bus and train in airport journeys and provides detailed analyses of the trip distribution by type of air passenger and by residence in the UK and abroad.

Table 5 shows the long-term trend of ground transport use at three major UK airports from 1972 to 1998: Heathrow, Gatwick and Manchester. Passenger numbers increased from 21 million to 105 million in the 27-year period. The trends over the period for each mode were as follows:

(1) The private car was the dominant mode at each airport, with shares in 1998 of 60 per cent at Manchester, 52 per cent at Gatwick and 36 per cent at Heathrow.

(2) Taxi share increased at all three airports -- from 5 per cent to 15 per cent at Gatwick, 15 per cent to 27 per cent at Heathrow and from 16 per cent to 28 per cent at Manchester. Adding in car-hire shares of 3 per cent at Gatwick, 4 per cent at Heathrow and 2 per cent at Manchester gives total car shares at Gatwick of 70 per cent, Heathrow of 67 per cent and Manchester of 90 per cent for private car, taxi and car hire combined. The 1972 shares were Gatwick 52 per cent, Heathrow 59 per cent and Manchester 83 per cent .

(3) The rail share at Gatwick, the best of the three airports in terms of rail access, fell from 37 per cent to 20 per cent over the period. The rail share at Manchester ranged from 5 to 6 per cent. Until the very end of the period, rail access to Heathrow was by London underground, and fell from 20 per cent to 15 per cent.

(4) The bus share at Heathrow fell sharply from 32 per cent to 14 per cent when the Underground reached the airport, but has since averaged 14.6 per cent . The Gatwick bus share was 9 per cent at the start of the period and 10 per cent at the end, with an average of

11.9 per cent. The bus share at Manchester fell throughout the period from 16 per cent to 4 per cent. Only half this decline in market share was taken up by the provision of rail services to the airport.

(5) The car hire share has remained stable since the mid-1970s, at 4 per cent at Heathrow and 2 per cent at Manchester and is currently 3 per cent at Heathrow.

Table 5. **Mode of transport access to major UK airports, 1972-98**

	1972	1978	1984	1987	1991	1996	1997	1998
GATWICK								
Car	42	42	47	52	52	50	49	52
Hire car	5	2	3	3	3	3	3	3
Taxi/Cab	5	5	6	7	9	12	13	15
Rail	37	38	32	26	24	20	21	20
Bus/Coach	2	1	1	0	1	0	0	0
Terminating Pass. (m)	5.0	7.2	12.6	17.6	16.8	19.8	21.1	22.9
HEATHROW								
Car	39	39	41	40	42	38	37	36
Hire car	5	4	5	4	4	5	4	4
Taxi/Cab	15	20	20	20	20	24	25	27
Bus/Coach	32	14	14	15	13	16	16	14
Underground Rail	0	20	20	20	20	16	16	14
Express Rail (HEX)	0	0	0	0	0	0	0	3
Other	2	1	1	1	1	1	1	1
Terminating Pass. (m)	14.3	20.8	22.6	26.8	29.8	37.3	38.5	40.6
MANCHESTER								
Car	65	71	73	69	68	65	63	60
Hire car	2	2	2	3	3	3	3	2
Taxi/Cab	16	15	13	16	24	24	15	28
Rail	0	0	0	0	0	5	5	6
Bus/Coach	16	11	11	11	6	4	4	4
Other	1	1	1	1	0	0	0	0
Terminating Pass. (m)	1.7	2.5	5.0	8.6	11.5	14.0	15.7	16.5

Notes: HEX began in summer of 1998 with a coach transfer.
Private car includes passengers using car park courtesy buses.

Source: Civil Aviation Authority (1999), Passengers at Garwick, Heathrow and Manchester Airports in 1998, CAP 703, Table 28.

3.1. Airport access by passenger category

Table 6 indicates the breakdown of ground access transport used at the three airports by six passenger types in 1998. There are a number of striking divergences from average at each airport.

UK-based leisure passengers on inclusive tours using Gatwick use private cars to the extent of 69 per cent, that is, 1.33 times the car use rate for all passengers at the airport. At 8.4 million passengers, this category is the biggest single category of user at Gatwick, accounting for 37 per cent of all passengers. The second largest category of passenger at Gatwick, UK-based leisure "other", just under 6 million passengers, has a 1.12 times greater propensity to use private car transport at Gatwick than the average passenger. At Heathrow, the use of private cars by UK leisure passengers is 1.34 for the inclusive tour sector and 1.31 for the "other" leisure sector, which is the largest category with 10.4 million passengers, or 25 per cent of the 40.6 million passengers covered by the study.

Table 6. **Mode of transport access at major UK airports by passenger type, 1998**

	United Kingdom			Foreign			All passengers
	Business	Leisure IT	Leisure other	Business	Leisure IT	Leisure other	
GATWICK							
Car	44.2	69.0	58.1	14.1	8.3	26.9	51.7
Hire car	5.4	0.4	0.7	10.3	1.0	7.1	2.7
Taxi/Cab	22.6	15.6	13.9	14.8	11.4	9.7	14.8
Rail	24.5	9.3	21.4	36.3	33.8	34.5	20.4
Bus/Coach	3.0	5.6	5.8	28.3	45.4	21.7	10.3
Other	0.3	0.0	0.0	1.2	0.1	0.1	0.1
Pax (m)	2.5	8.4	5.9	1.5	0.8	3.6	22.8
HEATHROW							
Car	45.3	49.3	48.3	19.9	3.2	26.8	36.6
Hire car	4.0	0.6	0.7	7.1	3.2	6.6	4.0
Taxi/Cab	30.9	21.3	21.0	39.1	19.7	22.4	26.7
Rail	4.1	1.8	2.6	4.4	0.8	2.8	3.2
Bus/Coach	5.8	18.5	13.3	14.8	49.7	18.9	14.5
Other	0.3	0.0	0.1	0.9	0.0	0.3	0.3
Pax (m)	9.5	2.4	10.4	7.2	1.6	9.6	40.6
MANCHESTER							
Car	60.8	61.3	65.4	35.5	34.6	56.3	60.4
Hire car	3.3	0.1	0.5	14.8	11.2	10.2	2.2
Taxi/Cab	28.4	30.3	23.5	36.6	36.2	13.5	27.5
Rail	5.5	4.0	7.8	7.2	5.4	13.7	6.0
Bus/Coach	1.3	4.3	2.8	5.5	12.6	6.2	3.7
Other	0.7	0.0	0.0	0.5	0.0	0.1	0.1
Pax (m)	2.4	7.9	3.9	1.0	0.1	1.3	16.5

Source: Civil Aviation Authority, *op. cit*., Table 29.

In view of the general policy intention of reducing private car use at airports, an examination of the leisure passengers based in the UK is a good starting point for such a policy. At Gatwick, these categories account for 63 per cent of passengers covered in the CAA study.

The outgoing leisure trip has typical characteristics: it originates at home, involves significant quantities of luggage for an extended trip abroad, the event occurs relatively infrequently -- and the advantages of the car include availability and convenience, direct house-to-airport service, security for luggage, less exposure to adverse weather at bus stops or train stations and fewer changes of mode of transport. Unless the air passenger lives beside a bus stop or train station, it is likely that the journey will begin by car in any case. The journey then requires unloading luggage at bus stop or train station, loading luggage on bus or train and unloading it at airport station for transfer to the airport check-in. Should the bus or train journey require either a change of route or mode, the problems of the leisure air passenger are further increased.

The CAA found that of 14.3 million UK leisure passengers at Gatwick and 12.8 million at Heathrow using cars for their journeys to and from the airport, 46.5 per cent and 57.6 per cent, respectively, gave as their reason that they were given lifts. Speed/ease/door-to-door were cited by 19.5 per cent of these car users. Apart from 8.6 per cent who chose car because of lower cost, no other of the fifteen reasons for UK leisure passengers choosing airport access by car exceeded the 3.4 per cent who cited luggage and early flight times as their reason.

In the UK and foreign business sectors, car use for airport journeys was characterised by a high level of company-provided transport: 45.5 per cent of foreign business travellers at Manchester and 42.8 per cent of the larger number in this category at Heathrow.

The foreign business, leisure inclusive-tour and leisure "other" categories all use train and bus at Gatwick to a significantly greater degree than passengers as a whole. At Heathrow and Manchester, the foreign business passenger tends to be a greater than average user of taxis rather than bus and train. Heathrow and Manchester both have foreign leisure passenger use of bus and train in excess of the use rate by average passengers. Foreign leisure passengers at airports presumably have a less dispersed pattern of ground destinations than residents, in that the tourist destinations are concentrated in high-density city centre areas. This market segment is thus easier for public transport to serve.

3.2. Airport access by workers at airports

The difficulties of operating public transport in residential areas with medium and low densities of population are long acknowledged in transport economics. In such areas there is likely to be a pattern of public transport service to the city centre primarily, rather than direct to airports on the periphery. As Graham (2001) notes, it has proved even more difficult to persuade staff at airports to use public transport than to persuade air passengers to do so. Employees at Heathrow use cars to and from the airport to the extent of 75 per cent, compared to 41 per cent of passengers. At Manchester 80 per cent of passengers use cars and taxis compared to 92 per cent for staff. At Stansted in the late 1990s, the car share of staff journeys to the airport was 99 per cent. Proposals to raise the 1 per cent public transport share to 4 per cent included the development of public transport, payment of £110 per annum to those who gave up their free car park spaces, promotion of car-sharing and cycleways and an airports travelcard with discounts of up to 80 per cent on normal fares and a charge of £30 per month or £300 per year.

Out of 10 000 staff at the airport, the transfers have been small. By March 2001, there were almost 400 users of the travelcard and the carshare scheme had 400 members. Employees' residences tend to be distributed widely around airports. There is usually a pattern of 24-hour working at airports, whereas public transport may not be available throughout the entire 24 hours. There is also a tradition of providing free parking for staff at airports. Taking a rule of thumb that each million passengers per year generates a thousand jobs at the airport, a million extra passengers at Heathrow

will generate 410 000 car trips by passengers and 355 000 car trips by airport staff. The latter estimate is based on 75 per cent car use by staff and 250 days' working per year, and a return airport journey per staff member per working day (BAA, 2002).

3.3. Car access at airports

This is the dominant mode of access to airports. It is a form of access which is attractive to users and to airports as a source of revenue. The user requirements are for reasonable charges and easy access to terminals. It is a matter for analysis to advise whether the welfare case made against car use in city centres also applies to car use to and from airports. In cases where car users pay their road track costs, such as infrastructure and accident costs, and pay full-cost airport parking charges, it is not obvious that governments should intervene to restrict car use at airports without causing a net reduction in economic welfare. Airports are almost always outside the central business districts where traffic management measures, such as road pricing in Singapore and London, and normal restrictions on car parking and use in city centres usually apply. Journeys such as suburb to airport, other than through the city centres, and rural area to airport, may have minimal social cost, and measures to restrict them may generate social costs rather than social benefits. The point is made here merely to emphasize that it is not universally the case that airports should seek to limit car access by either their passengers or staff without the evidence to support the proposition.

Car hire was used by 2.6 million terminating passengers in 1998 at the three major UK universities examined in Table 5. The share of car-hire users was an average of 3.3 per cent, with Heathrow the highest of the three airports, at 4 per cent. In the new airports being promoted by the new-entrant, low-cost airlines, the car-hire share is higher because of greater use of fly-drive packages. The sector is a significant source of income for airports.

The car-hire sector requirements at airports include reasonable prices for renting stands and that car-hire desks and car-hire parks should be visible and accessible. Concerns expressed by the sector include the lack of certainty due to the bidding systems used at airports and the wish of some airport managers to move car hire away from arrivals terminals and, in some cases, off the airport.

3.4. Regulation of airport access by public transport -- taxi and bus regulation

In the airports surveyed by the CAA and shown in Table 5, the taxi shares of terminating passengers were high, at 28 per cent in Manchester, 27 per cent at Heathrow and 15 per cent at Gatwick . The service is valued by passengers because it is convenient, operates door to door and is easier for those with baggage. The passenger interest in this sector is to secure full availability of this service at low prices. The suppliers of taxi services have, however, frequently achieved regulatory capture. As a result, new entrants are restricted, licences acquire large scarcity values and passenger waiting times increase.

Even in jurisdictions where there is an aspiration to promote public transport, there may frequently be legislation preventing new market entry to the provision of public transport. This makes the public transport product more expensive, reduces supply and restricts investment, in direct contradiction of the policy of promoting public transport. This problem frequently arises in the case of taxi and bus transport.

At Gatwick, taxis are the second choice mode of airport access by leisure air passengers. In countries where market entry to the taxi sector is restricted and taxi licences thereby acquire a scarcity value, the supply of taxis is reduced and the incumbents earn supernormal profits. In Ireland, in November 2000, the High Court deregulated the taxi sector after a period of severe restriction of new entrants since 1977, at the behest of the incumbent taxi licence-holders. The legal judgement was based on the right of persons to enter an occupation for which they had the necessary training and the right of other EU citizens to enter an occupation by ending a policy of restricting entry which, *de facto*, favoured the citizens of Ireland, who held the vast bulk of the licences and excluded other EU citizens. Because of restricted entry, taxi licences acquired a scarcity value of over 100 000 euros, representing the expected supernormal profit stream arising from the ban on new entrants. There were long delays at taxi ranks due to the shortage of supply of taxis. Since deregulation, the number of taxis has increased from 3 913 to 11 630 nationwide and from 2 722 to 9 300 in Dublin.

A review of taxi deregulation in Dublin, by Goodbody Economic Consultants in 2001, found that over two-thirds of people surveyed believed that deregulation was a good idea, with 14 per cent disagreeing. The review found significant time savings to passengers from taxi deregulation. *"In 2001, 48 per cent of persons waited for less than five minutes, a considerable improvement compared to 25 per cent in 1997."* After midnight, the average waiting time was in excess of 30 minutes for 43 per cent of the hours surveyed in 1997 and for only 6.2 per cent in 2001. Only 20.3 per cent of hours surveyed had waiting times of less than five minutes in 1997. Under deregulation, this had risen to 60.2 per cent in 2001.

The Irish case study indicates that cities or states which restrict entry to the taxi sector should not be surprised either that the would-be customers will turn to driving their own cars, the taxi service will deteriorate and the taxi licence-holders will organise to retain the restrictions on new market entry.

Taxi deregulation should also permit shared taxi, minibus and limousine services, in order to put in the market public transport services which rival private cars, the dominant form of ground transport at most airports.

The ISOTOPE Report, prepared for the Lisbon EU Summit in 2000, contrasted bus costs under the traditional EU closed market system, the reformed system of competitive tendering in some EU States such as Denmark and deregulation, as in the UK. The OECD (2001) noted that there were savings of 24 per cent in the costs of operating the bus system in Copenhagen when public service tendering was introduced in 1990. The costs of the three options in organising the bus market, as estimated by ISOTOPE, are shown in Table 7.

Table 7. **Comparative bus costs per vehicle-km in 1996 (Euro)**

	Cost per vehicle-km	**Index**
Closed markets	3.02	100
Controlled markets	2.26	75
Deregulated markets	1.44	47

Source: ISOTOPE Report, 1997. Commission of the European Communities, COM (2000/0212).

If we wish to increase the bus market share at airports, the message from the ISOTOPE report is clear. The market should not ban new entrants and competitive behaviour. Much of the economic arguments against bus competition date from the 1930s, when the airports examined in this section were minuscule. The bulk of their growth in numbers has been since the mid-1980s, by which time economic policy, over a wide range of sectors, had returned to favouring competition as a spur to efficiency. In view of the gains from deregulation in transport in general, the policy implication here is that, even in countries which still ban or restrict competition in bus services, there should be deregulation on routes to airports. Bus services to airports have potential advantages, such as fewer passengers required per service than on trains, thus facilitating services on thinner routes and at greater frequency, a larger potential network and lower costs. Heathrow is the second biggest long-distance bus station in Britain after Victoria coach station.

The obstacles to bus deregulation in most European countries are likely to derive from regulatory capture by the bus sector. There is a history of government intervention in public transport to prevent or severely restrict competition in the sector, at the behest of the incumbents rather than in the interest of consumers or the wider economy. In the UK, market entry is easier and subsidies are tied to routes rather than operators, but the regulatory authorities have failed to deal with predatory pricing by larger bus companies against their smaller rivals.

Airport authorities wishing to reduce car travel and to increase bus travel at airports might examine the differing ground transport choice by UK leisure inclusive-tour passengers and their foreign counterparts. The unweighted market share for the three airports examined by the CAA is 9.5 per cent bus use by UK-based passengers compared to 35.9 per cent for the foreign-based passengers. There appears to be some scope therefore for inclusive-tour UK passengers to assemble off the airport site at, say, an hotel, and then go by bus to the airport. The foreign leisure inclusive-tour sector passengers are heavy users of bus transport at both Gatwick and Heathrow.

Under present rules and prices, an airport authority reducing the number of cars using the airport will lose revenues. A general policy of road pricing, as in London city centre from 17 February 2003, will reward public transport for its greater efficiency in the use of infrastructure, but the case for road pricing on routes to airports has not been part of the present debate. If car users at airports already cover their social costs, there is no case in welfare economics for intervention to distort that choice away from the car mode. Nonetheless, the Heathrow Surface Access Strategy has a target of increasing public transport use by passengers to 50 per cent, compared to actual shares of underground (17 per cent) and bus/coach (16 per cent) in 1997 (BAA, 2002).

3.5. The Heathrow surface transport shares in 2001

Table 8 shows the surface transport shares at Heathrow in 2001. Non-transfer passengers at the airport declined from 44.7 million to 40.7 million and the number of rail passengers declined by 0.4 million. The rail line to the airport was opened in June 1998, with a journey time of fifteen minutes from central London and a fare of £25 return. The investment cost was £500 million. The rail line's highest rate of usage is from foreign business travellers, who declined in number after September 11 2001. It has made only a small impact on the UK leisure segment, where its market share averaged 4.5 per cent in the three years 1999, 2000 and 2001. In 2002, an investment of £12 million on new carriages and ticketing and rolling stock refurbishment was announced.

The 1999 survey by the BAA of staff's travel-to-work patterns showed market shares of 76 per cent for cars, 11 per cent for bus, 6 per cent by underground rail, 2 per cent by motorcycle and 1 per cent each for taxi, cycling and walking. One per cent came to work by air and the Heathrow Express share was zero.

Table 8. **Surface Transport Use at Heathrow, 2001 (%)**

Car	35.6
Car hire	3.2
Taxi/minicab	26.6
Bus/coach	13.0
Underground	13.1
Rail	8.4
Other	0.2

Source: BAA, Heathrow (2002), *Delivering for London and the Regions*.

4. FREIGHT, AIRLINES AND AIRPORTS

Gillingwater (1994) develops an earlier list of thirteen requirements of express cargo operators at airports, drawn up by Lambert (1986):

1. 24-hour operation.
2. No night-flying restrictions.
3. Night weather record.
4. Airfield capacity including runway, apron and transit building.
5. Full airport services, such as ATC, security, landing aids.
6. No restrictive practices by airport labour.
7. Full customs facilities.
8. Surface access of high standard with uncongested landside vehicle facilities.
9. Airport management support.
10. Competitive airport fees for landing, handling and rent.
11. Route licences.
12. Service network of other passenger and freight airlines to add to own network.
13. Market location for the origin and destination of the express cargo.

Two of the above requirements are not now needed within the single European market -- customs facilities and route licences. On the other hand, security is a much greater problem now than in 1986. The Irish Exporters Association, in December 2002, requested *"a security zone within Europe with all the EU countries agreeing to a one-stop security checking system at the country of departure."* The Association also requested governments, airlines and cargo handlers to ensure low-cost x-ray, compression chambers and holding space to reduce the cost burden on exporters.

Zhang and Zhang (2002) note the November 1997 amendments to the Federal Aviation Act, which deregulated domestic all-cargo air service in the USA, removing government control over rates, routes and aircraft size. They state that infrastructure is needed to ensure efficient freight movement through intermodal terminals. *"It is thus important to enhance cargo movement, facilitation, storage and clearance facilities at all international airports to bring them in line with international trade facilitation expectations."* They further state that "*it is also important to liberalise market access to intermodal transport sectors.*" They refer to anticompetitive regulations designed to protect local postal services, ground transport, trucking and telecommunications *"which are critical to a foreign carrier's ability to provide competitive services in the host economy."* Their conclusion is that "to fully capture the benefit of air cargo liberalisation, problems related to customs administration and intermodal transportation must be addressed."

Sharp (1999) sees three opportunities to develop rail freight at airports -- the carriage of construction materials, transport of fuel and air cargo. *"Construction needs large quantities of heavy bulky raw materials -- ideal traffic for rail. Hence the development of a special freight siding and terminal at Manchester Airport, used for bringing in stone for construction of the second runway. This keeps 70 000 lorry movements off sensitive roads each year* (p. 64)."

Sharp's examples of rail transport of aviation fuel are Wick in northern Scotland, a rail journey of 700 miles from the refinery, and the line to Oslo airport, which is 50 kilometres long and carries a million litres of aviation fuel a day. At Frankfurt, the airport railway line from Hamburg and Osnabruk carries five truckloads of containers per day. At Shannon on the west coast of Ireland, aviation fuel is delivered by sea tanker to the jetty attached to the airport.

An interesting example of better interface between the freight sector and airports is the Heathrow Consolidation Centre. Its goal is to reduce the number of delivery vehicles at airports. In its first year, from May 2001 to May 2002, it achieved a 61 per cent reduction in the number of journeys made by retailers and suppliers to the four Heathrow terminals (BAA, May 2002).

SUMMARY

The choice of airports as a topic for this Round Table is in many ways an inspired one. The 1997 deregulation of aviation in the European Economic Area of the EU, Norway and Switzerland has had some spectacular results in the island countries, Britain and Ireland, and in the links between Britain, Scandinavia, Italy, France, Germany and Austria. When the new EU members join, ratified by the Nice Treaty, there will be a large, extended market in aviation in which air transport will have an enhanced role, since the distances will be so much greater and the time competitiveness of surface transport will be correspondingly less. We may be delineating the new transport map of Europe, with low air fares redrawing the iso-curves of journey times and journey costs.

Prices have fallen spectacularly since airline deregulation. The low-cost airlines deliver these price reductions by vastly superior productivity and by redefining the airline product. Airports which choose not to meet the requirements of the budget airlines lose market share to lesser-used airports available in large numbers. Europe has a surprisingly contestable market in airports, as the case studies indicate. The new airlines and their passengers have readily transferred to the new airports.

The next set of new market entries at hubs such as Brussels South, Frankfurt Hahn and Stockholm Skavsta, will compete with surface links and also divert passengers away from congested hubs and lead to increased aircraft efficiency. Airports will thus be much more important than in the past and their links with other transport modes will be the subject of greater study and greater market opportunity for operators of surface transport.

The studies cited here indicate that the traditional public transport sector has missed out on much of the market opportunities created by the boom in air travel since deregulation. Most airport journeys by passengers are made by private car or taxi, and airport staff almost universally use cars rather than public transport. Some of the initiative shown by new entrant airlines is needed among the suppliers of public transport at airports.

In the era of multimodal impact studies, better interchange at airports between road freight and freight aircraft is required. Rail freight and coastal shipping links to airports present interesting case studies for further work.

Above all, aviation is an extremely dynamic sector since deregulation in Europe. Since the hub airports are frequently slot-constrained and controlled by the old, former national airlines through the "grandfather rights" system, the dynamic is switching to new airlines, new airports and new market opportunities in a globalised economy. These are exciting times for airport managers and their customers, airlines and passengers. There is a new market relationship between new and old airports and the airlines. There is also a new relationship between airports and the rest of the transport markets.

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AIRPORT SYSTEMS AND CONNECTIVITY

Renato PICARDI
Logistica and Organizzazione del Trasporto Aereo
Dipartimento di Ingegneria Aerospaziale
Politecnico di Milano
MILAN
Italy

AIRPORT SYSTEMS AND CONNECTIVITY

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Milan, December 2002

FOREWORD

Multi- and intermodality are the backbone of airport infrastructure, similar to the situation existing at the turn of the last century in the railway era. Awareness of this fact could lead to solutions to air traffic congestion and build-up.

Academic studies, no matter how futuristic they might appear, do stimulate new ideas and solutions. Economic implications in the short to medium term do work as a filter, even for promising and effective options. This paper presents an analysis from the functionality point of view, without dwelling on economic aspects.

The requirements of northern Italy are therefore analysed as an example, taking into consideration a number of factors and background information: the White Paper, "European Transport Policy for 2010: time to decide"; the Jacqueline Foster report to the European Commission on regional policies; traffic build-up forecasts, environmental impacts and air transport safety. This example can be tailored to other specific situations in Europe.

Strong interdependence and intermodal links are sought between rail, road and air transport and between individual networked airports, aiming at segment focusing and complementarity.

The "Single Sky" initiative and the high-speed rail network are the way forward towards sustainable development in Europe. This paper presents a possible interlinking of different transport modes aiming at higher efficiency through increased synergy, along the lines set by recent EU directives and priorities.

1. OVERVIEW

1.1. Present situation

By 2020, global passenger traffic will be two and a half times its current volume, growing at an annual average rate of 4.7 per cent. Freight tonne-kilometres will triple during the period, growing at an even more rapid annual 5.5 per cent. The active passenger fleet will increase by more than 80 per cent. In order to provide the required increase in capacity, the number of passenger aircraft in service will rise to 19 732 from 10 900 at the end of 2000. The active world freight fleet will grow to 3 338 aircraft from 1 540. The number of departures offered on existing and new passenger routes will increase by 86 per cent. Despite current levels of congestion and delays, this represents a more rapid rise than in the past, and will present a major challenge to the world's airports and air traffic management systems. The continuing success of air traffic and the high market growth rate has led to heavy problems in the present-day air transport system. These impinge on quality of service, in particular creating congestion and delays in airports [1].

This situation is most critical in Europe and the US, where the route liberalisation of the 70s and 80s led to a strong increase in competition and price reductions. The air transport community can solve its short- and long-term problems by exploiting its potentialities, by co-operating with governments and local administrations, but also by better interfacing with other transport modes. A number of initiatives have been set worldwide in order to address the problems affecting the vast majority of the travelling population. Airports are getting most of the attention on this score as the main stumbling block of air transport, whether as starting point, final destination or transit area for passengers. The proper use of present airport capacity, the revision of outdated procedures and protocols are low-cost-impact means to good results in the short term. But this is not enough. A further step towards sustainable progress can be achieved by integrating different transport modalities with airport access. The environmental issue should not be discarded and is now high on the agenda of airport authorities. A balance is being sought by local administrations between mobility needs and environmental impacts.

1.1.1 White paper recommendations

Transport is crucial for our economic competitiveness and commercial, economic and cultural exchanges. This sector of the economy accounts for some 1 000 billion €, or over 10 per cent of the EU's Gross Domestic Product, and employs 10 million people. Transport also helps to bring Europe's citizens closer together, and the Common Transport Policy is one of the cornerstones of the building of Europe. However, the warning signs are clear. Congestion, resulting in environmental nuisance and accidents, is getting worse day by day, and penalising both users and the economy. If nothing is done, the cost of congestion alone will account for 1 per cent of the EU's Gross Domestic Product in 2010 while, paradoxically, the outermost regions remain poorly connected to the central markets. Europe must bring about a real change in the Common Transport Policy. The time has come to set new objectives for it: restoring the balance between modes of transport and developing intermodality, fighting congestion and putting safety and the quality of services at the heart of our efforts, while

maintaining the right to mobility. One of the main challenges is to define common principles for fair charges for the different modes of transport. This new framework for charges should promote the use of both less polluting modes and less congested networks [2].

1.1.2 Sustainable development

Reading of some amendments from a project on regional politics, transport and tourism, presented by Jacqueline Foster to the European Commission in May 2000, leads to some interesting comments:

- According to the Amsterdam Treaty, the principle of sustainable progress must find application in all modes of transport (road, rail, air, water);

- According to the Brundtland Project and the Rio Declaration, the fields to be considered are at least three: environmental -- to allow suitable development with low noise pollution and to contain the environmental impact; economic -- focusing on efficiency and development; and social -- providing equity and balance between the modes of transport.

In aiming to reach this target, all Community States need to approve new rules and laws to provide a sustainable airport policy. These regulations may increase the complementarity and co-operation between regional and national airports. The best means of traffic spreading could be achieved with more co-operation between airports. The heavy traffic concentrations in most hubs are the cause of environmental degradation and a low quality of life for those who live near them. The Commission should elaborate a programme to promote a multimodal transport policy. It is important to have the advantage of the positive features which each mode of transport can offer, in order to solve their weak points.

1.2. Airline deregulation

The most significant trend since the early 1980s has been the gradual liberalisation of international air transport. This has had profound effects, both on market structure and on operating patterns. It started in 1978 with domestic deregulation in the United States. In Europe, the first bilateral "open market" was between the UK and the Netherlands in 1984, followed in December 1987 by the first "package" of liberalisation measures introduced by the European Community [3].

Deregulation accomplished the transformation of a static, cartel-ised aviation market into a dynamic, continually changing one. This process has gone through several stages and is still continuing.

1.2.1 Deregulation's initial stage: Hub and spokes

During the first ten years of deregulation (1980s), major airlines shifted dramatically from point-to-point to hub-and-spokes route systems. First, those living in the hub airport area have benefited from a manyfold increase in the number of destinations and the number of flights. They have lost some point-to-point service but gained access to potentially hundreds of destinations via the hub. But these changes, triggered by airlines, were constrained by the limitations of the aviation infrastructure -- airports and ATC (air traffic control) -- which had not been altered by the deregulation. Large increases in landings and takeoffs at hub airports put enormous strains on the ATC system.

1.2.2 Second stage: Low fare, point-to-point service

The growing level of congestion at major hub airports during the 1980s created opportunities for alternatives. One such alternative was low-fare, no-frills, point-to-point service. Southwest Airlines, whose origins predate deregulation, was freed by deregulation to offer its unique type of short-haul service on an interstate basis. Shunning congested airports and direct competition with the major airlines, it carved out a thriving market niche during the 1980s by reviving point-to-point service. During the 1990s, Southwest moved into the ranks of the nation's top 10 airlines. Southwest and its competitors have deliberately avoided most congested hub airports and the most congested air routes, concentrating on under-served city markets and secondary airports in major urban areas.

1.2.3 Next stage: Regional air jet service

The term "regional jet" (or RJ) refers to a new type of small jet airliner, which began service in 1997. Bombardier was the first to enter the market, with 50- and 70-seat versions of its Canadair Regional Jet, along with Embraer's 50-seater RJ-145. The initial use of RJs is by regional airlines which serve as feeders to the hubs of major airlines like American, Delta and United. The ability to serve such markets economically with jet airliners opens up the possibility of adding smaller cities and more frequent services to the spokes of the hubs. But it also offers the prospect of a new market for point-to-point service, whether it is offered by existing regional airlines or by another generation of new airlines, applying something like the Southwest model to a much smaller size of aircraft. The possibilities for new RJ point-to-point service are breathtaking, if current, low-fare airlines can profitably offer point-to-point service between scores of destinations. Boeing forecasts that one of the fastest growing areas for airlines over the next ten years will be point-to-point routes over flying hubs. RJs will accelerate this development, by meeting the demand for better service to smaller cities and to secondary airports in major urban areas. But the ability of the US aviation system to accommodate this next stage is a real question mark. The air traffic control system is a major impediment to aviation growth. It had difficulty coping with the shift to hub-and-spokes in the 1980s and the revival of point-to-point in the 1990s, and will have major difficulties coping with a doubling of landings and takeoffs, due to regional jets, over the next decade [4].

1.2.4 Bi- and multilateralism

Similarly to the United States, Europe was also moving towards "open skies" but the approach was quite different structurally. The US strategy was essentially bilateral. The implementation of "open skies" was being promoted by one country through a series of bilateral air service agreements.

In contrast to this approach, the development of a single, open aviation market in Europe was to be achieved initially through a comprehensive multilateral agreement by the Member States of the European Union. This multilateral approach to the opening up of the skies enabled the Europeans to go further in pursuit of deregulation than was possible under US bilateralism [3].

2. COMPARING TWO APPROACHES

Focusing on the airport side of the air traffic issue, the different traffic handling and build-up strategies to be considered need to be the most successful over time.

In broad terms, the various approaches can be brought down to two main models, Hub & Spokes (H&S) and Point-to-Point (PtP). These two modalities have different basic principles but can co-exist in practice within the same airport infrastructure.

PtP and H&S identify two different airport networks, by the respective presence or absence of direct connections between the different nodes (individual airports) of the network.

Differences between the two models identify reciprocal pros and cons, but it is clear that there is no absolute best option; it will depend on each particular case and, in most cases, is a reasoned compromise.

2.1. Hub & Spokes

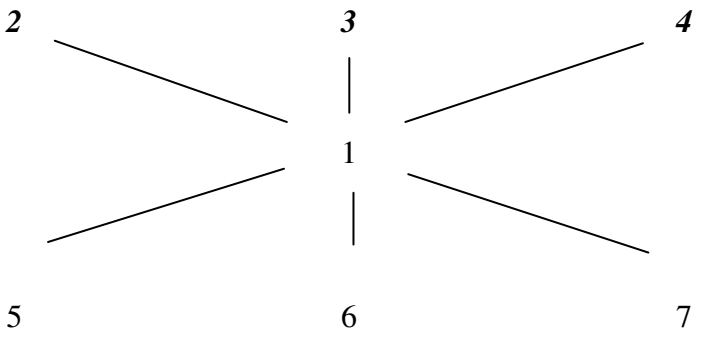
2.1.1 Definition

The term "airport hub"' is perhaps the most abused in aviation terminology. It is used frequently to describe an airport, which could be termed more simply as "busy". A true airport hub is a much more refined and sophisticated infrastructure.

The concept is basically mathematical in nature: the most efficient way of linking a number of remote points on a network ("spokes") is by a one-stop connection via a central point ("hub"). For example, on a point-to-point basis, assuming that binary connections are served by one aircraft each, a carrier needs six aircraft to connect four cities.

cities	***1***	***2***	***3***	***4***
1		+	+	+
2			+	+
3				+
4				

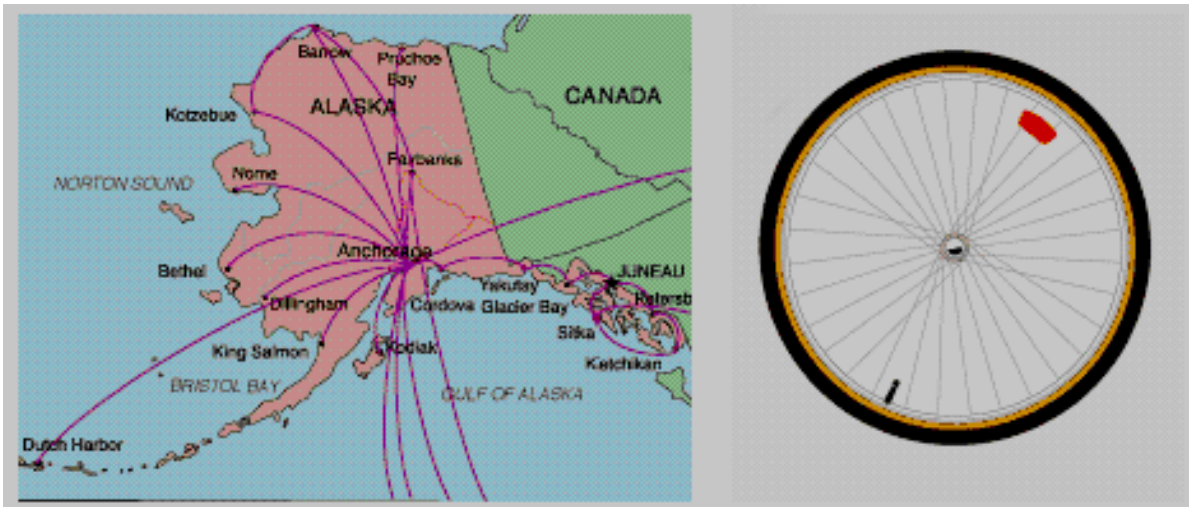
With the same number of aircraft the carrier could connect seven cities with a central hub, called city one:



Connecting seven cities by a point-to-point system would require 21 aircraft. This translates directly into an airline/airport environment: the most cost-effective way of linking a number of dispersed cities is by using flights to a central hub airport.

This approach takes into account the fact that, in practice, there is usually insufficient demand to profitably link every conceivable city to another one [5]. An H&S-type airport establishes a master/slave relationship with secondary airports, which feed into it through different transport modalities. The hub concentrates all main activities and all departing, arriving and transit passengers orbiting within the airport system network.

The hub-dominated airport system has also gained relevance from the need to lower the impact of fixed costs on airport handling charges and to exploit the economy of scale and the capacity of large, intercontinental aircraft.

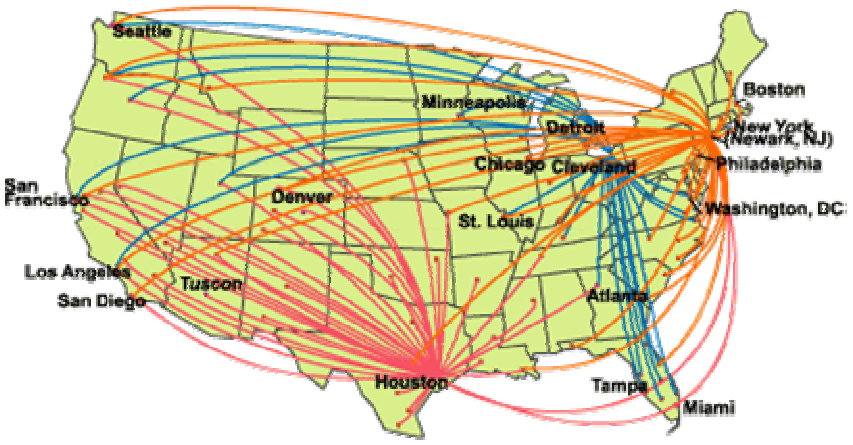


Source: NASA.

2.1.2 Model description

The Hub & Spokes concept arose in 1978, following American deregulation and the consequent elimination of the routing monopoly of major airlines. The same situation arose in Europe following the opening of air services to air companies worldwide, and there are numerous examples of airport hubs and feeding spokes. The H&S concept is different on the two continents.

(*Source NASA*)



Air companies in Europe are well linked to the original Member States and the market is focused in part within Member States. On the other hand, the federation of US States has led to wide co-operation areas with three or four main hubs.

There are different H&S networks, depending on the area covered, the total number of nodes and the type of traffic that is managed. Single terminal (ST) is the main option so far; the multiple terminal (MT) option, where more airports have a hub role simultaneously, has not taken off properly yet. It all boils down to cost. It is not economically feasible to move large banks of flights out of existing hubs to alternative hubs unless the infrastructure is in place, and there is significant local demand. American Airlines tried to use alternative hubs at Raleigh, Durham and Nashville; US Airways tried to use alternative hubs at both Dayton and Indianapolis. In all four cases, the infrastructure was in place but the local market was not adequate to sustain the airlines' economic requirements. Spreading system traffic over multiple hubs is a costly proposition [15]. However, MT has the great advantage of a shorter feeding distance to the nearest hub for a given area of coverage.

Shortcuts

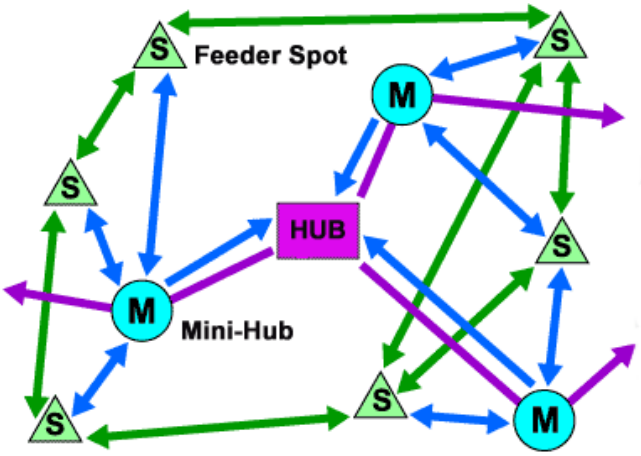
A hub-and-spokes network could evolve in the direction of shortcuts between two network spokes, exploiting shorter transport lead times due to the shorter distance. This evolution is constrained, mostly economically, by a minimum required passenger flux through the hub.

Spoke extension

The addition of a new node is the most intuitive extension of an existing network. The new airport must be connected to the main hub or to another peripheral airport already connected to the hub. In this last case, the peripheral node is a transit node for the new one. Variations exist which describe, for instance, the lengthening of the feeding range up to a closed loop. This option stems from the possibility of a single (air/rail) transport means collecting different feeding fluxes, which would otherwise travel back and forth between hub and spokes by different ways. A further optimisation would be a co- and counter-clockwise feeding route. Substituting one node with another changes the network morphology without extending it.

Hybrid system

An airport system is hardly ever a pure PtP, nor does it consist of airports feeding a main hub connected worldwide. More realistically, its "hub" will not reach all destinations and act as a spoke to "mega hubs". Hybrid situations exist where H&S networks include a number of direct linked destinations, or PtP-type airports, with a sizeable portion of traffic towards important ports of call. When analysing such a complex system, one should not only consider the overall system efficiency but also costs and passenger benefits. A better connected network with long transit times could be preferred to a more efficient but loosely connected one.



2.1.3 Hub-and-spokes benefits

The hub benefits most from an H&S network, with lower airport management costs, thanks to a scale economy and higher operativity. On the other hand, spokes can support traffic to far away destinations via the hub, in spite of uneconomically low local demand. In any case, airlines are the main beneficiaries.

The hub-and-spokes system has been introduced to the aviation transport market as the standard system for enjoying the increasing return to scale, e.g. economy of scale, economy of scope and so forth. The H&S system concentrates the demand on the hub airports, so that it becomes an efficient transport means for the airlines as a result.

The H&S system also expands the market much more widely by englobing cities and regions not involved previously. The interaction between the demand concentration and the market expansion gives rise to the so-called snowball effect of hub airports on market dominance. Actually, it can be easily found that few mega-hub airports, for example, Chicago O'Hare and Heathrow, or gateway airports, e.g. Narita in Tokyo and JFK in New York, occupy a large share of total demand. It is well known that hub-to-hub transport is more cost efficient than spoke-to-spoke [6]. Further benefits are: better use of resources, such as the loading factor; high flight frequency with shorter time gaps between flights; take-off delays are minimised in the H&S concept; easier inclusion of new nodes, allowing to serve low traffic rates from remote areas.

An H&S system generates a high traffic volume and manages a large number of flights, with higher overall but lower pro-rata costs. This practice has now been adopted extensively by most of the world's airlines. Hub airports have carefully co-ordinated flows of arriving and departing flights (often referred to as waves or banks) which create large volumes of passengers connected to other flights on the network, as well as "local" passengers simply flying from the spoke city to the central hub. Most short-haul hub airports operate with "away-based" aircraft. In simple terms, this refers to the overnight operation of an airline fleet away from the airline's home base. The main advantage of this type of operation is that it maximises connecting opportunities early in the morning and late in the evening, which is highly attractive for business traffic.

2.1.4 Impact for passengers

Opponents claim that a hub-and-spokes environment provides the perfect breeding ground for monopoly, inefficient, costly operations and overpriced fares. Some suggest that government should re-enter the aeronautical fray to increase competition by limiting the number of gates a carrier can lease at one hub or the number of departures it can schedule.

However, according to the economist Pablo T. Spiller from the University of California, Berkeley, what may look like a quest to monopolise an airport is a natural consequence of operating efficiently. *"This system is working",* says Spiller, "*and consumers are benefitting. As you develop a hub, your products become more attractive -- more direct flights, more frequent flights, more connections -- and with that, you gain the ability to mark up prices, because those are product qualities that, according to our data, customers are willing to pay for."* If airlines are exploiting anything, it is *"this peculiar demand for large networks that business travellers have."*

Consumers are doing well: for a tourist, the cost of a flight has actually come down slightly. Business travellers are paying more, but are offered more frequent departures and other perks [13].

Major airlines have used the H&S system as a means of reducing costs but also in order to impose higher than competitive fares on routes departing from hubs. They have increased their market share on some airports almost up to monopolistic limits. Passenger's itineraries are often re-routed on towards heavily congested hubs in order to increase profits and compensate the effect of fare policies where point-to-point competitors are most effective. From a fully competitive situation, as foreseen by deregulation supporters, the sector has become highly oligopolistic, and monopolistic in places. In practice, many of the positive effects of the period following deregulation with respect to pricing have been nullified. The US experience has shown this -- even if, in a free market environment, conditions do not always exist to guarantee freedom of enterprise to individuals. It is then essential that antitrust authorities be active on the market. Learning from this experience, the European Commission policy is not focused on a total and immediate deregulation, but foresees a progressive approach to liberalisation [14].

2.2. Present limits of hub-and-spokes airports

Airports operating nowadays were designed decades ago and are not error-free. It is essential to upgrade airport infrastructure to new levels of demand, quality of service and mean flight delays. The area where the airport is located is important as the limiting factor to airport handling capability.

In practice, the way towards solving air transport congestion is not only by increasing slots and airports. There are further ways which help towards limiting the environmental impact and increasing the efficiency of the airport system.

2.2.1 Capacity, demand and delays

Congestion sets in when operation requirements in terms of take-offs, landings, taxiing, etc., overwhelm the airport handling capability.

There are many elements constraining airport performance: its organisation, its operational procedures, the number of runways and the kind of technology that is implemented. As a consequence, there are many causes to traffic congestion and delays.

It is useful to analyse the relationships among the three main parameters: (operational) capacity, (traffic) demand and delays (defined as the time difference between the operation carried out in real conditions and the same carried out in a non-congested airport. Generally speaking, higher demand for a given capacity leads to longer delays. In other words, the duration of operations increases with the frequency of operations. Therefore, delays in a large hub with a high traffic concentration derive mostly from this workload and not so much from specific handling efficiency. Airport capacity is another parameter, which can be influenced by weather conditions and emergency procedures in case of accidents. Let us focus on the possible ways to increase airport capacity.

2.2.2 Standard approach

The first thing that comes to mind when increasing capacity is the building of new runways, taxiing areas or even new airports. The hub airport of an H&S network would develop in this way, in order to ensure higher feeding rates, so strengthening and extending the leadership over wider areas. Even if this is the easiest line of development, it is very difficult in practice due to difficult hurdles to overcome, such as environmental impacts, limited space availability and prohibitive costs.

Let us consider some facts. Seventy per cent of all US air traffic is handled by about thirty US airports. The thirty busiest airports over the last ten years have expanded their total number of new runways by only six. With the rate of air traffic growth, the US would need to add about twenty-five more runways to keep up with the demand. Right now, fifteen new runways are being built, with completion planned anywhere from three to seven years away. Building more runways at many of the major airports would only help marginally. First, it would take quite a few years to build additional runways. The amount of air traffic will continue to increase while the construction is going on, meaning that the operational capacity for those runways will have already been surpassed by the time all the runways are operational. In other words, the problem would be solved if enough runways were built in a short period of time.

Denver International Airport in the US, the last large commercial airport to be built, has succeeded in diminishing delays, not only in its direct area of competence, but also in the whole airport system to which it is connected, at the cost of at least $5 billion. Many feasibility studies have been performed in air traffic congested areas such as Los Angeles, Chicago and New York. The outcomes have not always been positive, confirming that building new airports is neither an easy nor an economical solution.

In any case, a $6.6 billion project for the O'Hare airport in Chicago is under study, which includes significant runway realignment. The moves will increase parallel runways from two to six, will increase the total length of five runways and are projected to reduce delays by 79 per cent and to increase capacity from 900 000 yearly operations to 1.6 million.

Building more airports will help only if the following constraints are met:

- Ensuring that airports are built to meet anticipated traffic capacity for up to 10-20 years after construction begins;
- Building new airports in areas where a future air transport need is predicted;
- Runways to accommodate aircraft of the future (in length and load-bearing capacity).

A more cost-effective alternative is the conversion of military airports to civil use or the hybrid approach of dual use. Intermodality has also grown in recent years as a further means to lower traffic loads between cities and airports and hubs and spokes. Features of this approach will be analysed in detail in the following chapter.

2.2.3 Other approaches

Further initiatives are considered, still with the scope of reducing delays, by means of well-established procedures aimed at distributing the traffic load over a wider area than a single hub.

Rules are established, which airports should adopt in order to reach a proper distribution of traffic loads and utilisation of airport resources.

Air traffic re-routing

The vast majority of air traffic affecting a given area usually pivots around a single, heavily congested hub. Re-routing part of this traffic towards nearby ports of call is a way out of this situation.

The potential impact of re-routing is high; there are 51 airports in the Los Angeles area and 53 around Dallas-Fort Worth, which have the capability of absorbing traffic peaks, mainly consisting of small and medium-sized aircraft. This capability is not used at present, due to the dislocation of these extra airports and the lack of co-operation between the airlines and main airports. An active, adequate partition of traffic activities does not exist in large urban areas. Examples are San Francisco and the nearby, under-utilised Oakland, also Dulles IA and Baltimore-Washington International, which have low operating rates, while Dallas National is overloaded.

Other measures alleviating heavy traffic congestion are:

- Restrictions by aircraft type;
- Maximum operations and traffic quotas;
- Rebugging;
- Fare differentiation and slot auctions.

2.3. Present and future hub-and-spokes

2.3.1 The example of Frankfurt

Frankfurt Fraport is an example in Europe of the H&S approach. It stands out every year as the main continental port of call and the second in Europe, handling all cargo and passenger activities which in London, for instance, are distributed over four different airports. This gives Frankfurt the status of a "mega hub", with feeding routes across Europe, thanks to a strategically central position. Growth forecasts and traffic analysis indicate a passenger build-up from 49 million in 2000 to 81 million in 2015, an increase of 3.4 per cent. Without major airport upgrading, its capacity will remain at a peak of 80 movements per hour, with 48 take-offs and 45 landings hourly, adding up to about 480 thousand movements per annum. This situation will lead to the onset of a capacity gap in 2005, reaching 200 thousand movements per annum. At present, an H&S-type feeding strategy is applied from nearby or secondary airports (plus feeding from other hubs, e.g. Milan Malpensa). Strategies are now changing and the airport is fed not only with flights, but also via high-speed trains from all over Germany. The hope is to increase the percentage of railway feeding, thus reducing congestion due to small feeding aircraft.

But how is Frankfurt airport getting ready for the future? Up until 2006, it is planned to optimise management of the infrastructure already available, co-operate with other airports and soundly redistribute domestic traffic towards other transport modalities. A new runway will be built after that

date in order to substantially increase capacity. The goals of increasing capacity and maintaining a leading position among continental hubs impose an ambitious development plan. An additional runway and a new terminal, capable of hosting 25 million passengers, will be two main milestones of the *Airport Expansion Programme* [12].

2.3.2 Risks

The shortcomings of the H&S concept are mainly quality of service, with lower standards compared to the direct links, cross-delay risks and hub localisation. The hub is exploited by major airlines, which concentrate all their takeoffs and landings on it, thus binding the airport to their decided routes, transit schedules and traffic. Kuala Lumpur International Airport serves as an example of how a critical traffic situation can set in, following the withdrawal of major airlines. The airport becomes a passive element at the service of three or four main carriers instead of servicing real transport needs. A hub-and-spoke system is only an efficient solution if the spokes are not able to generate enough passengers in all directions on their own. Current growth rates for air transport are high. If this level of growth continues for another ten years, hubs will became superfluous, as spokes will have enough passengers to efficiently supply point-to-point flights**.**

2.3.3 Kuala Lumpur International Airport failure

A recent *Asiaweek* article stated that, with the advent of super jumbos like the new Airbus A-380 or Boeing's 747-StretchX, airports around the world will be further divided into hubs and spokes. Instead of becoming an important international aviation hub of the 21st century, KLIA is now in danger of becoming the world's most expensive "spoke" airport. Malaysia needs to do some real "soul-searching" on how to turn the KLIA from a white elephant and the most expensive "spoke" airport in the world into an international hub for airlines. The position of KLIA for 1999 and 2000 worsened when British Airways (BA) announced it would suspend its flights to Kuala Lumpur. BA would not be the only airline to terminate its air services to and from KLIA. Australia's Qantas and Ansett Airlines and Germany's Lufthansa have also pulled out of Kuala Lumpur in the past two years.

KLIA was built to handle up to 25 million passengers in its first year of operation, followed by 50, 75 and ultimately 100 million a year. However, Malaysia Airports' Executive Director, Rosman Abdullah, said early this year that KLIA was operating at a level catering for 25 million passengers even though the actual number was 13.2 million last year. The old Subang airport could have coped with the air traffic without the country having to spend RM 10 billion to build an "airport of the future" [8].

2.4. Point-to-point

2.4.1 Definition

A point-to-point (PtP) connection is simply a direct, non-stop flight between origin and destination.

PtP prevailed from the 1930s until 1978, when routes were liberalised. It is regaining strength now following deregulation, and could be a valid alternative to the H&S system in the future.

2.4.2 Advantages

A PtP-type airport contributes the most to the local economy when compared to an H&S airport of similar size. Many passengers feeding the big hubs change flight without ever leaving the terminal area. For example, charter passengers board direct flights and are not usually frequent flyers. They arrive at airports well in advance of departure, thus becoming potential clients for the airport's commercial infrastructure, allowing it a profitable turnover.

2.5. Present and future point-to-point

2.5.1 Southwest Airlines model

Not all airlines use the hub-and-spokes approach. For example, Southwest Airlines is one of the exceptions to the H&S network system. It used the old-fashioned point-to-point system, hauling people short distances with few non-stop connecting flights. However, Southwest offers very few longer non-stop flight routes. At the end of 2000, Southwest served approximately 306 one-way, non-stop city pairs. Its PtP system provides a more direct route than an H&S airline can offer [9].

Southwest tries, wherever possible, to use smaller, less congested airports to serve major cities. By using these airports, the average flying time can be reduced by 15-20 minutes as a result of short ground taxiing times, fewer delays at the aircraft gates and less congestion and circling in the air when on approach. Punctuality is also easier to maintain [3].

2.5.2 The NASA report

On 2 August 2002, Dr. Jesse Johnson of the Logistics Management Institute (LMI) completed an OAT-sponsored (Office Aerospace Transport) study on the OAT's capacity objective of tripling the capacity of the aviation system by 2022.

Today

2020

Source: NASA-OAT study: Today – 2020.

The purpose of the study was to determine the level of technology and system changes required in order to meet the enterprise stretch goals for the National Airspace System (NAS). The study methodology relied on a computer model of scheduled air traffic at the top 102 airports, which generate 94 per cent of scheduled air carrier passenger traffic in the United States.

The first step was to create a flight schedule that would accommodate three times the passenger volume of the 1997 system. In contrast to today's hub-and-spoke system, nearly all passengers would be taken directly to their destinations, thereby providing better service and reducing the number of operations (takeoffs and landings) required. The resulting flight schedule was compared to the future capacity of each airport, and several options were examined where the demand for flights exceeded the airport capacity.

The next step was distributing some flights to other nearby airports that would otherwise have excess capacity; this strategy fully alleviated the capacity problem at two of the airports and helped at six others. Two alternatives were considered for the final step: distributing flights to additional airports and employing runway-independent aircraft.

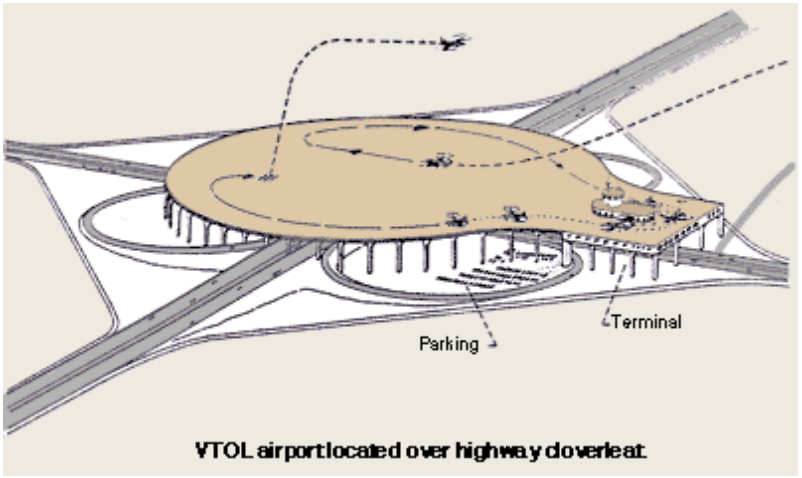
The first option extends service to some of the more than 4 000 national airports which currently have no scheduled air carrier service.

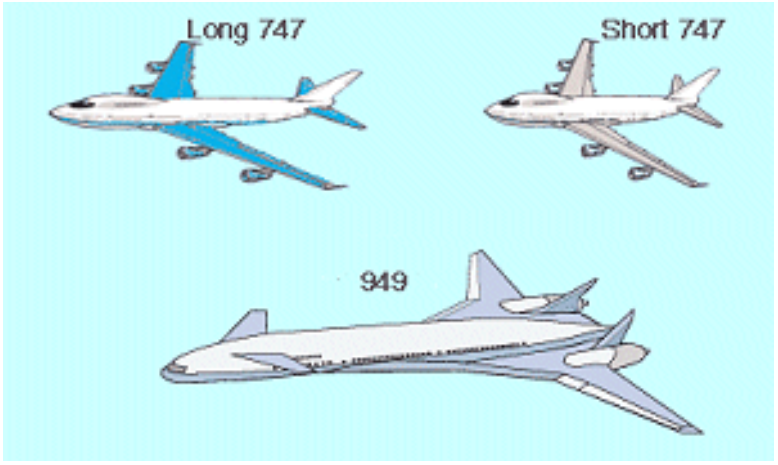
However, many of these airports are general aviation airports, and instituting scheduled services could be controversial, both technically and politically.

The study found that some routes had too few passengers to justify point-to-point flights, even with relatively small aircraft: accommodating the last three per cent of the passengers with non-stop service would double the number of flights in the system.

Therefore, the future system will still retain a limited amount of hub-and-spoke traffic, but at a much lower level than the current system.

This effort indicates that increasing the efficiency of runway usage is one of the most effective steps to increase system capacity. Also, as air travel demand grows, more point-to-point flights become economically justifiable and improve service to travellers. Finally, the future system is likely to require efficient small aircraft for longer routes, more complex demands on the air traffic management system to accommodate a larger number of routes and airports and, perhaps, a new generation of runway-independent aircraft [10].





Source: NASA.

3. THE MODERN AIRPORT SYSTEM

3.1. Examples worldwide

It is common experience that similar activities are carried out in different ways in different parts of the world. Reasons for this diversity are differences in the local morphology, climate, cultural heritage, state of progress, etc.

Analysing airport systems worldwide, and spotting differences and similarities under similar circumstances, forms the basis for a realistic global approach to designing them.

3.1.1 The US situation

Many examples of airport systems can be found in the US, for instance, Chicago, Washington and New York. The latter comprises three airports, Kennedy, Newark and La Guardia, each handling a specific traffic segment: respectively, international and intercontinental flights; national and international flights; and domestic flights.

3.1.2 The situation in Europe

Examples of airport networks can also be found in Europe.

In London, for instance, there are four airports: Heathrow is a hub, linked to major cities worldwide; Gatwick handles charter flights; Stansted concentrates on low-cost and short-haul operations, due to its central position with respect to the City. Finally, the smaller London City Airport, in central London, deals with business activities.

Similarly, the Paris airport system shares with London the independence of individual airports, each with specific market and passenger shares. This independence is strengthened by the lack of rail connections between airports, as only low-capacity roads exist.

3.1.3 The situation in Asia

Tokyo is a further example of functional specialisation of airport systems. Haneda Airport, the largest in Asia and sixth in the world by traffic volume, has no intercontinental connections and very few international ones. All foreign traffic is handled through Narita Airport. The presence of interconnected national and international networks has two main justifications: the need of proper logistics in a given area for managing large aircraft; and an intermodal feeding system through high-speed trains between the two airports, ensuring nationwide coverage.

A similar situation exists in Osaka, the second city in Japan. National traffic is dealt with at the old Itami Airport, while the modern Kansai Airport, built on a man-made island, handles medium-haul and long-haul traffic.

In Japan, for instance, travellers using Kansai International Airport can go to city air terminals (CAT) located in Osaka, Kyoto and Kobe, where they can check in remotely, check their luggage and catch a train to the airport. At the Kobe CAT, departing passengers can even pass through immigration before going to the airport. Because Kansai is located on a man-made island, passengers can also access the airport from four boat terminals around the region. Upon reaching the airport, shuttle buses transport passengers to the terminal building.

3.2. The functional specialisation

It is clear from the examples given above that functional specialisation stems from two main factors: the existence of nearby airports and their competitive role. Each individual airport identifies its market share by providing specific services exploiting its own specificities, such as location and size.

The Tokyo system is a rare example of a common design aimed at distributing traffic loads by exploiting intermodality, with the objective of creating an intermodal network within the airport system.

The hub-and-spokes concept concentrates all flights in one airport, exploiting connection and transfer options, thus maximising the efficiency and profitability of the airport infrastructure. The concept does not rule out secondary airports supporting the hub activity by specialising in secondary services. These airports already manage general aviation flights and all non-feeding flights to the hub. General aviation, charter and small business flights do not increase too much the connectivity of the main airport, but are slot-expensive. A structure is in place by traffic type and some of these are re-routed from main to supporting airports.

For instance, low-cost traffic is focused onto distant airports with low handling costs. Point-to-point business traffic is also best dealt with by low-congestion, secondary airports near the city.

3.2.1 Nearby, complementary airports

Major cities are inevitably serviced by more airports. At the same time, it is a market-driven choice to identify one airport as the hub, capable of handling most traffic for most destinations. In many cases, other airports provide complementary rather than alternative services. It is hard to find an integrated airport system where market shares are not dictated by functional specialisation and route complementarity. One wonders then whether a surface transport system, transferring passengers between airports, would be competitive. This option is always feasible, in case of need, or when no other option exists, as in the case of a traveller heading towards a destination connected to Orly Airport, who gets into the Paris airport system at Charles de Gaulle Airport. However, in the case of the Bergamo, Malpensa and Linate airport system in northern Italy, a substantially different situation arises. Malpensa handles all destinations but two (Luxembourg and Foggia), which are handled by the other airports. Limited travellers, local or from Luxembourg or Foggia and landing in Linate or Bergamo, would be using a surface transport system to Malpensa.

Furthermore, this very limited market element could even choose another hub, such as Fiumicino in Rome, when flying from the area of Foggia.

It follows that transit discontinuities should be avoided whenever nearby airports are not strongly specialised, leading to the conclusion that the H&S concept is the most competitive for a large airport system.

3.2.2 The Ryanair model

The idea of air travel in Europe conjures up such familiar names as London Heathrow, Paris Charles de Gaulle and Amsterdam Schiphol. But overseas travellers, and even airport managers, are less likely to think of Aarhus, Dinard or Ancona (in Denmark, France and Italy, respectively).

However, that may be changing. The rise of low-cost airlines, led by Ireland's Ryanair, is giving a higher profile to Europe's secondary airports and creating new markets for air travel. Ryanair's low-fare approach has been followed by such carriers as EasyJet, Go and Buzz. Apart from the influence of the low-cost airlines, Europe is well suited to the further development of regional airports. Europe's major international airports frequently suffer from bottlenecks that support the creation of direct links between smaller airports. Furthermore, environmental considerations on a very crowded continent often make it difficult for the larger airports to expand. Within Britain, congestion at London's airports is encouraging the growth of regional airports. Scotland's Edinburgh Airport, for instance, has seen its traffic increase after being targeted as a low-cost destination by Ryanair, EasyJet and Go. BAA, Edinburgh Airport's owner, has put a priority on developing its regional airports, partly in order to relieve pressure on its three London airports: Heathrow, Gatwick and Stansted. The

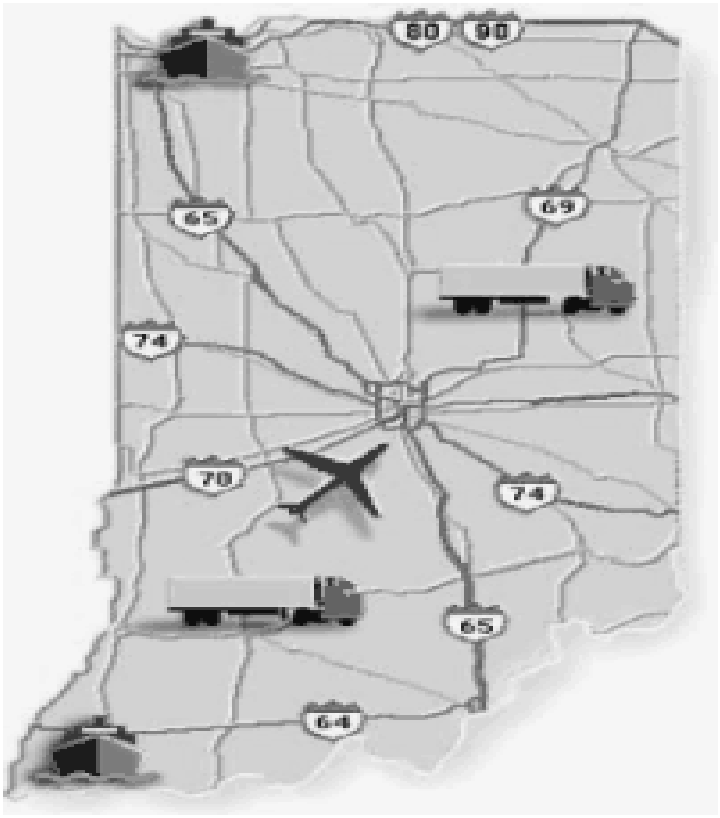
low-fare carriers do not encourage their customers to think in terms of connecting services. Smaller airports are likely to offer only limited opportunities to transfer to other flights, and major airports may suffer from delays which can make connections uncertain. Missing an anticipated transfer can cause irritation and spoil the goodwill created by the low fare. In contrast to Ryanair, EasyJet Airline has largely avoided secondary airports. Apart from Liverpool in northwest England and the airline's home base at London Luton, EasyJet has concentrated on serving primary airports. It flies to such major destinations as Barcelona, Nice, Paris, Zurich, Geneva and Amsterdam. Toby Nicol, Luton-based Corporate Communications Manager for EasyJet, says the use of major airports means that EasyJet can charge a bit more on fares than Ryanair. *"Ryanair gets some very good landing deals*", Nicol says. *"We don't so much; therefore, we expect that people will pay more to travel to the main airport in the city"* [16].

4. MULTIMODALITY AND INTERMODALITY

The sustained growth in demand for air travel has led airlines to give increasing attention to how they can maximise the effectiveness of their networks by improving linkages with other transport modes.

Intermodality of an airport system corresponds to the inclusion of different transport means in an airport network, resulting in the airport itself being just one element of the extended network. Multimodality is a concept where the airport is the focal point of all transport activities, with a master/slave relationship to rail and road systems feeding the airport. It can involve a combination of:

- access to airports: local services between the airport and the neighbouring city (e.g. via train, metro, bus or even boat);
- feeder services between the airport and the various parts of the surrounding region (mainly provided by train, high-speed train or bus); and
- complementary or alternative services between the airport and the centres of neighbouring regions.



Transport intermodality consists of using different networks (road, rail, air, maritime) and vehicles in order to optimise time and costs. A request to an intermodal transport service is constrained by factors such as: origin and destination, implementation times, routing and what is transported (goods, people). Different transport means are employed in order to meet technical efficiency -- measured by the ratio between service provided and energy resources spent -- and economics, quantified by the relation between displacement costs and added value produced. Approaches based on multimodal transport principles and technologies are getting more and more attention. However, up until a few years ago, operatives in this sector were using mostly monomodal transport and excluding alternative and more flexible concepts that could improve the efficiency and effectiveness of the whole system.

The protracted hegemony of monomodal transport has strengthened conservative and static views, focusing on classic solutions and not investing enough resources in innovative multimodal solutions. It is necessary to increase the momentum of multimodal transport activities, which represent the only realistic solution to the problem, mainly in countries like Italy, where manufacturing industries rely on imports for raw materials and exports for marketing their products abroad. There is evidently a very close relationship between quality and functionality of transport technologies and a sound national economy.

Multimodal transport allows the optimising of time and costs. The term “combined transport” is used to indicate different transport modalities of people and goods. Displacements (of people or goods) should be carried out using the best means from the technical, economic and environmental points of view; transit between different transport means should be easy, in order to make the transport system attractive. Standard transport facilities for goods (pallets, containers) have been developed for this purpose.

It can be said that the transport system network must be: accessible; unbroken; integrated; structured.

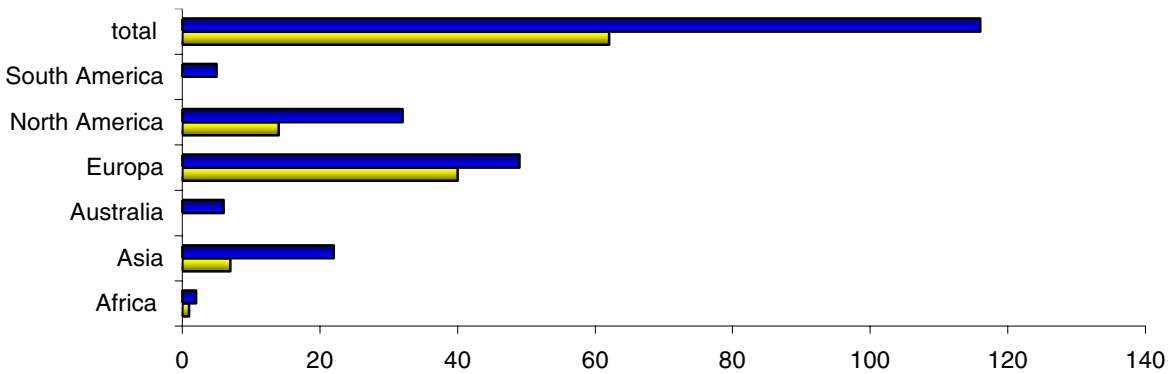
Multimodal transport is considered efficient because it reduces transport time and costs for people and goods, and effective because it meets its objectives. It is very flexible, using all known transport means and easing the task of the user to reach the destination speedily and economically. Large, medium and small enterprises can use it, building an image of reliability through efficiency and economically viable, targeted services.

Air transport is best interfaced with rail, which allows the timely and reliable movement of a large number of people and goods in a more environmentally friendly way than roads.

4.1. Air rail links

A railway line through an airport is a modern and efficient way of feeding the latter and handling passenger flows. Most examples of intermodality operate on a bilateral basis (e.g. a combined journey involving a railway and an airline). However, the next step requires an "integrated approach", with a common information and distribution system across the airline and railway system. This will allow passengers to benefit fully from the "seamless" travel experience. To achieve such integration, airports and rail infrastructure providers will need to facilitate interlinkages between rail and air and apply best practices such as common handling of baggage and information. Projects are both operational and under development in Europe, Australia, Asia and America, where airports are connected to cities increasingly integrating other transport means, such as high-speed rail, the underground, dedicated shuttles and cars.

Projects on air-rail links (ARL data, 1998)



	Africa	Asia	Australia	Europa	North America	South America	total
planned	2	22	6	49	32	5	116
running	1	7	0	40	14	0	62

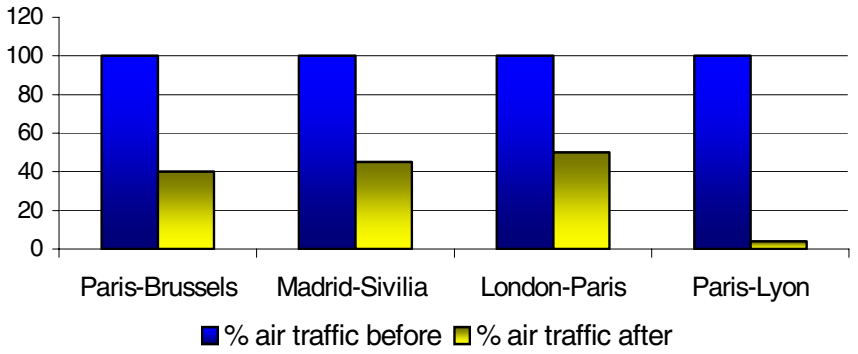
A short analysis follows of possible connections between airports and railways.

4.1.1 Dedicated high-speed links

Narita Express, Gatwick Express and Stansted Skytrain have been the first to offer a targeted service to and from the airport, reducing intermediate stops and focusing quality of service on air travellers. Further dedicated lines exist in other European cities, such as Stockholm, Oslo and the Heathrow Express in London. Examples in Asia include Hong Kong and Kuala Lumpur airports. Johannesburg is now assessing the feasibility of a dedicated high-speed rail link.

4.1.2 High-speed networks

High-speed rail networks allow further decongestion of airport traffic by competing directly on routes below 500 km. The Madrid-Seville and Paris-Brussels air links have been reduced by roughly 50 per cent, while the air connection between Paris and Lyons has almost totally disappeared.



A sure, positive outcome of this situation is the widening of the airport system's area of influence, by connecting distant destinations efficiently. Forefront countries, such as Germany and France, are investing heavily in these projects.

These competing rail lines, contrary to dedicated links, must be part of a national network in order to generate a sufficient flow to feed all destinations.

4.1.3 Comparison of air/rail environmental impact

Rail links lose their attractiveness on longer routes due to the environmental impact of present-day railway technology.

A comparative study into high-speed rail and regional aircraft noise has been carried out and published by the ERA Directorate. The study demonstrates that the noise perceived by residents living between 30 and 150 metres from TGV lines can be as much as twice that of a typical regional jet measured at only 280 metres from takeoff, i.e. at its most noise-critical phase. Furthermore, the duration of peak noise recorded for a typical regional aircraft is between two and three seconds, compared with eight to nine seconds for a standard high-speed train.

While peak air noise is restricted to the immediate vicinity of the airport at the points of departure and arrival, rail transport leaves its noise imprint all along its journey, affecting a much wider area and a higher population. Additionally, unlike air transport, rail is not normally subject to night curfews. In fact, there are currently no internationally imposed noise regulations for rail which compare with those applied to airlines.

4.1.4 Regional links

Airports could be part of a dense regional rail network, in order to become even more central and a focus of activities and services. For instance, Heathrow, already an important trading node, is planning to become a node of a regional rail network with the purpose of increasing its connectivity length by land. Frankfurt, Geneva and Zurich are examples in Europe of airports enclosed in a regional rail network which includes international railway lines. A regional network is being built in Australia in order to connect airports between Sydney and Brisbane within a single railway network.

4.1.5 Metro links

This is surely the most common connection and, if underground, the least invasive. The metro, mainly in the US, is the most sought-after option for short distances. The Cleveland, Boston, Atlanta and Chicago lines are operational already, but there are more than thirty projects underway. Examples in Europe are the Piccadilly Line for Heathrow in London; Stuttgart, Düsseldorf and Munich in Germany; and Barcelona in Spain. Examples in Asia are the Shanghai and the Singapore Changi lines.

4.1.6 Incidental links

A further set-up to be considered is that of airports which are close enough to a pre-existing railway network to afford a small railway station within their premises.

Prestwick is a clear example of a fruitful connection with the nearby railway line. Edinburgh could develop in a similar way by exploiting a railway station predating the airport and used for different purposes.

4.1.7 Cargo air rail links

In the past, fuel was the only good that was passed on from train to plane. The idea is developing now of exploiting the characteristics of the cargo train to the full.

Frankfurt, Liège, Milan Malpensa, Amsterdam Schipol, London Heathrow and Paris Charles de Gaulle are airports which are taking this route.

The way forward is to standardize the containers and modify the railway containers, in order to streamline loading and unloading and avoid multiple cargo manipulations.

4.1.8 Horizontal elevator

Another interesting, more sophisticated, ground transportation system could be produced at O'Hare. The Raytheon Company says it is developing a Personal Rapid Transit (PRT) system for Rosemont, Illinois, adjacent to the airport. Automated guideway transit systems are becoming common at airports such as Tampa, Orlando, Atlanta, Denver and others. Instead of the large vehicles

in use in most airports today, this is a four-passenger rail car which provides a dedicated trip from origin to destination within the airport system without stopping at other stations en route. This futuristic concept has been referred to as the "horizontal elevator" [10].

4.2. Intermodality in Frankfurt

The intermodal infrastructure at Frankfurt Airport (Fraport) is the best and most efficient airport dedicated railway network in Europe. Existing connections allow short transfers, previously by air, thus reducing airport congestion and enhancing the ATM capability of longer routes. This approach is constrained by the quality of service to passengers, in particular maintaining travel times within acceptable limits. The railway network includes three passenger stations and one cargo train station, handling about 100 IC and 230 regional trains per day, for a total of 225 thousand passengers monthly. In this respect, the agreement between the Lufthansa airline and Deutsche Bahn has led to a decrease in domestic flights, while the total number of movements has increased noticeably.

4.2.1 Train to plane

Fraport AG is the only airport that guarantees transfer from train to plane in 45 minutes. The Stuttgart-Frankfurt connection has been operational since March 2001 and allows an easier connection with southwestern Germany. The connection with Cologne from 2002 will bring closer the two largest German *Länder*, reducing the maximum journey time to Fraport from two hours to 58 minutes. The railway connection will provide a means of widening the airport's area of influence.

Co-operation with other airports (Saarbrücken, Hanover and Frankfurt-Main), where Fraport AG is a shareholder, will increase capacity and shorten delays.

Unfortunately, short-distance transfer potential is only 5 per cent of present capacity, showing that intermodality and co-operation with neighbouring airports do not provide a complete answer to airport expansion needs.

The management experience of the Stuttgart-Frankfurt rail link shows that the train-plane connection, even if efficient, still has to overcome public resistance, due to the human tendency to be wary of anything new and different [12].

5. THE "VIRTUAL HUB" CONCEPT

The "virtual hub" idea is a way of analysing features and advantages of intermodal airport integration, in an ever more complex air traffic situation, which is expected to double in the next twenty years.

5.1. Definition

The "virtual hub" (VH) is an airport network where the positive features of the hub-and-spokes and point-to-point systems are strengthened, in order to optimise performance and capacity by considering the role and purpose of each airport. Intermodality, rail in particular, and fast links are the basic elements of the concept. A VH is a network of airports connected together by high-speed rail.

5.2. Why the "virtual hub"?

The VH solution means more than simply increasing the hub capacity:

- Wider area distribution of environmental impacts;
- Higher specialisation and better connections;
- Higher efficiency of each node.

Each VH component must be analysed in detail, in order to avoid limitations and bottlenecks. A high-speed link is a challenging choice, economically speaking. But so are the construction of a new airport and the disadvantages of congested airports.

To assess the potential development of a VH system, an actual situation will be discussed. The area of northern Italy is an appropriate case for considering the VH solution, in terms of level of activity, terrain morphology, population and infrastructure density and distribution.

6. NETWORK NODES

6.1. Area of influence

The northern Italian area encompassing Lombardy, Emilia-Romagna and Veneto is central to the Italian economy. It is a crossing point of the two main transport and trade routes, connecting Italy to the rest of Europe. The Iberic-Russian route [1-1] and that connecting northern Europe with the Mediterranean Basin [2-2] cross over in this area, thus requiring roads, railway lines and airports of the highest possible efficiency.

6.2. Possible nodes

As far as airports are concerned, there are 17 handling commercial air traffic in northern Italy, and a further 34 dealing with general aviation.

Six airports have been selected to be part of a future VH network, on the basis of location, degree of specialisation and traffic level, with a view to developing a co-ordinated and interoperative airport system.

Strong competition in recent years has made regional airports depend heavily upon carriers' strategies, with particular reference to connections and fares. They risk losing much in comparison with continental and intercontinental airports. In this situation, *"efficiency, as a key to success, is constrained by economies of scale […]; synergies, integration and co-operation with other Italian airports should be sought […]. Synergies can develop more easily between small regional airports, but a change of role of airports could arise from shifts in business strategies of Italian carriers, Alitalia in particular."*

Analysis of the individual nodes allows us to identify their main features:

1.	Bologna	Main airport in central northern Italy;
2.	Brescia, Ghedi-Montichiari	Hub;
3.	Milan Linate	Second airport in the Milan area;
4.	Milan Orio al Serio	Third airport in the Milan area;
5.	Piacenza S. Damiano	Interport, serving north-west Italy and France;
6.	Verona Villafranca	Interport, serving north-east Italy and the Brenner–Austria–Germany route.

6.2.1 Bologna

Bologna Airport

Bologna Airport is important, both within the Italian airport system and on the European scene, as it is the main international airport in central northern Italy, connecting Tuscany, Emilia Romagna, Marche and Umbria with main European destinations. It is defined as a Regional Connecting Point (RCP) by the Transport Committee of the European Union, which means an international airport with regional service. A higher number of long-haul flights in the future will not change its status.

The airport has a 2.5 km-long runway restricted to intercontinental routes below three hours' duration or with stopovers. The cargo section has a 3 750 m^2 centre, adequate to its strategic position, with many cross routes passing by, e.g., the Brenner route.

Bologna Airport is technically efficient and up-to-date. The presence of an Environmental Impact Evaluation Centre ensures its environmental compatibility.

Traffic type

The airport's influence extends well beyond regional boundaries. Many passengers come from Lombardy (Mantua), Veneto (Rovigo, Padua and Verona), Tuscany (Florence) and Marche (Pesaro and Ancona). Bologna houses more than 70 thousand enterprises, employing about 650 thousand people out of a total population of 4 million. Region-wide activities put Emilia Romagna among the top five purchasing power regions in Europe. More than 40 per cent of its production is exported, mainly towards the European Union. Traffic forecasts predict average increases of 10 per cent for passengers and 6.5 per cent for cargo. The airport should therefore surpass the foreseen target of five million passengers a year by 2005, a substantial build-up considering the figure of 3.5 million in 2001 and the predicted slump in 2002. Short-term cargo build-up (20 thousand tonnes in 2000) is estimated at 27 thousand tonnes in 2005. Bologna has the features of a national and international airport, with an increasing intercontinental segment. Intercontinental traffic will remain a negligible fraction of the total traffic dealt with, due to the still small demand, which would not justify regular intercontinental connections. A limited number of seasonal charter flights to tourist destinations, such as the Caribbean and the Maldive Islands, can be justified. Market surveys would support destinations such as New York and Boston, while Los Angeles, for instance, would be disproportionate to the demand.

Future scenario

Runway upgrading is now essential, in order to satisfy a growing demand and the increasingly stringent environmental laws with regard to acoustic pollution. A project is running to extend the runway by 350 metres westward, accommodating up to five thousand miles of intercontinental routes. Traffic build-up will be dealt with by using larger aircraft, with a higher passenger intake per flight. A further reduction of the environmental impact will come from earlier turning, diminishing the urban impact of aircraft. In the near future, Bologna Airport will host wide-body aircraft and will handle intercontinental routes beyond Egypt and of up to 5 000 miles, while reducing its environmental impact, thus consolidating its interregional hub position for central northern Italy. It is difficult to predict the future of such a dynamic airport structure. If traffic forecasts are fulfilled, the addition of a shorter, two-kilometre runway would be justified, handling regional and small business aircraft and freeing slots on the main runway. Due to the airport's topography, the second runway would impact slightly on the main one, but would still allow an increase in the peak traffic capacity of from 32 to 45 movements per hour.

6.2.2 Brescia-Montichiari

Montichiari Airport in Brescia

Originally a military airport, it now handles authorised civil air traffic. It is under the same management as Verona Airport, but the management activity has been separated recently with the creation of a new enterprise. Its objective is to develop the airport as a complementary and specialised, non-conflicting unit to Verona, thus creating an airport network for the Garda area. Montichiari has a three-km-long runway.

Traffic type

The commercial use is too recent to yet have representative data with respect to the airport's potentialities. About 275 thousand passengers went through it in 2001, an increase of 70 per cent over the previous year. The airport is geared to handle charter and low-fare traffic, with limited competition with Verona on some routes. Cargo will not represent a major traffic component, due to its proximity to Verona interport and the express cargo hub of Milan Orio al Serio. It could specialise in heavy cargo traffic.

Future scenario

Brescia Montichiari Airport has a high development potential. Due to its proximity to Ghedi Airport, it could develop into a hub with two parallel runways, three kilometres apart and three km long, thanks to the low population density in the area near both airports, allowing the controlled landing of two aircraft simultaneously. Airport terminals would be integrated and located centrally in between the runways. With full ATM, the hourly capacity could reach ninety movements. Along these lines, a future Montichiari-Ghedi airport could manage the major airlines' intercontinental traffic. The high-speed rail link between Milan and Verona could widen the area serviced.

6.2.3 Milan-Linate

Linate Airport

Linate was the main airport in Lombardy until recently, due both to its strategic position near Milan, in a very active area of Europe, and to the low competitivity of other regional airports.

Traffic type

Linate has a 2.45 km-long runway and was able to handle intercontinental, international and national routes with scheduled and charter flights. In the past, it managed about 500 thousand movements a year, corresponding to more than 14 million passengers.

Today, regulations on the Milan airport system limit to 18 the maximum number of hourly movements, with a decrease in the number of yearly passengers to six million. Twenty-six airlines are operating on a total of 25 routes, 12 national and 13 international.

Linate is becoming more and more a city airport, operating a point-to-point system, and is moving towards handling business-type traffic.

Future scenario

The present limit of 18 hourly movements, from 45 until recently, comes from the flight distribution strategy within the Milan Airport system, including Malpensa and Orio al Serio. If traffic evolution requires it, this airport has a traffic build-up margin of 25 m/h.

6.2.4 Milan-Orio al Serio (Bergamo)

Orio al Serio (Bergamo) Airport

Orio al Serio Airport, a few kilometres from Bergamo, is in a central position in Lombardy and northern Italy. It started operation as a military airport, but since 1978 is a fully civil airport with 24-hour operability.

It has two runways, one three km long by 45 metres wide and a second one of 750 metres by 18 metres for general aviation use. The main runway has a capacity of 18 m/h, as in Linate, while the yearly passenger traffic capacity amounts to three million a year. About 1.5 million passengers transited in 2001, using half its capacity. A traffic surge of 8-9 per cent a year is estimated for passengers, while cargo has seen a linear increase, with 15 per cent in 2001.

Traffic type

Orio al Serio has specialised in cargo transport since 1985 and, since the development of fast couriers, has maintained a steady growth, thus reaching a national leadership in the sector of light goods air transport. Orio al Serio is DHL's only Italian hub and the feeding branch of its European hub in Brussels. It can handle intercontinental, international, national and general passenger traffic.

Up until 2002, the total number of movements has declined by 11.5 per cent with respect to the same period last year, with an increase of 11.3 per cent in passenger and 4 per cent in cargo traffic. This indicates a lesser traffic volume but larger aircraft with a higher loading factor, causing a lower environmental impact locally.

Future scenario

New ATC hard- and software will increase hourly capacity. More advanced approaching radar will enhance the aircrafts' visibility range. These upgradings will allow increasing hourly movements, up to 24. It can be predicted that the Class 4E runway, with a new ILS 3b, will lead to potential peak traffic of 45 m/h, as seen in Linate previously.

Orio al Serio cannot remain simply a charter and express cargo airport, however important. It is now already handling major airlines and will continue to do so in the future. Its evolution from cargo to cargo + charter to include passenger traffic has reached a substantial equilibrium among these three modes of operation. Heavy cargo traffic will decrease, transferring in part to the new cargo centre of Malpensa and to the developing Montichiari Airport. Building of the new cargo area is postponed until development of the area south of Orio al Serio and of Montichiari is assessed within the Italian cargo market.

6.2.5 Piacenza-San Damiano

Piacenza San Damiano Airport

This airport is presently under the jurisdiction of the Italian Air Force and only military operations are carried out on the 2.99 km-long runway. The airport area's yearly fog average is 19 per cent, lower than eastern areas in the Padana Valley. The Province of Piacenza can play an important logistic and infrastructural role. The airport is located near the high productivity region around Milan, which is undergoing two major changes: a shift of production and servicing activities towards regional borders and settling of commercial enterprises along the main transit routes. These two phenomena give rise to different mobility demands and network congestion.

Traffic type

In order to evaluate the impact of San Damiano Airport on the traffic pattern, the isochronous lines could be used to determine the limits of the user area. They identify areas fifteen minutes apart in travel time, which could be reached in 90 minutes by car from the airport. The overall area is 120 km in diameter, from the Modena Province in the East up to Alessandria Province towards the West. Areas in Lombardy that would fall within this area are Cremona, Pavia, Lodi, part of the Province of Mantua and the territory south of Brescia and Milan. This basin has an import-export turnover in excess of € 30 billion. Keeping in mind that transport costs are about 12-15 per cent, it is clear that San Damiano Airport could benefit from a transition from military to civil and commercial activities with medium- to long-haul flights. The future role of San Damiano Airport with regard to cargo traffic can be estimated easily, using a similar approach to that employed when analysing the impact of Orio al Serio near Bergamo. The two airports are similar in size and infrastructure, and the potential exists for comparable levels of cargo traffic.

Yearly movements in 2004 could be around a thousand, with an increase of 20 per cent in 2006. Goods turnover could be 15 thousand tonnes in 2004, reaching 18 thousand in 2006. Over the longer term, ten movements daily could be envisaged, on the basis of 250 working days a year, nearing 38 thousand tonnes transported.

Future scenario

Evolving markets which increasingly use air transport, and the strategic positioning and ease of access of the area of Piacenza, could focus the future activity of this airport on cargo transport, without ruling out passenger transport as well. The airport could concentrate on cargo activity in the short term, expanding later towards charter and small-business air transport and then evolving towards scheduled national flights and a few international ones. Intercontinental flights would not be foreseen, due to the proximity of Bologna Airport and the possibility of a hub in Brescia.

6.2.6 Verona-Villafranca

Verona Villafranca Airport

Originally a military airport, it is now open to civilian traffic. Verona Villafranca serves an area with one of the highest social and economic development rates in Europe. North-eastern Italy is a well-known development model: the provinces of Brescia, Mantua, Rovigo, Vicenza, Trento, Bolzano and Verona, with four million inhabitants, supply more than 12 per cent of the Italian GNP. The airport has a single 2.99 km-long runway and handled more than two million passengers in 2001.

Around 30 per cent of overall internal Italian traffic and 50 per cent of international traffic passes through the interport of Verona. This data does not take into account the minor cargo activity of the airport, which is but a negligible percentage of the national average.

Traffic type

Air traffic is mainly national and international. The user basin has an international tourism component, thanks to the cultural, sporting, natural and gastronomic attractions of the area. There is some charter activity, which should benefit from co-operation and interoperability with nearby Montichiari Airport in Brescia. The airport has a complete infrastructure, from in/out cargo handling to assistance in all customs procedures. The cargo sector at Verona Airport includes both surface and air transport. It provides reception and temporary storage in customs areas and organises surface transportation towards Malpensa, Frankfurt and Paris airports, while the Brenner network allows easy and convenient road transport of non-express goods towards Austria and Germany.

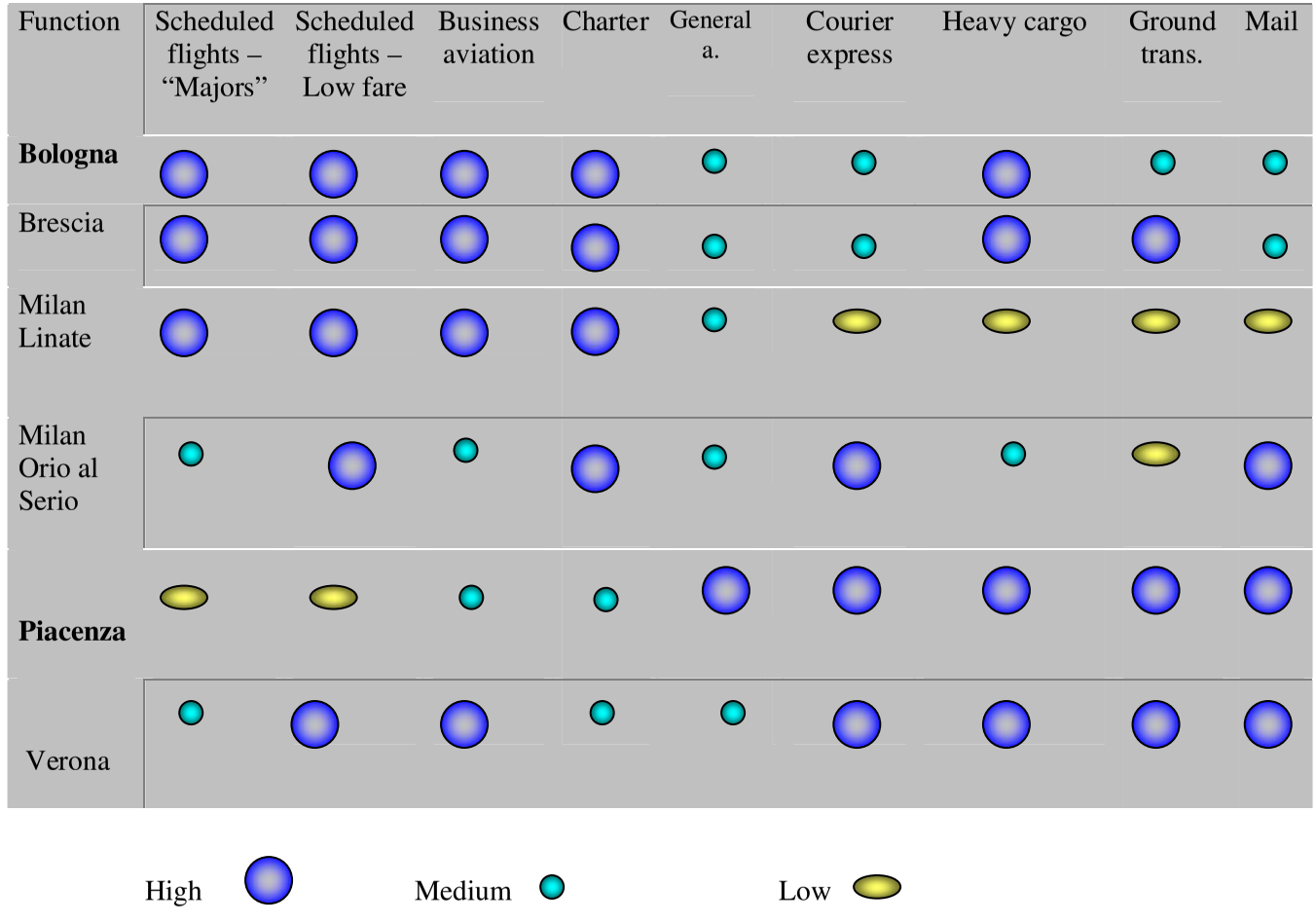
Future scenario

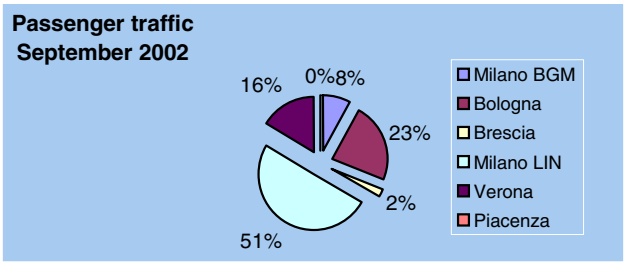
Verona Airport can increase the efficiency of its services, already among the highest in Italy. The development of its infrastructure is constrained by its proximity to the city, which imposes landing and take-off routing boundaries. Presently, the military area neighbouring the airport is the main obstacle to infrastructure development and routing flexibility.

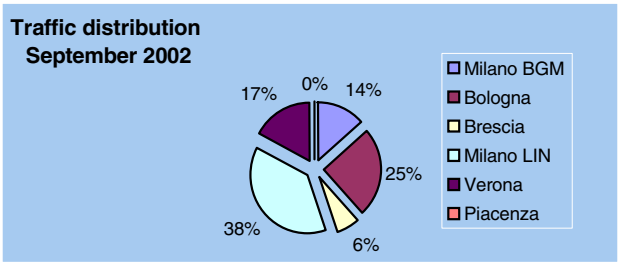
Among external infrastructures contributing to airport activity, the Agro-food Centre is presently under construction. It will be the main platform of its type in Italy, with an impact at European level.

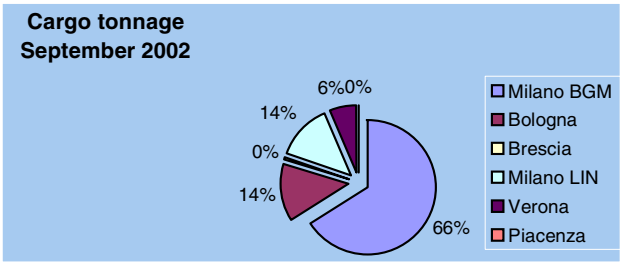
This will lead to the setting up of a very advanced goods network near the airport, thus demanding a major upgrade in cargo transport efficiency.

Characteristics of future scenario









7. CONNECTING INFRASTRUCTURES

7.1. High speed trains

The potential demand for transport services in Europe involves more than 350 million inhabitants in the Union, plus those in Switzerland, Norway and other countries, including those from the newly associated Member States from Eastern Europe. In the meantime, transport mode distribution is leaning heavily towards road transport. Goods transport via rail in the Union accounts for only 14 per cent of the total, against more than 60 per cent by road. A similar pattern exists for passenger traffic. It is clear that mobility in Europe is increasing constantly, leading to inevitable road congestion. Infrastructure saturation is then likely to become a serious obstacle to further development of mobility, which is a basic condition for growth.

Completion of the high-speed rail network in continental Europe is a milestone set for 2010. Creating trans-European routes is an essential condition for achieving higher cohesion and competitiveness, with particular reference to high-speed and combined transport lines.

A further priority of the European Union is the completion of projects assessing intermodal relationships between high-speed rail and air and regional and urban transport. Studies of direct importance to Italy are those on the connection between Turin and Lyons and the Brenner route, which would allow integration of the Italian high-speed network with the European network. The Italian high-speed rail network project includes the reassessment of urban nodes and a fourfold increase of high-density traffic lines along main routes such as Milan-Naples, Turin-Milan-Venice and the connection between Milan and the Po Valley.

7.1.1 Connection features

High-speed, advanced technology lines are conceived in accordance with European directives, and will be dedicated to transport of passengers and goods over medium and long distances. A close integration with the existing European and Italian network will be achieved by means of numerous connections, with the aim of increasing the capacity of the Italian rail system, by increasing safely the number of routes and trains, their frequency and the quality of service. Existing lines can be devoted to local and regional transport. The main objective is to create an efficient transport network with direct access to the main transport and exchange nodes, namely, ports, interports and airports, thus creating an efficient and environmentally acceptable intermodal system.

General features of an integrated rail-airport connection:

- Check-in on the train;
- Double boarding card;
- Automatic luggage handling;
- Host/hostess and catering service on board;
- Improved quality of service;
- Low number of intermediate stops;
- All weather service.

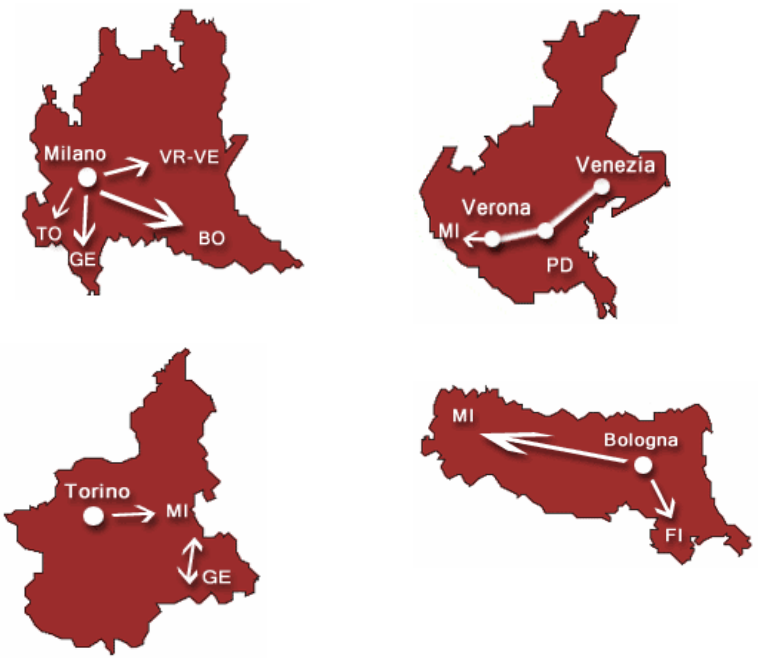
Technical features of the integrated connection between high-speed rail and airports:

- Traffic type: passengers and cargo
- Maximum design speed: 300 km/h
- Minimum bending radius: 5 450 m
- Maximum outdoors slope: 18‰
- Maximum indoors slope: 15‰
- Maximum rise: 10.5 cm
- Minimum radius of altimetric connections: 20 km
- Maximum load per axle: 25 t
- Basin width: 13.6 m
- Track width: 5 m
- Natural galleries cross section: 82 m^2

7.1.2 The "virtual hub" high-speed area

Milan is the focal point of the whole northern Italian high-speed network, playing the role of the "rail hub" for all high-speed trains to connect France, Germany and Austria through the Lyons-Turin-Milan-Brescia-Verona-Brenner route, thus contributing to the improvement of commercial traffic across Europe.

Three high-speed links will be built in Lombardy: Milan-Bologna (45 out of a total of 182 km), Turin-Milan (27 out of 125 km) and Milan-Verona (about 115 km). Milan and Brescia will be upgraded to high-speed nodes.



Source: FS site.

The 182 km-long high-speed Milan-Bologna line spans 42 municipalities within the Po Valley and the provinces of Milan, Lodi, Piacenza, Parma, Reggio Emilia, Modena and Bologna. It will link with the existing network through eight nodes and will allow an 88 per cent transport capacity increase.

It foresees the reorganisation of the Bologna railway node, with the upgrading of the railway station and the creation of ten new nodes linking it regionally to the existing lines. Further upgrading will refurbish regional and urban networks. The Milan-Verona line will span 31 municipalities in Lombardy and four in Veneto. In order to minimise environmental impacts, the new line will run along existing or already planned connection lines for 125 of its 136 km total and will connect to the existing network through six new nodes north-eastwards from Milan towards Verona.

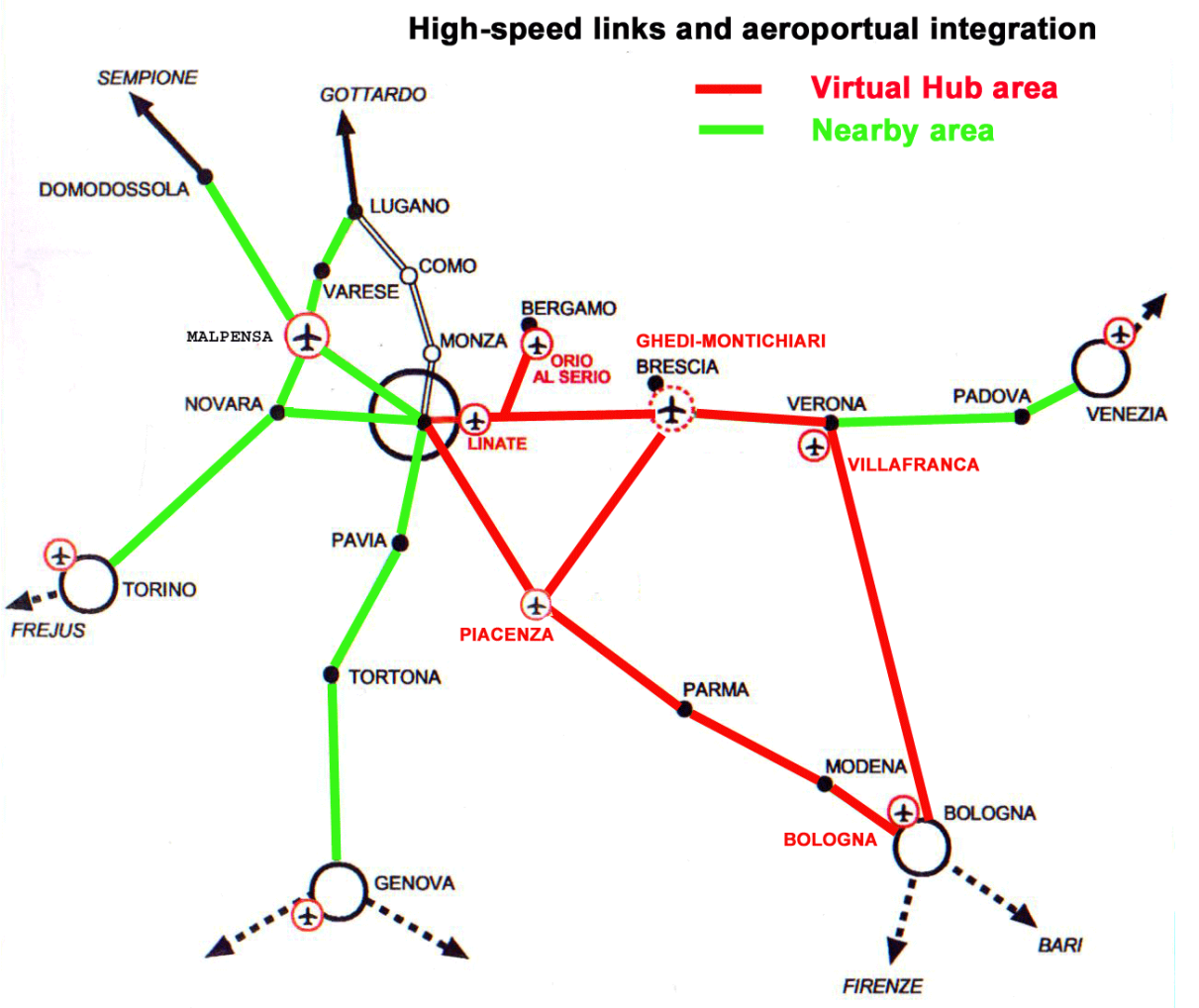
Route/Node	End of construction
Turin–Milan	2005 Turin-Novara 2007 Novara-Milan
Node of Turin (1)	2005
Milan-Bologna	2006
Node of Milan (1)	2003
Node of Bologna	2006/beginning 2007 (first phase)
Bologna–Florence	2006
Node of Florence (2)	2006/beginning 2007 (first phase)

7.1.3 Journey times

The use of advanced technologies, adoption of higher safety standards on tracks and trains and the proper selection of routes will allow the shortening of journey times across the whole network. By strong interlinking with the existing network, benefits will overflow to the whole rail network, thus bringing northern and southern Italy closer together and to the rest of Europe.

Line	Length (km)	Present duration*	Future duration
Turin-Milan	153	1h35'	50'
Milan-Bologna	215	1h46'	1h
Bologna-Florence	92	58'	30'
Milan Verona	136	1h30'	45'

Source: National Railways 2002, including five-minute stopovers at every station.



7.2. Mobility network of individual airports

Bologna

The airport area has two main features: a high level of urbanisation of the region and the strategic position of the city. The airport is near Bologna, capital city of the Emilia-Romagna region in central Italy. Four main roads and five main railway lines go through this area:

Highways:

Switzerland-Milan-Bologna
Brennero-Verona-Bologna
Rome-Florence-Bologna
Ancona-Pesaro-Bologna

Railways:

Rome-Florence-Bologna (AV)
Brennero-Verona-Bologna
Milan-Bologna
Ancona-Bologna
Genova-Bologna

The airport is not well connected to the city. It is close to a railway line, but also a highway and a ringroad and 95 per cent of passengers travel there by car. A shuttle service runs from the central railway station every 15 minutes with a 30-minute journey time. Two studies are looking for solutions to overcome the present situation: the first one is considering a raised, non-stop, light metro line, called a "people-mover", linking four railway lines to the airport, with only two intermediate stops. The second study is investigating the creation of a hybrid tram-metro line, linking the airport and the central railway station through more nodes, including expo and university sites.

This would be a slower link with a higher air passenger load, limiting delays to 15 minutes.

Brescia Montichiari

Links to downtown Brescia (20 kms) and a highway network are possible through a high-capacity ring road. The vicinity of the A4 Milan-Venice highway (six kilometres away, appropriate for cargo connection), the A21 Brescia-Piacenza and the Brenner route (50 kms away) allows the airport to be effective in a very busy area. The airport is three kilometres away from the planned high-speed rail line, and a dedicated stop is possible without excessive costs.

Milan Linate

Located on the outskirts of Milan, seven kilometres from the city centre, it is near Lambrate railway station -- which has a metro station -- and the highway network around Milan. Linking Linate to the high-speed line will not require major changes: a dedicated line between Linate and the central railway station, with a stopover at Lambrate station, is a possibility.

Milan Orio al Serio

The main hindrance to further developing this airport is the lack of surface connections to other airports in the region and to other municipalities nearby. The main highway does not have the necessary capacity to handle the ever-increasing traffic volumes, and the need for infrastructure development -- such as the already planned links, north to the Brenner route and south to the A1 highway -- is becoming urgent. The local rail network must improve, englobing the area of Bergamo more effectively, doubling the number of lines and linking all airports in Lombardy with their feeding area. A link to the high-speed rail line is not planned, but the airport is halfway between Milan and Brescia, less than sixty kms from both. Airport development plans are based on a full separation between passenger and cargo traffic.

Piacenza San Damiano

This area is a very important road and rail node. Its future enhancement is based on three success factors: a large number of important settlements; the existence of intermodal infrastructure; and the possibility of developing a mobility network beyond the region including the airport.

The airport is 16 km from Piacenza, near the A1 highway and the A21 serving the Brescia-Piacenza-Turin basin. The local road network feeding onto the main one is centred south of Piacenza. The railway network follows the same routing.

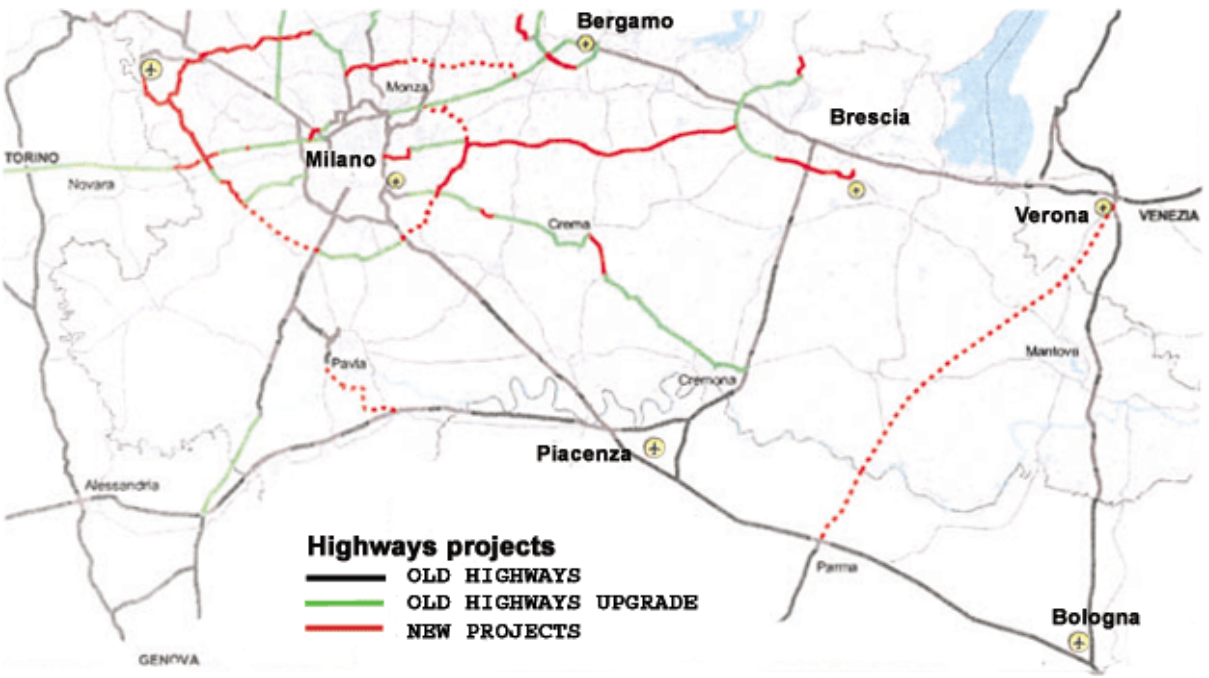
Upgrading the airport will lead to an increase in road traffic without hampering its present efficiency, as an aircraft load corresponds to two double-axle vehicles on the road. The remaining impact is negligible compared to the present flow of about 400 vehicles per hour, and the present road system capacity would be sufficient to feed the planned cargo traffic.

Verona Villafranca

The airport of Verona Villafranca is in Veneto, 160 kms east of Milan and 120 kms west of Venice. It is at the centre of a highway network connecting Turin to Venice and crossing, near Verona, the Brenner-Modena route which connects central Europe to Italy. Verona is an important railway node and the focus of a wide-ranging road-air-rail intermodal system called "European Quadrant".

Links with downtown Verona (12 kms) and with the highway system are provided by a high-capacity ringroad system. Due to its vicinity to main routes in the area, it has an important strategic role to play in the region. Its area of influence includes six provinces located in three different regions: Verona and Vicenza in Veneto; Bolzano and Trento in the Special Statute region of Trentino Alto Adige; and Brescia and Mantua in Lombardy. Furthermore, the airport serves other provinces in Lombardy (Cremona), in Veneto (Rovigo and Padua) and in Emilia (Parma, Modena, Reggio and Ferrara).

Villafranca is linked with a shuttle bus to Verona and Brescia railway stations, making it an attractive proposition for tourist and commercial traffic.



8. FULL NETWORK

8.1. The "virtual hub"

Establishing the "virtual hub" is not easy in practice. Some constraints have been set, which allow a preliminary analysis of the problem itself.

Feasibility constraints:

- Existence of a high-speed railway line in the area;
- Dedicated airport connections or links to the high-speed line;
- Common approach from all stakeholders aiming at global development in the area;
- Full development and upgrading of existing infrastructure in each airport;
- High demand traffic basin, justifying load distribution across neighbouring airports.

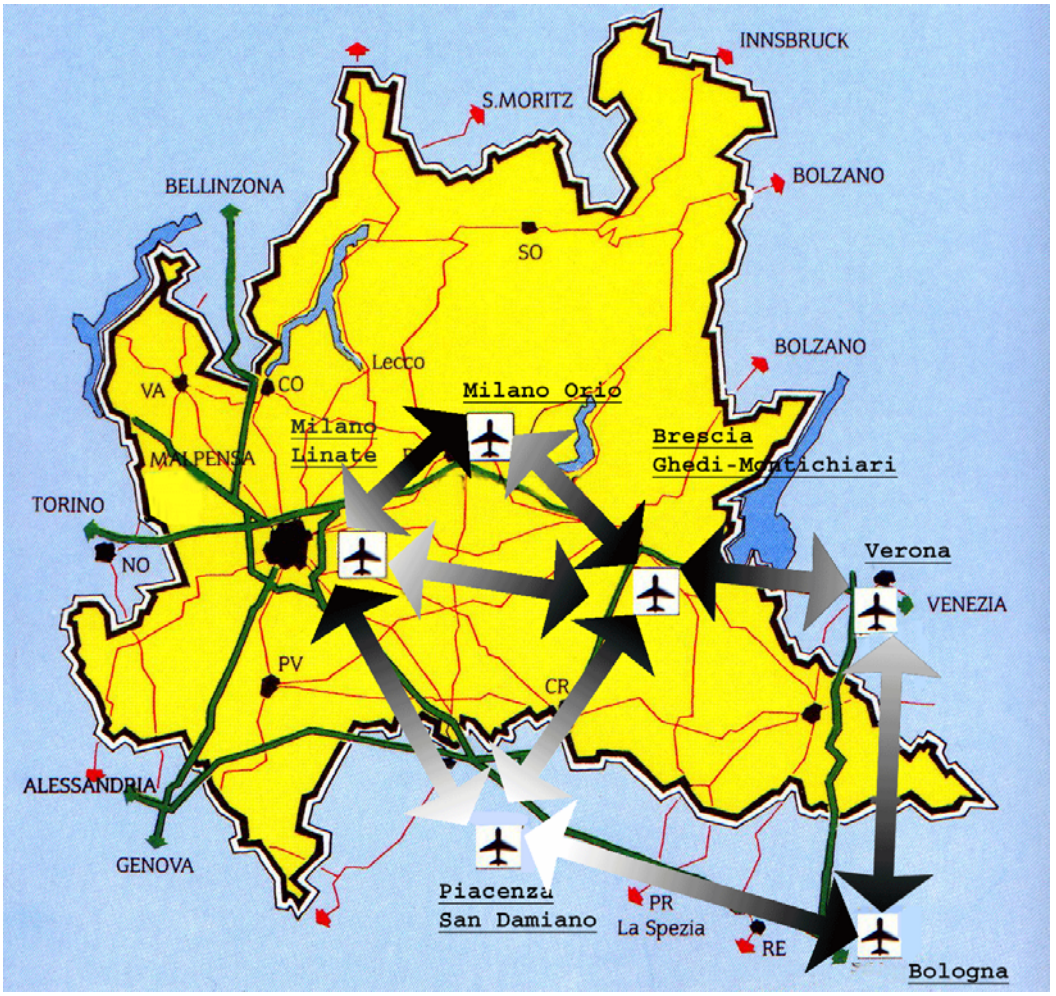
In the specific example considered, the "virtual hub", comprising six airports, is a system with seven main and two secondary runways, devoted mostly to general aviation traffic.

Each node in the system has two or three main features which can become the focal points of the node activity in the future.

Ghedi-Montichiari has been taken as the main hub, both due to the presence of two runways and because of the local morphology and land use. Two other runways could be built, parallel to the existing ones, allowing -- within the constraints of a minimum 1 035 metres distance between any two of them -- four simultaneous instrumental movements per hour, with a peak of 180.

The feasibility of a further runway would make the airport less sensitive to meteorological conditions. Bologna and Linate airports would play the role of mini-hubs, exploiting their relevance and position. The former would serve both passengers and cargo, while the latter would be devoted solely to passenger traffic. Piacenza, between Milan and Bologna, would be best placed to handle wide-range cargo mostly, taking advantage of its northwesterly feeding basin, the lack of competition nearby and the local interport. Orio al Serio near Bergamo would focus on express cargo, thus playing the hub role in this market segment, without neglecting the passenger segment.

In this scenario, Verona Villafranca Airport would exploit the nearby interport and concentrate on heavy cargo, even if a passenger segment could be considered in co-operation with the Ghedi-Montichiari hub.



8.1.1 Passenger segment

Milan Linate serves Milan's large, ever-increasing feeding basin and could become a city business airport.

Ghedi-Montichiari, located between Linate and Verona, would handle intercontinental, as well as national and international traffic.

Bologna Airport would also handle passenger traffic in all segments, due to its relative remoteness from Milan (250 km) and Verona (200 km).

Piacenza Airport would mostly, but not solely, handle charter traffic, evolving later to handle low-fare, national and international air traffic.

8.1.2 Cargo segment

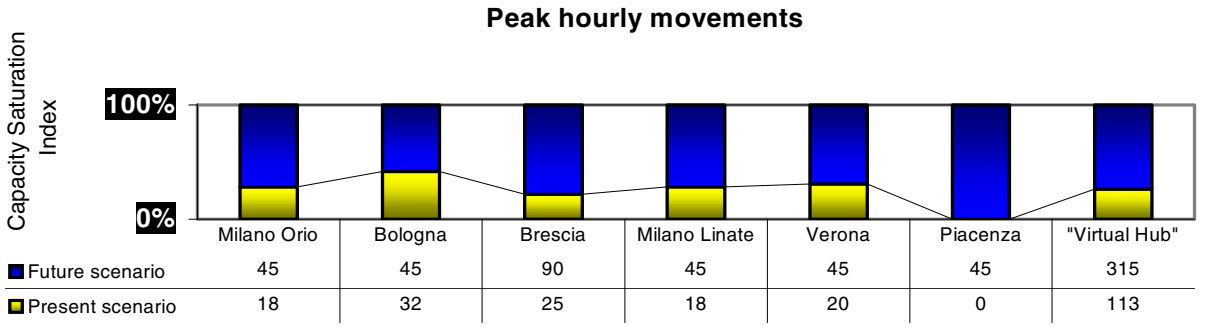
The "virtual hub", as conceived so far, has two interports and corresponding cargo centres at Verona and Piacenza. The nodes in Bologna and near Bergamo have a cargo centre already. If Ghedi-Montichiari were to develop the cargo segment as well, this virtual network would be complete, with five distribution nodes.

It is important to develop these scenarios in full, as the further segmentation of the cargo sector has to be more elaborate than for the passenger sector.

Cargo infrastructure is bigger and costlier than others, requiring round-the-clock operation, and thus making the sub-segment choice a sensitive one. For instance, express cargo requires speed and efficiency, while heavy cargo has high logistics and space demands, even considering that total national cargo traffic represents no more than 30 per cent of London's. No Italian airports (not even the entire airport system around Milan) figure among the world's 45 most important cargo airports. In spite of this fact, Italian industry is second in Europe after Germany with imports/exports of 1.3 billion tonnes by air. It is a sector with high potential for development and, according to airport operators, is limited presently by the lack of infrastructure, aerial links and cargo vectors [4]. It could be concluded that wider specialisation within the network and wider service, including new destinations, would enhance the air cargo transport market.

8.2. Benefits and performance level of the "virtual hub"

8.2.1 Performance



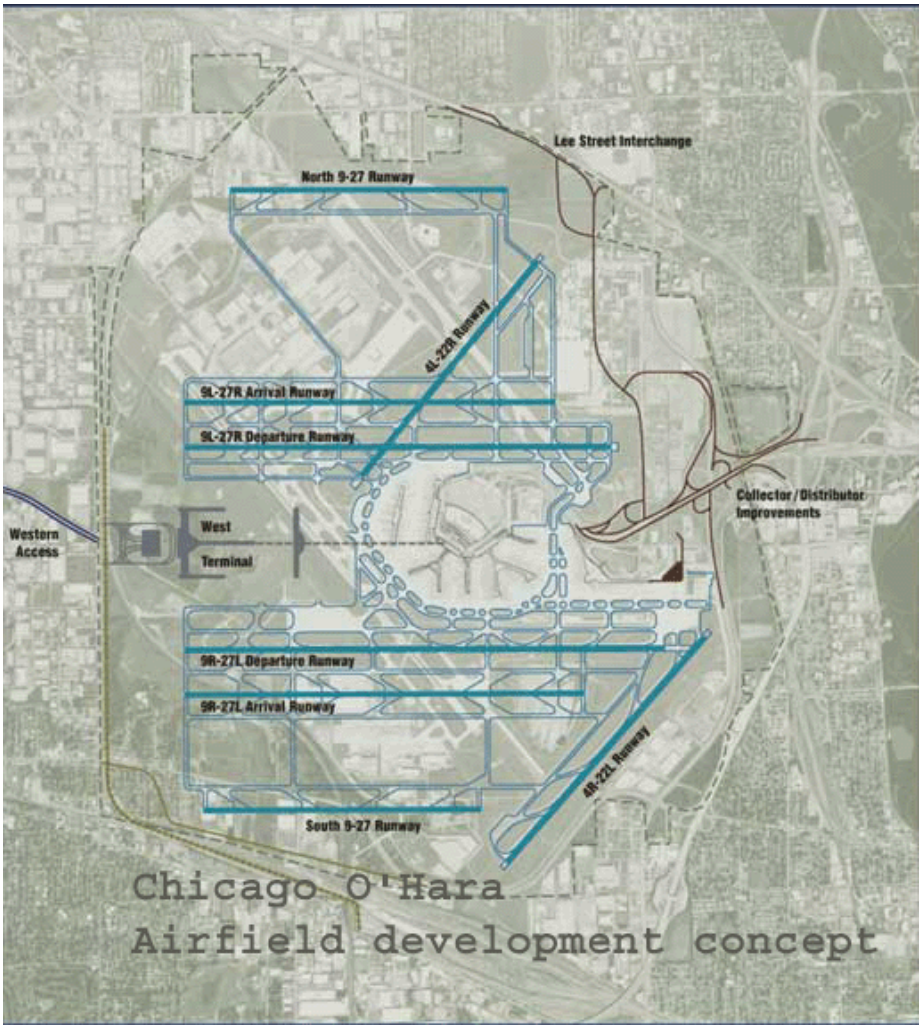
8.2.2 Connection times

Air Rail link	High speed link	Standard line
Milan Linate-Bologna M.	1h	1h46'
Milan Linate-Milan Orio al Serio	20'	40'
Milan Linate-Brescia M.	30'	35'
Brescia-Milan Orio al Serio	25'	35'
Brescia-Verona Villafranca	20'	40'
Verona Villafranca-Bologna	1h	1h30'
Bologna –Piacenza San Damiano	35'	50'
Piacenza San Damiano–Milan Linate	25'	40'
Piacenza San Damiano–Brescia M.	25'	40'

8.2.3 Comparison with Chicago O'Hara Airport

A comparison can be made with the O'Hara Airport in Chicago, presently among the first in the world regarding generated traffic.

Programme highlights of the "Ultimate Airfield Configuration of Eight Active Runways Plan" includes the addition of one runway and the relocation of three of the seven current runways.

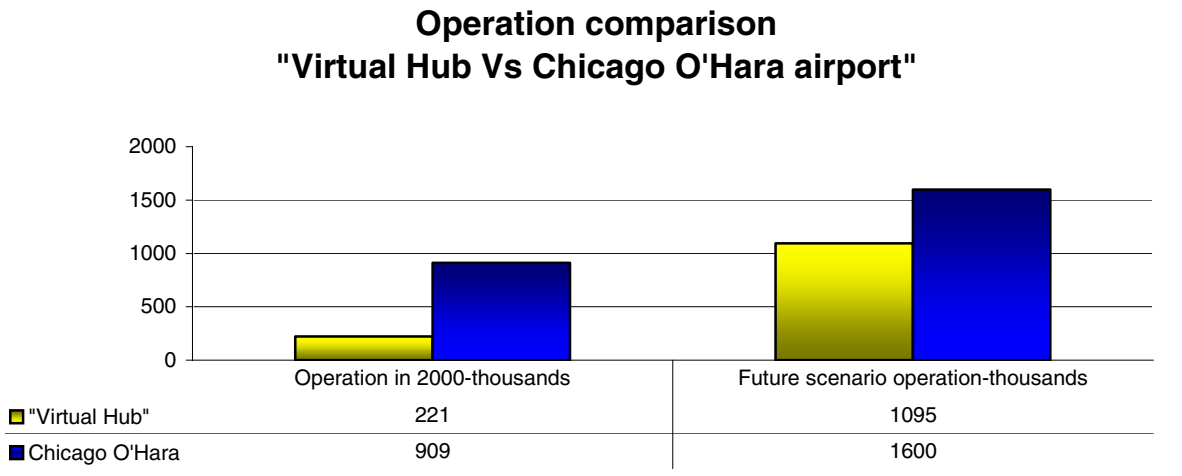


Source: Chicago O'Hara airport.

Advantages:

- A major reduction in delays, and congestion delays related to poor weather reduced by 95%;
- Overall delays reduced by 79%;
- Annual delay savings: $370 million;
- Annual passenger delay savings: $380 million;
- The Airline Improvement Program (AIP) grants an estimated annual capacity of 76 million placements;
- 1.6 million operations.

If the plan goes ahead, O'Hara Airport will become the largest ever complex, including all possible airport activities, but with advantages and disadvantages. This typical hub-and-spokes approach is viable in the US, where land is more readily available, but is far more difficult to realise in the Italian context.



Comparison of land occupation

Airports	Present - m^2	Future - m^2
Milan Orio	3,500,000	3,500,000
Bologna	2,145,000	2,145,000
Brescia *	1,600,000	3,700,000
Milan Linate	3,960,000	3,960,000
Verona	2,400,000	2,400,000
Piacenza	2,150,000	2,150,000
"Virtual hub"	15,755,000	17,855,000
Chicago O'Hara**	31,185,000	32,938,650

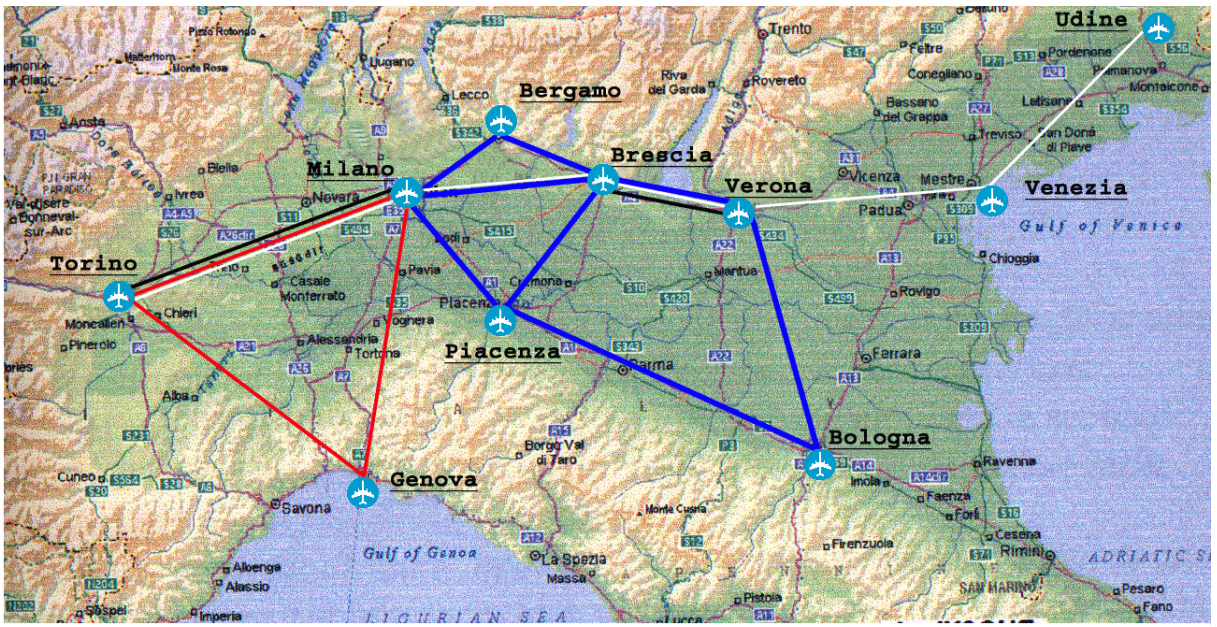
* The present surface includes Montichiari Airport only. The future one comprises Ghedi Airport as well.

** Impacts Land Acquisition: Approximately 433 acres to be added to 7 700 acres of the previous airport occupation [1 acre = 4 050 m^2].

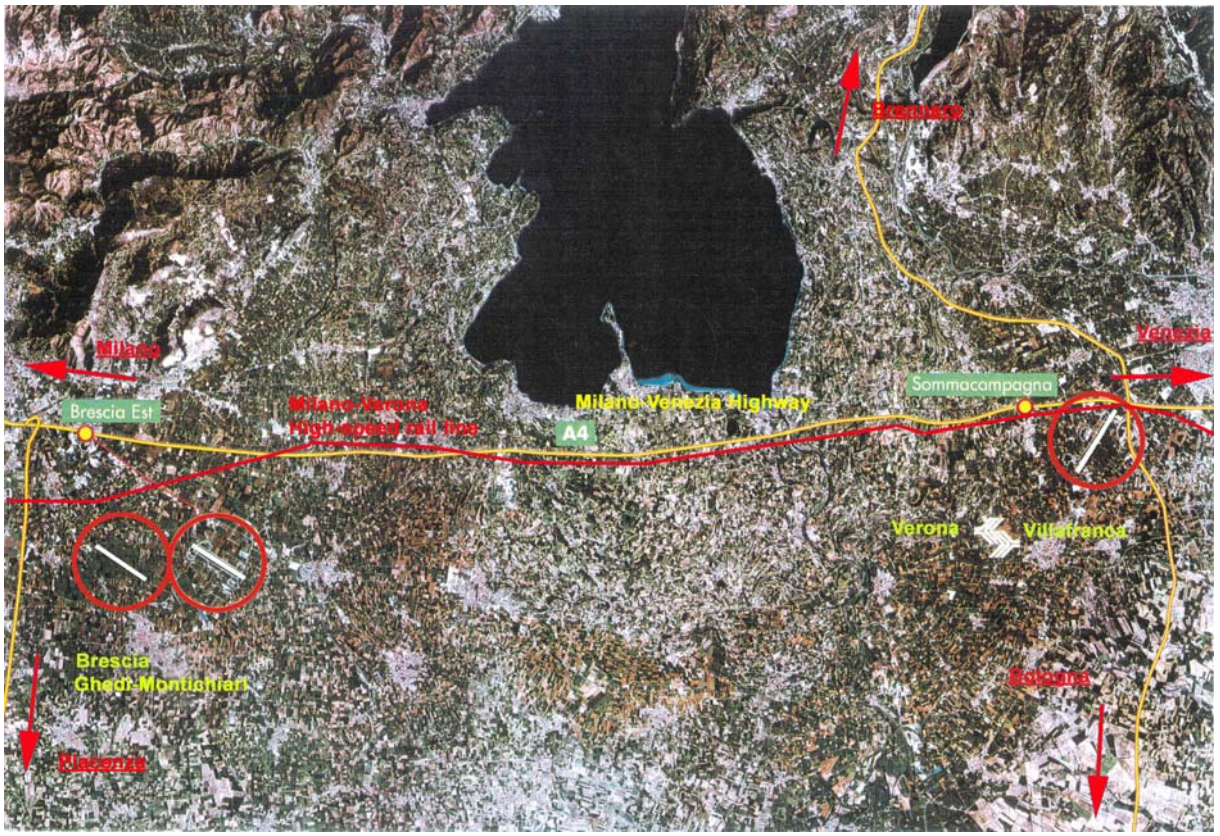
9. CONCLUSIONS

The situation in northern Italy -- where more than ten airports are located within an area 500 kilometres in diameter -- lies between individual, separated infrastructure and a self-contained traffic basin. The presence of a "virtual hub" type of airport network would allow a focused and exhaustive service provision. Some market segments could overlap, such as charter services, while others would be handled separately with a high degree of specialisation, such as express and heavy cargo transport.

The proposed system combines old and new ideas, with the objective of creating an airport network capable of handling an ever-increasing volume of air traffic, which would not be absorbed by separate infrastructure. A "virtual hub" could be a linear network crossing northern Italy from east to west or a two-node one based on the Milan-Malpensa and Turin-Caselle airports, and taking advantage of the future high-speed rail link connecting the two traffic areas.



Another possible example is the Brescia and Verona system, where the Milan-Venice high-speed rail line is planned to have a stop. It could become another two-node, virtual hub, facilitated in this development by being controlled by the same airport authority.



Air-rail intermodality is an important success factor for an airport system. The rail payload is a constraint in the assessment of link performances.

Finally, the virtual hub approach will allow the proper co-ordination of airport authority policies across regional boundaries, to the benefit of the communities at large.

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AIRPORTS AS MULTIMODAL INTERCHANGE NODES - THE EXAMPLE OF LONDON HEATHROW

Alastair DUFF
Chairman, Heathrow Area Transport Forum
Heathrow Airport Limited
London
United Kingdom

**AIRPORTS AS MULTIMODAL INTERCHANGE NODES -
THE EXAMPLE OF LONDON HEATHROW**

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London, December 2002

1. INTRODUCTION

"*Airports are important transport hubs within their regions…they need to be better integrated into the wider transport network to maintain and improve access…the larger airports have the potential to become important surface transport hubs in their own right, not just as destination points, but as interchanges between car, bus, coach and rail.*"

(*Transport 2010: The 10-Year Plan*, Department of the Environment, Transport and the Regions, 2000)

The purpose of this report is to identify the ways in which airports can provide, at the level of activity appropriate to their hinterland and by means of their ability to become integrated transport hubs, significant opportunities for further developing transport in their region. By establishing an Airport Surface Access Strategy, which is incorporated into the Local and Regional Transport Plans for the area, the surface access needs of the airport, and its role in transport, economic and social development, become part of the regional and local planning process.

Traditionally, airports, like seaports before them, have been seen as very much mode specific: a conglomeration of runways, taxi-ways and terminal buildings entirely focussed on ensuring that aircraft and their passengers were safely and efficiently handled. Questions of how passengers reached the airport were generally ignored by airport management, who believed that such responsibilities lay elsewhere, with local and national government, who, in turn, tended to see airports in the same context as industrial estates or large-scale urban developments, for which road access would be developed over time.

In practice, airports have several characteristics which are unusual, if not unique, in transport terms. Of all destinations, passengers are most concerned about getting to the airport on time to catch their flight; and if airport staff are unable to report on time, across a 24-hour operating schedule, essential facilities will not open as required to handle aircraft. Urban transportation planning takes little note of these characteristics, and the development of an intermodal strategy on surface access for airports, aimed at creating an integrated hub, is increasingly required.

The concentration of large numbers of air passengers and employees creates significant opportunities for transport providers. However, these opportunities are not always apparent to them, due either to a lack of data regarding the potential market, inappropriate assumptions about the airport's needs or a lack of consensus among the wide range of agencies associated with the delivery of public transport improvements. And in terms of commuter planning, airports provide a concentration of employment that makes large-scale, site-specific mobility management schemes successful.

An airport is a place where networks meet, integrating very different scales of distance and modes of transport, from walking to flying.

Six key points can be established about this kind of interchange. It:

- is a major focal point in its environment;
- relieves practical interchange problems and offers an image of quality;
- is service orientated;
- is developed though partnership;
- operates co-operatively between the service providers; and
- adopts an innovative approach.

In order to ensure that there is close understanding of the needs of the various parties involved, it is important that the airport's access development strategy should focus on:

- building partnerships with key regional and local organisations;
- understanding customer needs;
- improving key interchange points on and around the airport;
- working with stakeholders; and
- delivering customer-focused, quality-driven services.

To achieve this, Heathrow became the first airport in the UK to set up an Airport Area Transport Forum partnership, involving the local and regional authorities, transport operators and authorities, national agencies and adjoining business interests. The aim was to find ways in which surface access, both to the airport and within the surrounding area, could be improved, whilst also identifying other options, such as car-sharing and cycling, which could equally reduce car dependency. Its success has been such that all airports in the UK are now required by government to set up their own forum and establish a Five-Year Surface Access Strategy, setting out commitments, objectives and targets.

2. THE SOCIO-ECONOMIC IMPORTANCE OF AIRPORTS

"*Key world centres are likely to be located on the interchanges between road, rail and air…the international nodal points will be located where the global airlines have their hub operations and where good quality transport links are available to the local, regional and national centres of population and business activity.*"

(Proceedings of the International Air-Rail Conference, Milan, 2000)

"*An improved transport infrastructure can improve the profitability of investment in other sectors, and so encourage greater innovation by companies…we find evidence that an improved transport infrastructure has a noticeable impact on productivity. Good air transport links are one of the key considerations affecting where international companies choose to invest. The industry is part of the transport infrastructure on which many other parts of the economy depend.*"

(The Contribution of the Aviation Industry to the UK Economy, OEF, 1999)

When looking at the role of airports as regional transport interchanges, it is helpful to consider their wider economic importance. A recent study by Oxford Economic Forecasting has shown the crucial importance that aviation makes to the UK economy.

Key factors include:

- a contribution of £10.2 billion to GDP;
- the direct employment of 180 000 employees; equal to car manufacturing, hotels or telecommunications services;
- it supports up to three times as many additional jobs through supply chain and induced effects;
- provides two and a half times greater productivity than the average UK job;
- it exported £6.6 billion of services, equal to 11% of UK exports of services;
- it transported a further £35 billion of UK exports;
- it contributed £2.5 billion to the Exchequer (on a conservative estimate); and
- it invested £2.5 billion a year over the last five years, equal to 3% of total UK business investment.

Heathrow itself is a major economic catalyst, contributing around £5 billion in wages alone to the national economy and an estimated £2 billion locally. Direct, on-airport employment is 68 000, with an estimated 245 000 jobs nationwide in indirect employment related to the airport. BAA's annual value to the region in terms of procurement is £183 million (2000 figures.)

3. WHY SHOULD AIRPORTS BE CONCERNED ABOUT SURFACE ACCESS?

"*Whether by accident or design, airports are increasingly becoming interchange hubs for surface travellers who have no business at the airport. This includes people for whom the airport is a convenient access point to/from surface public transport. Interchange facilities must accommodate this, although the Committee accepts that interchange should not overwhelm the* raison d'être *of the airport. The facilities should ideally be planned from the start with all transport needs in mind, not just those of airport users. Non-airport-related interchange is also a reason why airports should have well-balanced service patterns, not just catering for air travellers."*

(Reaching the Skies. London Transport Users' Committee, 2002)

The question of surface access to airports has surfaced relatively recently. Traditionally, it was accepted that the appropriate mode of travel to an airport was by car, for which extensive parking facilities were provided. Rarely were airports positioned adjacent to a railway line or with railway access designed in from the beginning, as with Gatwick and Schipol. But in western Europe, and in Britain in particular, one of the most pressing transport issues is the rate of growth in car use and the need to find alternatives. Equally important is the continuing strong growth in air travel. Correctly or not, airports are seen as major generators of road traffic in their own right and, viewed from the opposite angle, can themselves be adversely affected by the growth in general congestion on the off-airport road network.

Several considerations therefore emerge:

- *Congestion*: This can affect the ability of passengers and staff to access the airport in a timely fashion. This creates difficulties for airlines and adds cost.

- *The environment*: Airports are uneasy neighbours, as they generate noise and emissions. Concerns about road-driven environmental impact need to be tackled and mitigated, although it is likely that the airport itself will generate only a small part of the peak-hour demand on the road network.

- *Planning approvals*: As national and international concerns about congestion and environmental issues rise, so will measures designed to manage and reduce them be applied. These measures are likely to affect the conditions under which an airport is allowed to develop its facilities to meet the capacity needs of the future.

- *Investment criteria*: Like any other business, airport management must consider how best to maximise its income stream and get best value for its capital investment. Many airports have finite resources in land for development and will face difficult choices between, for example, providing car parking for airport staff and building an office block or freight handling facility.

It can therefore be seen that there are strong incentives for airports to concern themselves with surface access and to start developing policies to ensure that their particular needs are understood and addressed.

But what kind of airport can aim to become a transport hub? It is tempting to avoid this subject as it raises more questions than it answers. But certain criteria need to be established, at least in principle if not in detail, in the context of establishing whether general-purpose or specific surface access links should or can be provided, and at what level of capacity.

It is suggested that the success factors will include:

- serving a national or regional capital city;
- a reasonable network of domestic and international air services and usually good-frequency trunk services to the national airport for long-haul connections;
- a runway capable of handling modern jet aircraft to medium-range destinations;
- a throughput of at least four million passengers a year;
- being the dominant airport in terms of route density, travel market access and facilities in its region; and
- an existing transport network serving its regional hinterland which can be built upon.

Accepting these criteria, one further important point may be made. An airport of any size is an important player in the economy of its region, making significant contributions in terms of wealth, job creation and economic regeneration. The last is of major importance to successful airport and airline growth. A survey in the Thames Valley found that over 80 per cent of firms gave proximity to Heathrow as one of their three top reasons for locating there. Within the long-term planning of its regional government, the airport will find itself playing a new role, that of catalyst for transport network improvement in its hinterland.

4. HEATHROW'S REGIONAL CONTEXT

"*Based on current plans and services, Heathrow is the most important integrated transport hub in the region and provides a developing focus for both short and longer distance movements by bus, and increasingly by rail. Feltham in particular has developed as a major rail-bus interchange and Hayes is likely to develop similar facilities. Planned new rail services include a shuttle service from Heathrow to Hayes with onward connections to Thames Trains. Over the longer term the Airtrack schemes would provide links to the south and west of Heathrow, including Waterloo. New interchange opportunities may also be realised which will support the development of intensified hubs of residential and commercial opportunity.*"

(The Western Wedge, Arup Economics & Planning, 2002)

London, Europe's largest city, has a population of over 7.4 million and, on current forecasts, could rise to 8.1 million by 2016. It is at the centre of Britain's road and rail networks and the development of these networks should take account of London's needs as well. The motorway

network around London, on which Heathrow is well positioned, enables a wide range of express coach services to serve it, a situation further enhanced by Heathrow's role as the second busiest express coach hub in the UK. The London Plan notes that London's international airports are important generators of economic activity and jobs; it will seek to maximise on this position, with particular reference to surface transport improvements which will increase accessibility to deprived areas. Each year, 49 million tourists visit London, nearly half of whom are foreign visitors. Inner London attracts 28 per cent of Heathrow's business passengers and 39 per cent of its leisure passengers, whilst Outer London draws in 13 per cent business and 20 per cent leisure.

Although the world's busiest international airport and Britain's primary gateway, Heathrow also functions in a regional context, with around 85 per cent of non-transfer passengers originating or destinating in London and the South-East.

The economy of South-East England is critical to the performance of the UK as a whole. With an estimated GDP of £130 billion in 2001, the South-East represents the second largest regional economy in the UK, marginally behind London and accounting for almost 16 per cent of the UK's GDP. With a population of over 8 million, one in seven of the UK's residents lives in the South-East region. With over 255 000 registered businesses, the South East accounts for 15 per cent of the UK's total business base. Total employment is estimated at 4 million, equalling 15 per cent of total UK employment. The South-East has a higher proportion of fast-growing sectors than any other UK region and, as a result, exports more goods, estimated at nearly £28 billion.

These factors are reflected in the long-term performance of the South-East's economy. Between 1990 and 2000 it grew faster than any other UK region, expanding at an annual average rate of 3.1 per cent. The scale and success of its economy is indicated by the contribution it makes to public finances. In 2000, it made a net contribution of £17 billion to the UK Exchequer, equivalent to 15 per cent of the region's GDP. This is the largest contribution of any UK region.

The South-East is the UK's key international gateway, with a substantial proportion of international passenger and freight movements transiting the region's airports and seaports; principally Gatwick, Southampton and the Channel Tunnel. Although located just outside of the region, Heathrow clearly has a substantial spatial and economic linkage with South-East England. Its focus as the UK's premier international gateway has major implications for the region's transport system, particularly the Thames Valley sub-region.

5. AIRPORT TRANSPORT STRATEGY

"*Regional, national and local planning bodies are relied upon to bring together the general needs of urban transportation and the specialized needs of airports by the development of comprehensive transportation plans for metropolitan and regional areas as a whole…with this diversification of responsibilities careful co-ordination is required.*"

[Alexander Wells (1996), *Airport Planning and Management*]

Interchange is not an end in itself but part of the travel process. By the nature of their operation, airports offer special potential for development as integrated interchanges. It is in the airport's interest to encourage this process. Surface access must develop in line with increases in terminal and runway capacity or bottlenecks will develop which will prevent the airport from realising its full potential. By setting out to become a regional or sub-regional transport hub, the airport will be seen as a good neighbour by working with others to improve network conditions; offering customer-focused, quality-driven transport services that collect air passengers and staff at as early a stage in their journey as possible and providing swift and efficient routes to the airport.

There is no single model which can be applied across the board. To clarify the details of a strategy appropriate to a specific airport will require considerable research into modal split, future air traffic growth by category and its impact on mode share, staff travel habits, off-airport travel network conditions and many other factors. Consideration must also be given to national and regional transport policies. The airport management will then need to determine the appropriate way in which to establish working relationships with those who are tasked with public transport development, the degree to which they wish to be involved and, of course, the service providers.

So the policy itself should take an holistic view of this wide range of considerations and needs, whilst ensuring that flexibility is at its core, so that the strategies adopted and implemented promote the full economic development of the airport whilst reflecting the wider business, social and environmental considerations relevant to its region.

Specific strategies could include:

- setting targets for increased use of public transport by air passengers;
- providing customer-focused facilities which encourage use of public transport;
- reducing single-car occupancy by staff;
- ensuring that operators are encouraged to provide more services through innovative financing and development schemes;
- developing an intermodal approach that integrates all forms of transport; and

- establishing effective partnerships with local planning authorities, transport authorities and operators, the local business community and others to develop area-wide, cost-effective and mutually beneficial strategies, on the premise of the airport as an integrating hub, which will exploit the full potential of public transport, including appropriate infrastructure.

6. THE ROLE OF THE TRANSPORT FORUM

"*CfIT recommends that in developing their Regional Transport Strategies, Regional Planning Bodies should ensure that interchanges are looked at from a strategic viewpoint (and) that projects are co-ordinated properly. One approach that the CfIT endorses is the establishment of a local transport forum. There are bodies like the Greater Manchester Partnership and the Heathrow Transport Forum, both dealing with major transport issues on a holistic basis with major funding involved…these groups deserve recognition and support for the work they are doing…airports are now recognized as providing a focus for transport interchange."*

(Physical Integration; Commission for Integrated Transport, 2000)

Partnerships are vital to making progress in England's multi-operator transport scene but it is essential to make effective partnerships that work. In 1994, Heathrow set out with the specific objective of creating a Transport Forum which would bring together all the key players in London and the South-East. Following several years of hard work by all parties, resulting in a number of successful projects, in 1999 a Five-Year Access Strategy was agreed, setting out commitments, objectives and targets.

Through the Transport Forum process, the Heathrow Airport Surface Access Strategy has been agreed with the 14 Borough, District, County and Regional Authorities involved and incorporated into their Local and Regional Transport Plans. For the first time, the surface access needs of the airport, and its role in transport development, is part of the regional and local transport planning process.

The Heathrow Area Transport Forum now comprises over 80 organisations. Controlled through a Steering Group, there are a number of Working Groups covering bus route development, rail planning, air quality, telematics, demand management corridors, travel planning, cycling/greenways and freight quality partnerships.

Typically, an Airport Transport Forum should include as members:

- the airport operator as chair;
- the relevant local authorities;
- the local transport authorities;
- the airline base operator;
- other employers at the airport;
- bus, coach and rail companies;

- Regional Development Agencies;
- infrastructure providers: e.g. the Strategic Rail Authority and the Highways Agency; and
- local business interests, Chambers of Commerce, etc.

Three key objectives for the Forum are:

- to agree short- and long-term targets for increasing the use of public transport;
- to devise a strategy for meeting these targets, for incorporation in the Local Transport Plan and the Regional Transport Strategy; and
- to oversee and monitor the implementation of the strategy.

To be successful, the Forum's access development strategy should focus on:

- building partnerships with key regional and local organisations;
- understanding customer needs;
- understanding key regional movement patterns and issues;
- working with stakeholders to identify holistic strategies within which the Forum strategy can sit;
- working with all parties to ensure the delivery of successful quality-driven transport services;
- improving key interchange points on and around the airport.

Figure 1 indicates the complex nature of the multimodal interchange and the wide variety of transport systems that the Transport Forum will have to consider when developing its strategy.

Figure 1. **The variety of transport modes that may impact on airport accessibility**

Public Transport Network			
	Air	**Rail**	**Road**
International Transport	Long-haul flights	HGV IC/EC	Express coach
Long-distance Transport	Trunk-route flights	HGV Intercity Express trains	Express coach
Regional Transport	Regional connectors	Regional express Regional interurban	Regional express Regional bus
Local Transport	n/a	Urban express Urban commuter Metro Underground Tram	City bus Local bus Taxi

7. THE STARTING POINT

"The Deputy Prime Minister asked me 'where is the best example of integrated transport in Britain?' I didn't hesitate and said Heathrow. It is the best example of physical integration between different modes of transport."

(David Begg, Chair of the Commission for Integrated Transport, 2000)

"*Essential components of an intermodal approach to local and regional passenger transport are:*

- *intermodal transport planning and infrastructure development, so that the modes are well connected and interchange is easy;*
- *intermodal transport operations, with co-ordinated timetables; and*
- *intermodal ancilliary services and technologies, making services like travel information, ticketing and payment mode-independent and, ideally, covering all transport in an area."*

(Passenger Interchanges. The Chartered Institute of Transport, 1998)

From the 1992 employee survey, it can be seen that car use was continuing its relentless climb, bus use and cycling were declining and walking non-existant. As far as air passengers were concerned, a fairly stable situation existed but with the abolition of the Air Traffic Distribution Rules Heathrow was having to absorb a large number of new entrant airlines as well as significant growth. The challenge was substantial and could only be met by taking a regional perspective.

Figure 2. **Heathrow Employee Modal Split**

	1975 %	1986 %	1992 %
Car	71.2	75.7	78.0
Car-sharing	7.6	5.3	4.0
Underground	1.2	3.8	6.0
Bus	12.8	11.0	6.0
Motorcycle	3.1	1.8	2.0
Bicycle	1.7	0.1	1.0
Walk	1.3	0.6	-
Rail	-	-	-
Taxi	-	0.7	1.0
Air	-	-	1.0

Figure 3. **Heathrow Air Passenger Modal Split**

	1978 %	1987 %	1991 %
Car	39.0	40.0	42.0
Car hire	4.0	4.0	4.0
Taxi	20.0	20.0	20.0
Underground	20.0	20.0	20.0
Coach/Bus	16.0	15.0	13.0
Rail	-	-	-
Other	1.0	1.0	1.0

Figure 4. **Heathrow Area Bus Strategy**

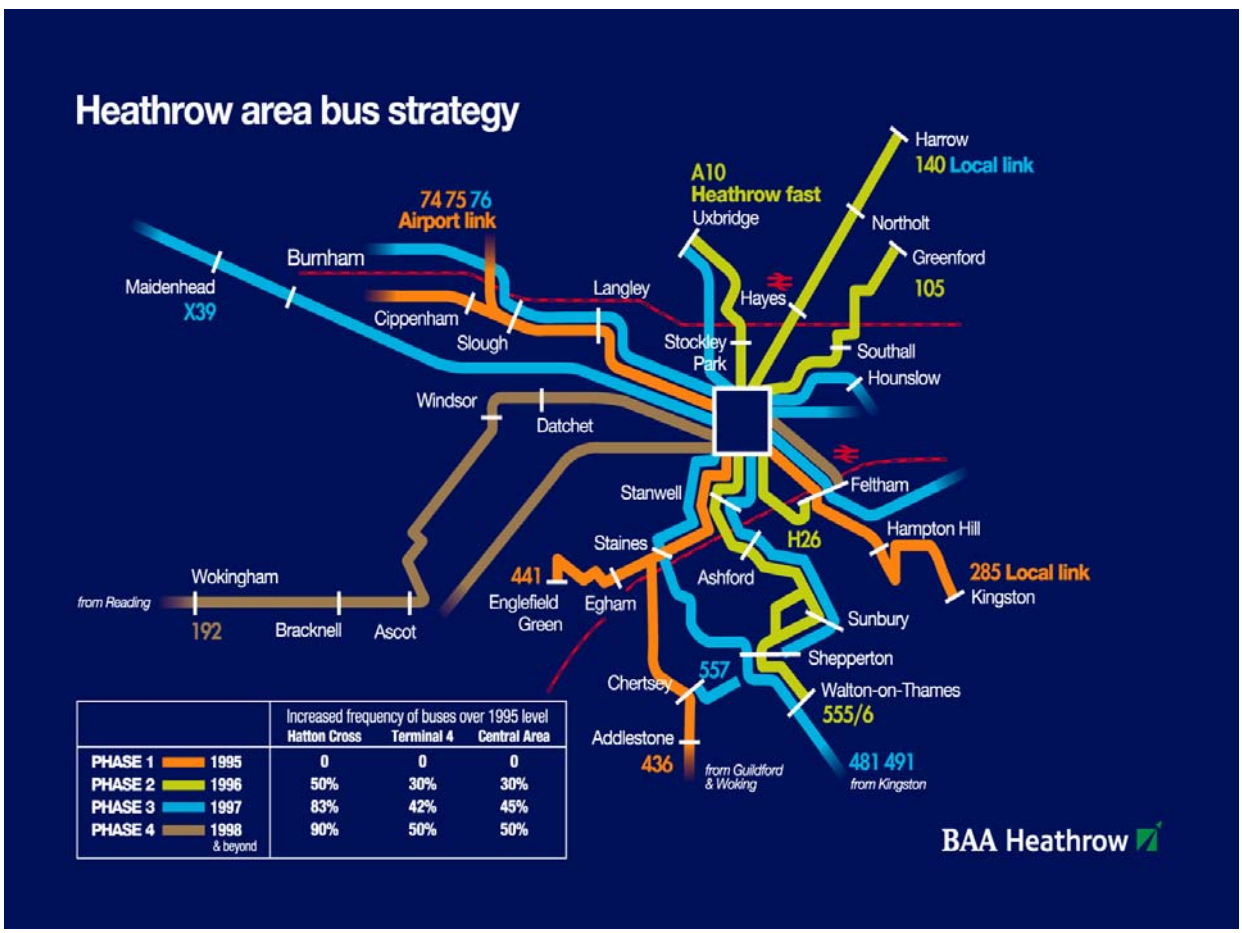
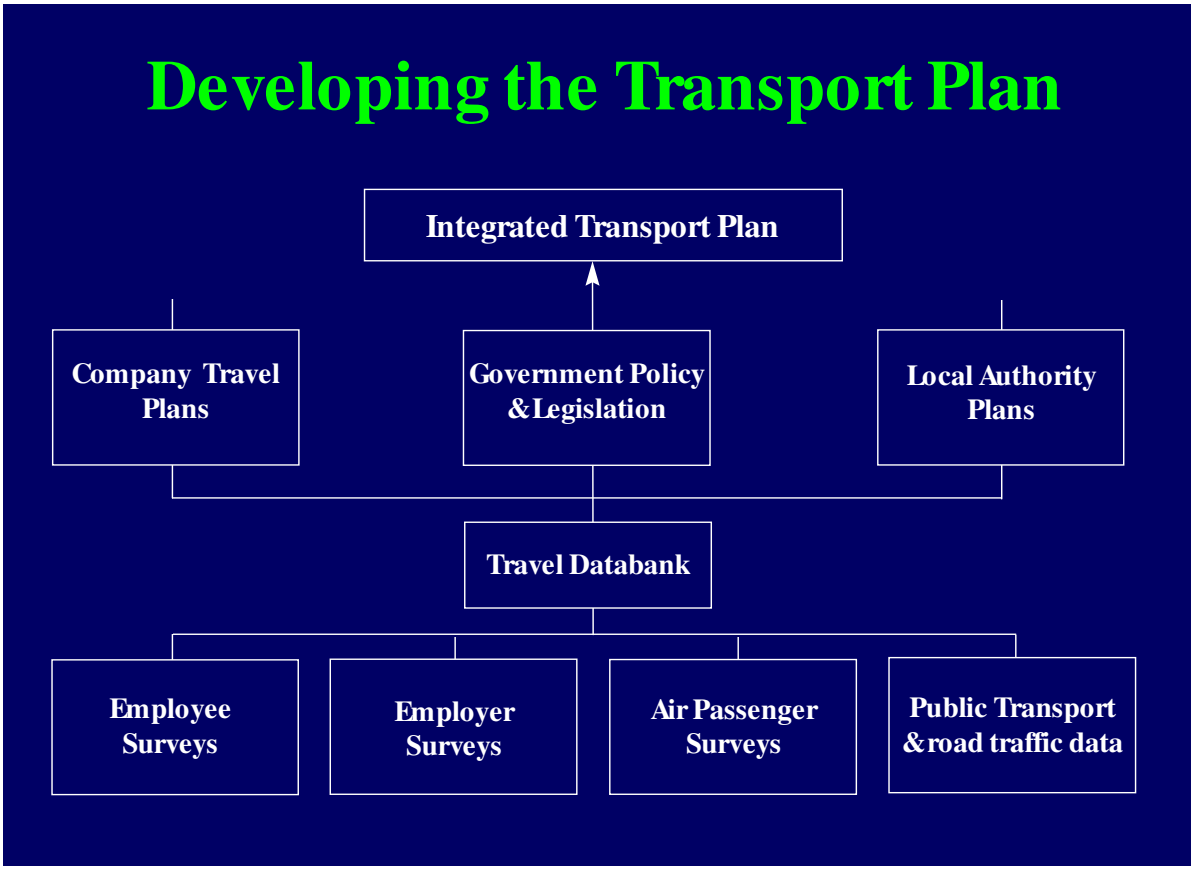


Figure 5. **Developing the Transport Plan**



In 1994, after extensive research into the travel patterns of the 53 000 airport employees and the 44 million air passengers (see Figure 5), as well as the range of existing bus and coach services in the local and regional network, a three-year initial programme was launched (see Figure 4). This was based on the belief that pump-priming specific routes, to benefit not only passenger travel to the airport but also general area traffic, could be justified by a strong, focused approach. The programme included:

- Investing £300 000 in the No. 285 bus service to Kingston, a key employee corridor; this included doubling the frequency, rebranding all the vehicles and an intensive marketing campaign. Within 12 months, growth of 92 per cent had occurred, of which one-quarter was general non-airport traffic and, after only 18 months, the No. 285 was so successful that funding was able to be diverted to other routes.

- Links to Slough, to the west of Heathrow, were poor and the Forum invested £200 000 on the No. 74/75 route, with a 25 per cent increase in patronage in the first 18 months.

- The No. 105 route was enhanced to a 12-minute frequency which, together with other improvements, led to a 40 per cent increase in ridership.

- The No. A10, a brand new service introduced in co-operation with a major off-airport business park, represented the largest single private-sector investment in a new bus service in London…£1 million on a high-speed express service with brand new vehicles, providing rapid transport along a prime, 12-mile long corridor. Very successful, it now forms part of West London's orbital network.

- In terms of facilities, £200 000 was invested in providing a computerized bus information system in the bus station, whilst the capacity of the station was increased at a further cost of £3 million, including high-capacity lifts linking the bus station with the rail station below.

- The bus station at Hatton Cross, on the east side of Heathrow, was enlarged and, in conjunction with the bus operators, the service schedule pattern rearranged so as to provide a one-change location, whereby all destinations on the airport could be easily accessed by staff. This, together with the London Underground station beneath, has resulted in a trebling of service frequency, with over 4 million passengers passing through.

- In conjunction with the mainline train operator, the No. 140 bus service is now officially linked with the 12 trains an hour stopping at Hayes Station, five miles to the north of Heathrow. With an improved schedule of every 10 minutes, the 140 not only serves the airport but also the 20 000 office jobs along the busy Bath Road corridor, with increased load factors of 50 per cent.

8. RAIL ACCESS

"*Airports are important transport hubs within their regions. They need to be better integrated into the wider transport network to maintain and improve access…the principal need is for new and improved rail access.*"

(Transport 2010: The 10 Year Plan, DETR, 2000)

"*Rail provides key public transport links to London's airports. These need to be developed, particularly on routes to Heathrow. Local access to Heathrow from the north would improve access, and the Airtrack proposal would allow direct services from Waterloo or Victoria, as well as south west London.*"

(The Mayor's Transport Strategy. Greater London Authority, 2001)

Rail as an access mode to airports is inherently attractive on several grounds. It offers high passenger capacity per movement, high frequency if the network capacity allows it, reliability of service schedule and the opportunity to build-in specific air passenger service products. In general terms, it has a much higher acceptance factor with the public. But there is one very serious issue with regard to new provision...it is very expensive and time-consuming to achieve. It is essential to choose the right type of rail mode for the airport's needs, although of necessity one has to start with what is available, and ensure that the track interface with the network maximises throughput. The relative

merits of light rail/intermediate mode, underground/urban metro, interurban, heavy rail and high-speed train are well understood. Generally, from the air passenger point of view, the last three are the most beneficial as they offer better levels of baggage storage and comfort.

So the type of rail link chosen will depend upon a variety of factors relating to airport location, type of traffic, layout and catchment area, as well as the needs of the region and its existing rail network and the development plans for the rail sector. Where there are rail proposals being developed within or through the region, it is appropriate for the airport's needs to be considered and modifications to the scheme at the design stage justified. It will obviously be necessary to show that the incremental gain to the airport, in its role as a transport hub, more than balances any downside to the network overall. If the airport is able to attract strategic rail services, then there is the possibility of using those with less than the three-hour journey time as alternatives to air services, thus benefiting medium- and long-haul air services.

It is the author's view that there are very few opportunities for a specific airport-city centre dedicated train service. The exceptions, like Heathrow Express, where there is density of demand, and Narita Express, where the airport is many miles from the centre and the road alternatives very badly congested, prove the point. The most appropriate rail service for an airport, and one which enhances its ability to act as a regional transport hub, is where existing regional and/or national rail services can be linked into the airport. The airport station thus becomes one more station on the national network, the additional costs of service are marginal compared to the full cost of a dedicated link, and the passengers are offered a wide range of destinations. In this context, Schipol and Birmingham are very good examples. Figure 7 shows current European airport rail links.

Figure 6

Type of rail link	**No. of airports**	**Airports (*Rail share shown in brackets, where known*)**
High speed trains	4	Frankfurt, Lyons-Satolas, London-Heathrow *(8.4%)*, Paris CDG *(18%)*, Stockholm-Arlanda
Long-distance trains	7	Amsterdam *(31%)*, Brussels-Zaventum *(14%)*, Berlin-Schonefeld, Birmingham *(5%)*, Copenhagen, Manchester *(5%)*, Southampton
Local trains	16	Barcelona, Belfast City, Dusseldorf, Dresden, Friedrichshafen, Graz, Hanover, London-Gatwick *(20%)*, London-Stansted *(19%)*, Malaga, Milan-Malpensa, Munich *(30%)*, Pisa, Rome, Stuttgart, Vienna
Underground trains	5	London-Heathrow (13%), Newcastle, Paris Orly (8%), Madrid-Barajas, Nurnberg
Tramway	2	Bremen, Essen-Mulheim
Note:	Lyons-Satolas has only high-speed train services. All other airports with high-speed or long-distance train services also have local train services.	

Source: Energy and Transport DG, International Air Rail Organisation**.**

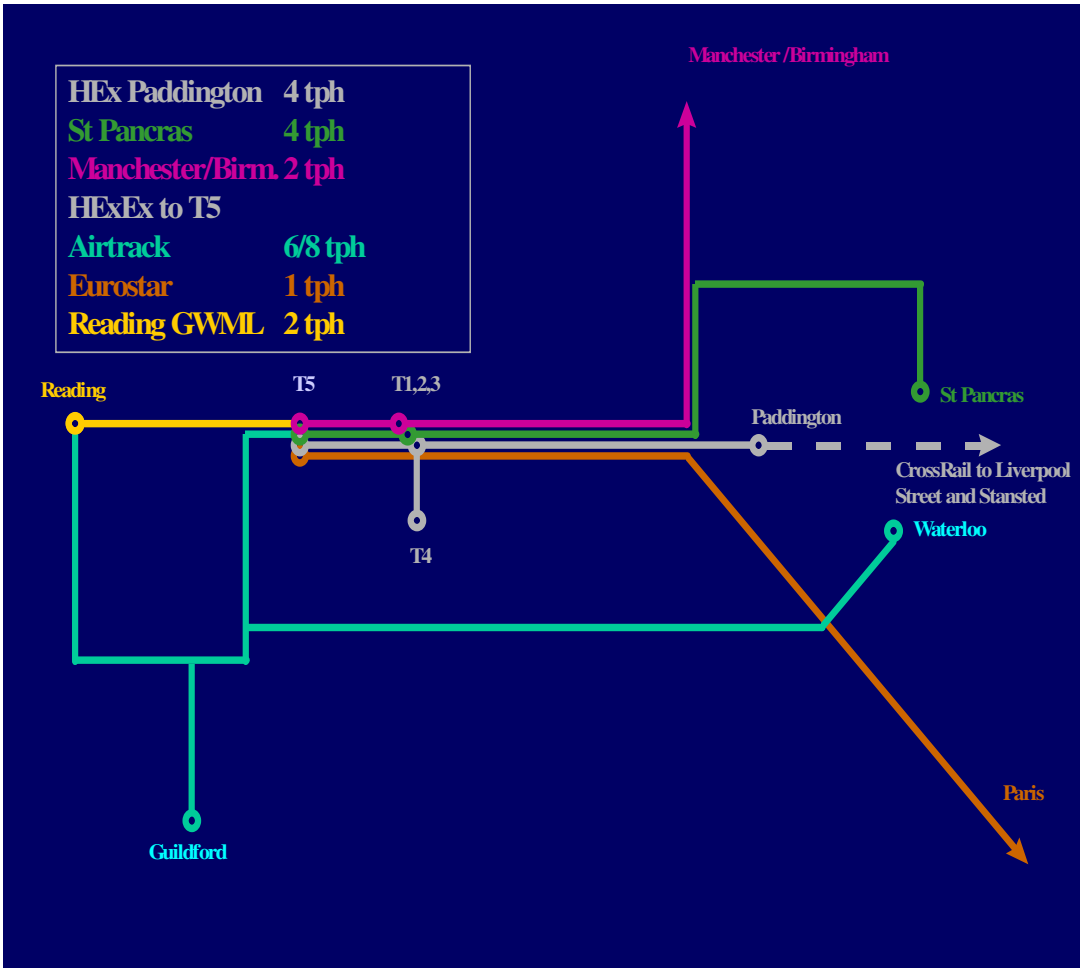
Taking Heathrow as a specific example, the planning approval granted this year to build Terminal 5 has opened a range of opportunities which will, if actually built, enable the airport to function as a major rail hub within the South-East Region. A carefully crafted strategy has been

developed (as shown in Figure 7) which will increase the present four-trains-an-hour capacity to 16 trains an hour.

The strategy is to:

- extend the present Heathrow Express branch line to Terminal 5;
- construct a headshunt beyond the T5 station which will enable a rail link from the south-west (known as Airtrack) to provide train paths connecting the southern train network with the north via Heathrow Central;
- utilise the headshunt to provide a connection to the West of England Mainline, providing services to Reading, Bristol, Birmingham and Manchester;
- provide access to the Crossrail trans-London scheme, connecting to the City of London and the Thamesmouth area; and
- create a link to the West Coast Mainline at Willesden Junction, offering high-speed services to Birmingham, Manchester and beyond.

Figure 7. **A Rail Strategy for** Heathrow



A typical pattern of services could be:

- 4tph Heathrow Express;
- 4tph Thames Valley Corridor services;
- 2tph Manchester/Birmingham-Heathrow-Southampton-Portsmouth high-speed services;
- 4tph Cross-London interurban services, calling at most stations;
- 2tph Watford-Heathrow-Guildford regional orbital metro service.

If this strategy were to be implemented, it would result in a remarkable transformation of rail accessibility to both Heathrow and within the surrounding region.

The plan for a total of 16tph at Heathrow is yet to be matched by plans to accommodate these trains on the adjacent rail infrastructure. On the Great Western Mainline, proposals to build two more tracks are not yet developed sufficiently to indicate how much extra capacity is to be provided and, currently, no more than two train paths an hour may become available on the existing infrastructure. Nor can paths be offered on the West Coast Mainline or with regard to the South-West lines and access to Waterloo; and some services to the South-West through Woking would require new infrastructure. Although all of these issues are being addressed, the objective should be to make the capacity on the adjacent mainlines match the potential capacity of the airport rail infrastructure, to the overall regional benefit.

The number of seats which these new services would offer would be significantly in excess of the airport's five terminal needs. Therefore many seats would be available for new regional through/ interconnecting journey opportunities. The full development of the strategy to create 16tph will require that all the routes are locked into the appropriate regional transport strategies. Combined with radically improved interchanges to maximise the use of these routes, the planned rail infrastructure could deliver far more passengers both to Heathrow and, through the new airport rail hub, to the newly created regional routes. The Strategic Rail Authority's 10-Year Transport Plan provides the opportunity to pursue this strategy.

Finally, a note of caution. Despite the attractions of rail, one must consider the customer base. One way of measuring potential demand is to take the airport catchment population and divide it by journey time and mode accessibility. Taking Manchester as an example, this indicates that between 5 and 7 million people live within one hour of travelling time to the airport by road, and this expands to 15-17 million within two hours' travelling time. The corresponding figures for rail are 1-2 million and 6-7 million. Based on these figures, the rail market potential at Manchester is only one-third of that by road. The rail network, generally speaking, is what we inherit from the past and this brings into focus the short- to medium-term opportunities offered by bus and coach services.

9. BUS ACCESS

"*On its own Heathrow cannot sustain enhanced bus service levels and new routes. An area wide approach will be important to generate sufficient patronage and revenues to support higher levels of service across any given corridor. Measures to date have shown that generation across entire routes will occur which will assist in maximizing the potential patronage outside Heathrow and will be a key factor in offsetting costs of enhanced services.*"

(Strategy for improved bus links to Heathrow, MVA, 1997)

Two issues quickly emerged from an examination of local bus access to Heathrow: firstly, a jurisdictional barrier, which the Forum was ideally suited to resolve. Because of the boundaries between the Greater London Area and the Home Counties, and between the counties themselves, no one transport authority was (or is) responsible for the provision of all-round public transport planning to Heathrow. The Forum proved to be an ideal mechanism to overcome this, aided by Heathrow's legal role as both a Traffic Authority and a Bus/Coach Licensing Authority.

Secondly, there was actually quite a good bus network in place but it was based on the supposition that the airport worked like an industrial estate; five days a week from 0700 to 1800. Of course, like any major airport, Heathrow is a 24-hour, 7-day-a-week operation, with around 75 per cent of its staff working shifts. The challenge was to change the network to meet users' needs.

Looking at the detail of Outer West London, the need is for a mix of services. Passengers want services that link the main areas of employment activity to key interchanges quickly, and which enable them to travel for work or leisure easily and efficiently. There is a need for smaller services, which penetrate areas, where to run frequent services would not be sustainable, but where a less frequent service would still be used. There is no point in providing high-frequency services if the key areas of activity or housing are not penetrated. There is a need for innovation by providing new services, such as demand-responsive or express links. Many of the routes on the present London bus network are the same, or variations of, routes which have been operating for 40 to 50 years. But that does not mean that they still meet the needs of those living in West London, for the needs of these people have changed.

The major barriers to using bus services in West London are reliability, journey time, quality and compatibility. There is a wide range of differing needs across West London which at present are not met by the bus network, for the network is planned around major flows. The social stigma of using the bus, which has grown up over the last twenty years, has further alienated the benefits of the bus network in the eyes of potential users. Yet, for example, with the Southall–Heathrow Southside link (where London Buses was unable to justify the provision of a link as the flows did not warrant a 15-minute service), a commercial operator has stepped in to provide a link (with Forum financial support) which, although very limited, still provides a public transport option for over 2 000 passenger journeys a week, journeys which would otherwise be made by car.

The Forum has pursued a policy of bus service support through the use of focused pump priming and capital contribution rather than total control. By working in partnership with the bus industry, it has encouraged them to develop new services by taking part of the risk and, once established, the Forum's role in the project drops back to marketing support. There are clearly cases where operators will try innovative services and the Forum approach means that, for a relatively small investment, major initiatives can be put in place. Heathrow's financial support also means that, through the Forum, it is often possible to lever-in additional funding from other parties.

Innovation in bus network development is central to widening travel choice, for example:

- demand-responsive services linking into key corridors;
- provision of new links off the main corridors to business parks and leisure facilities;
- introduction of variations to main routes, with splits at specific ends, so serving more than one need; and
- special travel promotions offered to businesses establishing themselves in West London and the Thames Valley, so that they can encourage staff to use buses.

These will stimulate travel choice, especially if backed up with good marketing. To gain maximum use of the bus network, bus travel must be promoted as the first choice for all and not the last solution for those with no choice.

The Forum has worked hard with service providers and transport authorities to improve the existing network; to make it work more reliably, increase frequencies and extend timetabling and market availability more powerfully. The results have been impressive. Based on 1999 Civil Aviation Authority survey data, there has been a reduction from 78 per cent to 71.5 per cent in employee car use and an increase of 85 per cent in bus patronage by airport employees…equivalent to 9 000 cars off the road. This shows that it is possible to achieve mode change by improving urban bus services, primarily through offering frequency, reliability, appropriate scheduling and modern, low-floor vehicles, as with the very successful A10 Uxbridge to Heathrow semi-express route. But the tender process must allow for quality; otherwise, as occurred with the first re-tender on the 285 route to Richmond, the benefits painfully gained will wither rapidly on the vine. Quality objectives are now set out in the new contract.

10. COACH NETWORKS

"*A distinctive feature of the transport system in the South East Region is the role of the coach network focused on the national coach hub at Heathrow…the Regional Assembly wishes to encourage the development of a stronger network of scheduled coach services that complement the rail network.*"

(From Crisis to Cutting Edge; South East Region Transport Strategy Consultation, 2002)

"*The Strategy recognizes and supports the role of coaches in providing cost-effective travel…coach travel is heavily concentrated in central London and at Heathrow. Additional commuter and scheduled express coach services on particular routes could fulfill a valuable role in further supplementing rail capacity.*"

(The Mayor's Transport Strategy, GLA, 2001)

Heathrow is an important objective for express coach service operators, and the availability of direct express services is a key factor in the airport's development as a regional hub. BAA does not give revenue support to coach operators but does assist in strong marketing campaigns that attract an additional customer base. Working very closely with Airlinks, the major provider of coach services to Heathrow, it has been possible to create a series of specific brands, including the Airbus service to Central London, the Cambridge-Stansted operation and the Heathrow-Gatwick Speedlink service. Beyond that, there are the two Railair services to Reading and Woking which, with the lack of direct rail links, provide swift access to the national rail network. A new link to Watford, in association with Virgin Rail and supported by BAA, is currently being exploited, and in the first 18 months of operation has carried over 60 000 passengers, against a backdrop of railway operating difficulties on the national network.

The development of the express coach network at Heathrow has led to the development of a specific airport express brand, Flightlink, which is operated by National Express. The Flightlink network is based on core corridors providing frequent links to Heathrow and service quality matched to the needs of the air traveller. The development of Flightlink has seen the frequency of the connection to Heathrow rise to nearly hourly for such corridors as Cardiff-Bristol-Heathrow.

As a result of the development of the coach network at Heathrow, National Express/Airlinks are now examining opportunities to develop further the regional interchange role of Heathrow. Many key towns within West London and the Home Counties have no direct interface with the UK express coach network, but do have an interface with Heathrow. The next stage in the development of the coach network will be to provide this market with access to the express coach network, using Heathrow and providing the total journey solution.

As a result of the policies actively pursued since 1992 by airport management, 10 per cent of the UK express coach operation passes through Heathrow's coach station. It is now possible to go to over

1 200 destinations directly from the airport coach station, and to a further 1 200 with only one change of coach en route. While it is difficult to get precise figures, it is estimated that around 700 000 coach passengers interchange at Heathrow from one service to another (these passengers having no air component), while there is increasing evidence that interlining from coach to rail services to Central London is occurring.

11. AREA-WIDE MOBILITY MANAGEMENT

> "*BAA Heathrow will pursue strategies and policies… which reflect the wider business, social and environmental considerations relevant to London and the South East and… provide customer focussed facilities; enhance and encourage pedestrian and cycle access; work with partners to develop, on an area-wide basis, relevant demand management measures and appropriate infrastructure and information systems; and pursue a balanced transport strategy that caters for all modes of surface access and for all groups, including those with special needs.*"
>
> (Heathrow Airport Transport Policy, 1996)

Many schemes which come before the Transport Forum only need relatively modest financing to be successful, but it is often difficult to raise the relatively small sums of money required. The Forum is able to bid for finance from the Heathrow Transport Fund, derived from a surcharge of 25p (plus VAT) on public parking at the airport and a £12 surcharge on the annual employee airport car park pass. This generates around £1.75 million a year, which is wholly assigned to improving local transport needs. For example, it contributed £1 million to the Feltham rail-head improvement scheme.

The key to developing an intermodal hub at Heathrow is efficient and reliable access for bus and coach. A study was commissioned into creating a bus priority lane on the Motorway Spur leading into the airport. With agreement from the Department of Transport, and in close association with the Highways Agency, the bus lane was opened in September 1997. Costing £1.8 million, the scheme was wholly funded by the Transport Forum, via the Transport Fund, and its benefits are being appreciated by the 7 million passengers on the more than 2 000 bus/coach movements using the Spur each day. A before-and-after survey shows that the project has met the design target of saving ten minutes per coach in the peak periods.

Heathrow has 435 companies based on site, as well as many others located in the surrounding area. Via the Forum Travel Planning Group, active promotion of travel plans, working with key companies, is now underway. Car-sharing or pooling is a major element in this and, since its relaunch in April 2001, the Heathrow Car Share Scheme is now the largest in the UK, with over 1 400 registered sharers.

Because Heathrow straddles a number of transport authority areas, it is important to create conditions which allow passengers to interchange easily from one service to another. Two initiatives have been developed. Firstly, the Heathrow Area Travelcard, which is valid on over fifty operators serving Heathrow, Gatwick and Stansted. A tiered pricing structure runs from £30 to £100 a month,

depending on the range of bus, coach and rail services that the user wants. Secondly, to encourage greater use of bus services on and around the airport, the Transport Forum funds a Free Travel Zone, whereby anyone within the zone, whether air passenger, airport employee or local resident, can travel free on local buses.

Accurate and easily available travel information is essential if car users are to be persuaded to try mass transport. On behalf of the Forum, BAA Heathrow has developed the largest interactive travel database in Europe, which brings together 15 existing journey planners, including Transport for London, National Express and Railtrack. This provides journey information for up to three connections on bus, coach and rail services within a fifty-mile radius of the airport. Now launched on the BAA intranet, it is being made available to Forum members. An Internet version is being developed, with a target date of Spring 2003.

Major airports with their large numbers of staff -- in Heathrow's case, 68 000 on-airport and a further 20 000 in the off-airport perimeter -- present opportunities for focused commuter planning which can attract staff away from car use. Through the development of car-sharing schemes, interest-free loans for public transport, bike pools, pedestrian routes, user-friendly ticketing and multimodal ticketing, it is possible to encourage greater use of mass transport by those off the airport, because the connectivity on-airport makes using mass travel more attractive.

12. REGIONAL IMPACT

"*The Mayor wants to encourage the development of high levels of public transport access to London's airports…Transport for London will work with the Airport Transport Forum to achieve a significant increase in the proportion of travel to Heathrow by public transport.*"

(The Mayor's Transport Strategy, GLA, 2001)

"Regional Transport Strategies should inform the development of Local Transport Plans so that there is a coherent regional approach. There is a clear role for regional strategies in tackling the complex interaction between different Local Transport Plans across each region. Regional and sub-regional approaches should have a key role in implementing policies which need the involvement of more than one authority and are of strategic importance."

(Better Buses. Confederation of Passenger Transport, 2002)

Before looking at the impact that an airport like Heathrow can have at the regional level, it is worth examining the special features which make the airport an attractive multimodal interchange. In general, most airports have modern facilities which are updated at regular intervals. Because of the nature of their operation, they are focused on providing their customers with quality-focused services and infrastructure which reflects the needs and aspirations of the travelling public. Accustomed to think of interchange facilities in terms of on-airport car parking and forecourt services, airport managements increasingly understand the role that they can play as transport interchanges, locations

where all modes of transport services are in sufficiently close proximity that transfer between them is practicable and easy.

The ideal transfer should be seamless, though in practice this is rarely wholly possible. In contrast to the general principles outlined above, making an interchange work effectively requires unremitting attention to detail. Some, but by no means all, of the issues are outlined below. Whilst some are within the domain of the airport management, others will require the support of external agencies and the use of leading-edge telematics to be resolved:

- One single agency or organisation managing the interchange on an inclusive basis;
- Through-fares and ticketing widely available, preferably as part of the air ticket purchase;
- Easy-to-understand and widely-distributed information about services;
- Signage and data about the airport available at the starting point of the passenger's journey;
- Strong marketing campaign to boost use of services;
- Use of the Internet for both travel information and ticket purchases;
- Excellent vertical and lateral connections, well-signed, between different modes;
- Timetables and schedules planned to interconnect wherever feasible;
- Provision of priority systems to speed mass transport through bottlenecks;
- Walking, cycling and the car are transport modes and should be integrated where feasible into the interchange matrix;
- Bring the bus as close to the rail platform as possible, and both bus and rail as close to the air terminal as can be arranged;
- Where demand warrants it, provide downtown check-in;
- Provide sales and information points in the air terminals;
- Ancillary facilities should be to the same standard as those in the terminal;
- Services for staff should be of equal quality as those for air passengers;
- Continuous assessment of quality standards.

The Transport Forum plays a pivotal role in the development and promotion of such services, and will continue to do so. Nor is the influence that the airport can have in developing high standards necessarily limited to on-airport facilities. Efficient interchanges can be achieved through sound partnerships focused on a common goal, such as: "*the Feltham Interchange, which was noted as an example of interchange between bus and rail for trips to Heathrow that achieves a high level of service*". (The Public Transport in Outer London Investigative Committee: London Assembly, 2002)

In terms of cross-boundary operations from Heathrow, the results of the last seven years show that the Forum partnership approach has provided a mechanism to bridge jurisdictional and legal boundaries, in order to enable a focused approach to be taken towards increasing bus and rail use and reducing car dependency. During this period, £450 million was invested in building Heathrow Express and £1 million contributed to the Feltham Interchange project. Nearly £3 million has been spent on bus start-ups and operating subsidies, with another £3 million on enlarging the airport bus and coach station and £2 million on building the M4 Spur bus lane. Smaller sums have been made available for a wide range of passenger facility projects, both on and off the airport.

In particular, the Forum's work has shown that the highly-focused, route-by-route funding process has been able to reverse the trend of the last twenty years. The table below shows that bus use has recovered, as have, to a smaller extent, cycling and walking. The improved scheduling of the Underground has increased ridership a little and the use of Heathrow Express by staff is encouraging. There is clearly much work still to do, but at least all the indicators are moving in the right direction.

Figure 8. **Heathrow Employee Modal Split**

	Heathrow Employee Modal Split			
	1975 %	**1986 %**	**1992 %**	**1999 %**
Car	71.2	75.7	78.0	71.5
Car-sharing	7.6	5.3	4.0	4.0
Underground	1.2	3.8	6.0	6.3
Bus	12.8	11.0	6.0	11.7
Motorcycle	3.1	1.8	2.0	2.1
Bicycle	1.7	0.1	1.0	1.3
Walk	1.3	0.6	-	0.6
Rail	-	-	-	0.8
Taxi	-	0.7	1.0	0.8
Air	-	-	1.0	0.9

Figure 9. **Heathrow Air Passenger Modal Split**

	Heathrow Air Passenger Modal Split			
	1978 %	**1987 %**	**1991 %**	**2001 %**
Car	39.0	40.0	42.0	35.6
Car hire	4.0	4.0	4.0	3.2
Taxi	0.0	20.0	20.0	26.6
Underground	20.0	20.0	20.0	13.1
Coach/bus	16.0	15.0	13.0	13.0
Rail	-	-	-	8.4
Other	1.0	1.0	1.0	0.1

Figure 10. **Percentage Patronage Increase on Heathrow Sponsored Bus Services, 1997**

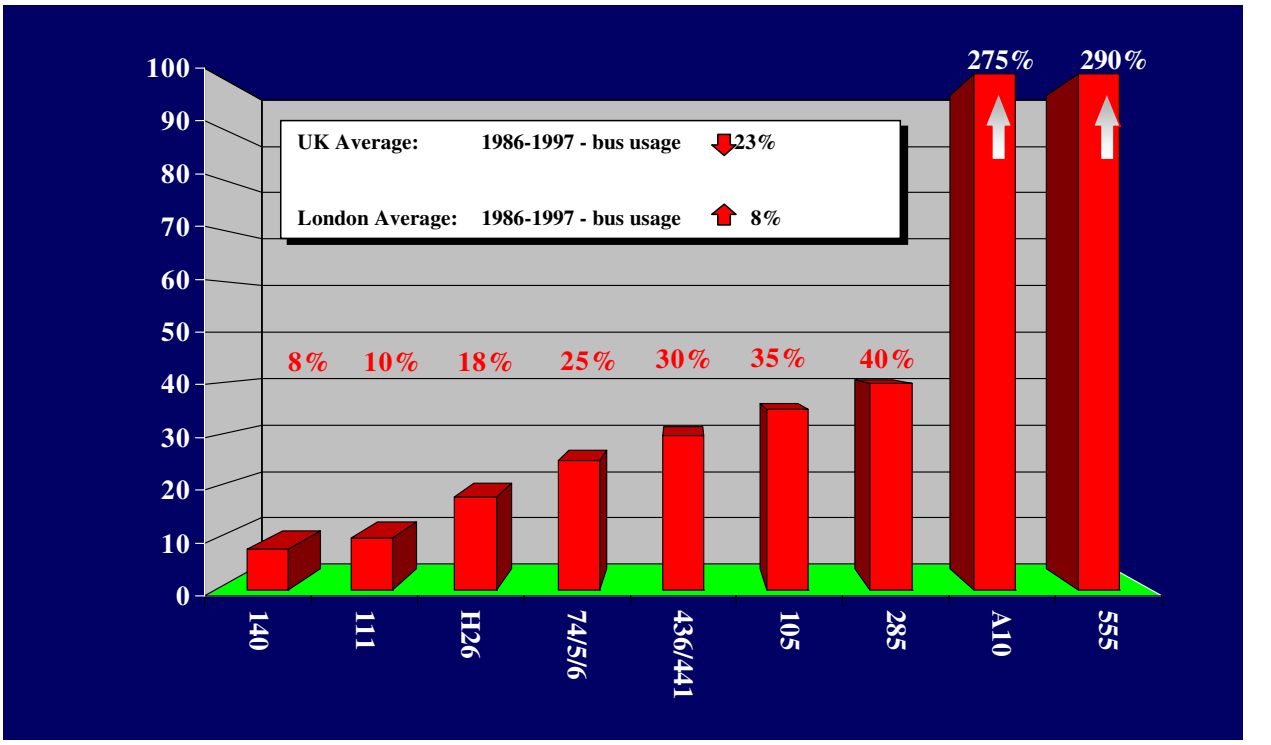
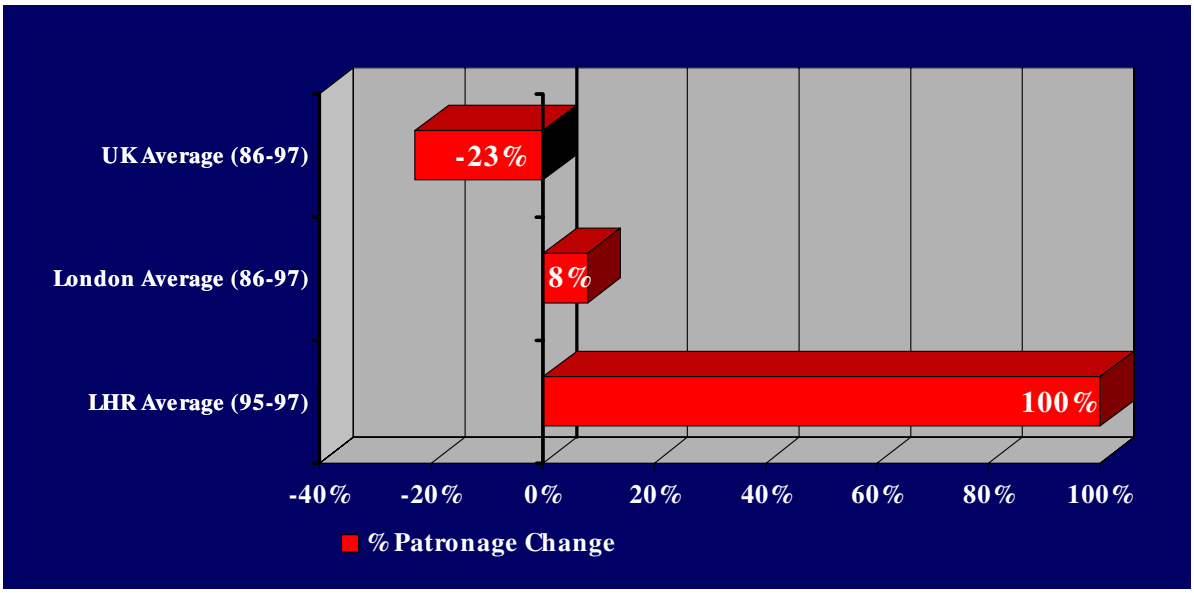


Figure 11. **Recent Changes in Heathrow Bus Use Compared with National Trends**



The deliberate policy of BAA Heathrow in pursuing an area-wide strategy, seeking to maximise on existing networks wherever possible, has resulted in the airport becoming the busiest bus/coach hub in the United Kingdom. Of course, it is necessary to build sufficient capacity to grow demand and the coach station has been extended three times since 1994. With both Heathrow Express and Underground rail services currently available and more anticipated (as noted above), further growth in interlining between coach and rail is expected, thereby releasing coaches from the necessity of having to access Central London via ever more congested roads. Furthermore, the significant improvements to local and subregional bus services has meant that many intending express coach passengers no longer have to go into London but can board the vehicle at Heathrow.

13. CONCLUSION

"*Surface access initiatives which have already been implemented, or are being planned, at airports in England show that, regardless of the size of the airport, significant steps can be taken towards increasing public transport use. I hope that Forums operating throughout the country will be inspired by the collaborative approach that has already achieved commendable results.*"

(Chris Mullins, Parliamentary Under-Secretary of State, DETR, 2000)

By the nature of their operation, airports offer special potential for development as multimodal interchanges. It is in everyone's interest to encourage this process. By setting out to become a regional or subregional transport hub, the airport is acting as a good neighbour, working with others to improve network conditions. Airports should be seen, in the context of evolving regional transport

plans, as having a positive role to play in an integrated regional transport strategy, which will lead to the creation of effective multimodal networks. Airport growth should not be seen as a negative; airports offer solutions to transport development and interchange which will be to the benefit of everyone in their region.

Airports are not only economic powerhouses but also natural gateways around which other transport modes should naturally gather. Regional transport authorities should take advantage of this modal combination in order to maximise benefits to the general population. In the 21st century, airports will play a key role in meeting European mobility management ambitions.

To achieve this, it is crucial that the national agencies charged with developing road and rail schemes for national and regional needs, take specific account of airport access needs and in particular how they can be structured so as to maximise benefits to the general area.

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SUMMARY OF DISCUSSIONS

Andreas KOPP
Chief Economist
OECD/ECMT JTRC

SUMMARY

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1. INTRODUCTION

Air transport will in all likelihood continue to grow, both in absolute terms and in relation to other modes. Given the high income elasticity of air passenger transport, the catching-up process in middle- and low-income countries will continue to push transport demand up substantially. The current increase in both airline and airport efficiency, triggered by deregulation in the industry, is also unlikely to cease, leading to fare reductions in at least some market segments. These fare reductions will generate future growth in air travel in terms of passenger-miles.

Where freight transport is concerned, the shortening of product cycles as a consequence of keener competition on the technology front means greater willingness to pay for short transport times and reliable transport on long hauls. Thus globalisation and heightened technology intensity in industrial production are laying the foundations for strong future growth in air freight transport.

The air transport growth which has already taken place and is forecast for the decades to come will require considerable expansion not only in airport capacity but also in land transport connections. In Europe, air passenger traffic increased steadily throughout the 90s, with passenger-miles doubling in the course of the decade. Market growth was even more dramatic over the longer term; by the year 2000, air travel was up 32-fold on 1960. With further East-West integration in Europe and continuing deregulation in the air transport sector, substantial further increases are to be expected (Button 2005, this issue).

How the provision of land transport connectivity for airports should be developed is contingent on factors such as the specialisation of airports, their size and geographical location, on the one hand, and the competitive position of land transport modes vis-à-vis air transport, the relative costs of land transport modes and their external costs and benefits, on the other. One aspect which has particularly complicated the planning of land transport connections for airports is that most of the above determinants of connectivity change rapidly and substantially over time. Many of these changes stem from government policy, above all, deregulation in the airline industry and its consequences for the volume of air transport and the intensity of airport competition. The external costs and benefits associated with the provision of land transport links for airports range from the environmental costs of road or rail transport and the impact of the various modes on the landscape to the agglomeration economies created by major airports which, if accommodated by land-use and transport policy, may even lead to the emergence of new industrial complexes.

Depending on their connectivity, airports have a substantial potential to generate value-added. An extreme example is Heathrow Airport in London which, in the year 2000, contributed £2 billion in wages to the local economy with 68 000 direct, on-airport jobs and £5 billion nationwide (Duff 2005, this issue). Given the high fixed costs of airports and their close interdependence, major improvements in the planning and implementation of land transport connections can be achieved by replacing policies for individual airports with policies which consider airports as a system and look at how they interact.

The Round Table discussed the impact that market structure in the airline industry has on the airport network, and the impact of that network on the transport policy challenges involved in providing land transport connections. The discussions produced recommendations on how to improve the modal split.

2. TRENDS IN AIRLINE COMPETITION AND THE ROLE OF AIRPORTS IN INTERMODAL NETWORKS

2.1. Changes in airline competition and multimodal connectivity

One determinant of an airport's role as a multimodal interchange node is the part it plays in the airport network. While there is little doubt that current changes in the market for airline services are strongly impacting on the function and competitive position of individual airports, it appears hard to predict whether and how major trends in the development of airport networks will be reflected in the future.

A major area of disagreement is whether the strong trend towards a hub-and-spoke system which has emerged in the United States as a consequence of airline deregulation, will become more pronounced there and affect Europe as well, or whether it will lose ground to point-to-point air transport. Which trend eventually dominates will depend to a large extent on the future of competition in the airline industry. The market structure of air transport and the consequences for airport competition will, in turn, shape demand for intermodal connectivity.

The Round Table discussed trends in the development of the hub-and-spoke system and point-to-point airport networks as a background to future transport policy challenges with respect to the provision of land transport connectivity.

2.2. Hub-and-spoke system

The hub-and-spoke system now dominant in the United States is characterised by the fact that major US airlines direct almost all of their international flights to the US to one airport serving other national destinations by national connecting flights. The hub-and-spoke system is based mainly on two economic phenomena, i.e. cost structures in the airline industry and the mechanisms whereby airport slots are allocated to airlines.

It is a widely held belief that the unit costs of air transport decrease with the volume of transport services on any airport pair market (Bailey and Panzar, 1981). Moreover, economies of scale are held to exist with respect to the size of the carriers, i.e. larger airlines are supposed to have smaller unit costs than small carriers. Indeed, large differences in unit costs for local service carriers and trunk carriers have been found by Caves *et al.* (1984) for the US. They found a difference of 44 per cent in unit costs explained by co-variates (output, number of points served, input prices, airline characteristics such as average stage length and load factors, time shifts and firm-specific shifts) and differences that are unexplained except by firm dummy variables. The firm dummy variables indicated that, at any given level of the co-variates, unit costs for the local service carrier would be 14 per cent below those of the trunk carrier. This cost advantage enjoyed by local service carriers indicated (implicit) cost advantages such as differences in managerial efficiency or in the network structure. The cost advantage of the local service carriers with respect to the firm dummy variables implies that the cost advantage of the trunk carriers in unit costs, net of firm specifics, was 58 per cent, i.e. even larger than the 44 per cent in overall costs.

A breakdown of these cost differences, in turn, reveals many of the cost advantages of a hub-and-spoke airport network over a point-to-point network: an overwhelming portion of the total difference (45 per cent) was due to the density of service for a given network size. The only other determinant of the total cost difference of major importance was stage length, which accounted for 18 per cent of the total cost difference. The hypothesis of increasing returns to scale, i.e. a decrease in unit costs associated with the scale of operations, regardless of service density, was not confirmed by empirical analysis.

A hub-and-spoke system contributes to the exploitation of both effects: routes to and from the hub will be high in density, with corresponding savings in unit costs. Due to the economies of stage length, the increases in unit costs resulting from extra distances, due to indirect connections between spokes via the hub, will be less than proportional.

Helped by conventional methods of slot allocation, individual airlines achieve a dominant position in individual hubs. The resulting airline-specific network economies and local market power create rents which benefit the dominant airline, the hub and/or the customers. Depending on the distribution of rents between the parties, airports and airlines might have an interest in creating a hub dominated by one airline. The distribution of rents will be decided in negotiations between the airport operators and the airlines (Borenstein, 1989; Brueckner *et al.*, 1992).

The major limitation of hub-and-spoke networks is hub congestion. Although hub dominance by airlines facilitates traffic allocation, in that unpriced congestion allows airlines to increase fares (Brueckner, 2002), it is bound to lead to under-investment in airport capacity.

As (private or public) airport developers do not receive the full marginal value product of airport investment, due to the sharing of rents with dominant airlines, they will tend to under-invest in airport capacity.

The development and reinforcement of a hub-and-spoke network makes the spokes increasingly dependent on the punctuality and reliability of hub operations. The less competition there is between hubs, the more airport operators will disregard the negative externalities affecting the spokes as a result of congestion and other operational problems in the hubs.

In Europe, the airline dominance of national hubs is largely attributable to the privileges inherited by national carriers from the pre-regulation era. In contrast to the air transport market in the US, the market was large and already far less regulated before steps were taken to reform the airline sector: more than 40 per cent of air passenger transport was supplied by non-scheduled air travel services which largely avoided the national hubs and operated from secondary airports. With these services there has always been an important, largely unregulated, air travel subsector using a network of point-to-point connections. Deregulation has triggered a broader trend of market segmentation with a strong impact on the overall network of airports and their function as an intermodal interface.

2.3. Airline competition and point-to-point networks

Deregulation in Europe has brought various developments with a strong impact on the market for airport services. Rather than excessive entry into the established air passenger market, Europe has seen a widening of the range of options available in a differentiated market (Barrett, 2005). Prior to deregulation:

- Business travel was largely served by scheduled services which were point-to-point for the national market and passed through national hubs for most international connections;

– A large share of mainly international tourist travel operated via non-scheduled point-to-point connections.

The scheduled services charged far more than the charter services but offered more and better-quality airport and in-flight services. Non-scheduled passenger transport was supplied by specialised airlines offering lower-quality services but lower fares. Both of these sub-markets have been largely unaffected by deregulation.

There are two main reasons for this market segmentation, the first being the potential for price discrimination based on a complicated fare structure which is difficult for firms to monitor, thus restricting competition between airlines for business customers.

In the tourism market, however, where customers are directly affected by higher fares and large tourism firms are in a strong bargaining position, competition between airlines is much keener. As connections are point-to-point, there has been far less demand for connecting flights and airport services. In some countries, airports smaller than the national hubs but crucial for national flight connections have specialised in non-scheduled tourist services.

European deregulation has generated a huge expansion in a new segment of the airline industry, the "no frills" or "low cost" airlines. There has been a massive entry of new airlines offering single-class services that are point-to-point rather than integrated into a hub-and-spoke system. Low-cost carriers make extensive use of online booking, often without seat reservation or in-flight service being included in the fare. While the market share of these low-cost carriers was still relatively low in 2000/2001, the number of successful carriers increased dramatically. The overall number of seats in this segment more than doubled in 2002. The impact of the low-cost segment was greatest in Britain, where the number of passengers carried by Easyjet and Ryanair was 84 per cent of the British Airways passenger total of 39 million.

The increase in services by these carriers has not been accommodated by major national airports or national hubs but by formerly minor regional airports with few or no international connections prior to deregulation. Thus deregulation in the airline industry has led to an increase in air travel, dependent on multimodal connections at locations previously confined to passengers using regional airlines for short-distance trips.

Some planners see the trend towards more point-to-point connections as a universal trend. The NASA-OAT study on the development of the US airport system, for example, took as its starting point a tripling of 1997 air passenger travel levels by the year 2020, with almost all passengers being offered direct flights to their destinations, an improvement in services and a reduction in the number of takeoffs and landings relative to the volume of transport services (NASA, 2002). The increase in passenger travel envisaged would require the extension and upgrading of smaller airports with a redesign of the network of over 4 000 airports. This would mainly involve upgrading and extending smaller, regional airports to provide support functions for services to major agglomerations.

Developments in the air freight transport sector have led to changes similar to those brought about by the emergence of the low-cost carrier subsector: smaller airports, some of them former military airports with only basic service functions, now serve as specialised freight airports. Compared to primary and secondary airports with freight and passenger services and international connections, they are located further away from the larger cities, with far fewer connections to the supra-regional railway and road network (Picardi, 2005).

The land transport infrastructure facilities required for airports to offer efficient multimodal connectivity depend very much on how the airport network develops. That in turn depends on the development of the airline market which will respond to cost structures in the airline industry, demand behaviour on the part of customers and the market conditions provided by the public sector, in the form of infrastructure and regulatory requirements.

3. CONSEQUENCES OF AIRPORT NETWORK DEVELOPMENT FOR MULTIMODAL CONNECTIVITY

3.1. Determinants of the airport network

The differentiation observed on air transport markets in the aftermath of deregulation, particularly in Europe, is to some extent a horizontal differentiation of airlines and airports, as they specialise exclusively in passenger travel or freight transport, for instance. But, to a greater extent, the differentiation appears to be vertical, i.e. differing in terms of quality, with better services commanding substantially higher fares. High-quality air travel services are provided under the airport system by the regulated air transport industry. Furthermore, the seasonal tourism transport activities of non-scheduled charter services are largely unaffected by deregulation. The greatest change stems from the emergence of low-cost carriers operating either from low-cost terminals in the traditional airports or from smaller airports, often poorly integrated into the land transport networks of roads and railways.

As investment in multimodal interchange nodes and the connecting road and rail links has a long time-horizon, an important question is whether the changes in market structure observed in the airline industry will be lasting, or merely transitory stages on the path towards a different, long-run equilibrium. While some airport network planners seem convinced that point-to-point services will eventually predominate, the determinants of the hub-and-spoke system are not set to wane in the near future. At the same time, some of the current drivers of growth in point-to-point services may weaken with time.

The first question to be addressed by transport policymakers is whether customer behaviour will remain unchanged, or more precisely how it will change in response to broad economic and demographic developments. Both an increase and a decrease in the share of high-quality air travel service are conceivable. On the one hand, the customer group now using low-cost carriers might demand higher quality service as incomes increase, without any new customers entering the low-cost carrier market. On the other hand, the low-cost carriers might successfully change their service attributes to attract a larger share of the overall market.

The traditional carriers, however, owing to the rents which some of them still enjoy, have the option of offering different classes of services and trying to discriminate against their low-cost competitors. Whether they succeed depends on further progress in deregulation and the size of the cost advantage that these traditional carriers derive from higher economies of density and stage length.

The expansion of the low-cost carrier business has been made possible, to some extent at least, by overcapacity in regional airports. As there is little extra cost involved in giving low-cost carriers access to spare capacity available in airports, airport charges might also be low and do little to cover the fixed airport costs. Once that spare capacity has been used up, airport costs in the regional airports might increase substantially.

Whether and to what extent additional capacity is provided should depend, in the long run at least, on demand for airport services at fares which cover the full costs. In many cases, however, the spare capacity stems from competition between regional or local governments to pre-empt other competing potential airport locations. Relatively large airport capacities were expected to lead to economies of scale which would allow potentially competing airports to outperform one another. Without co-ordination between competing authorities, there is a danger of wasteful cycles creating overcapacity which can only be maintained with government subsidies (on pre-emptive competition, see Dixit, 1980 and Bulow *et al*., 1985). Closer interregional co-ordination on airport policies would then generate less over-investment in regional and local airports, with potentially higher airport costs for the carriers using these airports and lower public expenditure on subsidizing them.

3.2. Multimodal connectivity

Private car use is the dominant mode of travel to all types of airport. Even with the growing risks of delay due to increased congestion, the share of private car use as the mode of access to airports is increasing. There is even evidence of this trend for airports with frequent rail connections, such as Gatwick in the United Kingdom. Public transport, as a share of total transport to and from airports, is greatest in metropolitan areas with airports relatively close to the city centre. Case studies report shares of between 60 and 40 per cent for Oslo, Zurich, Amsterdam and Munich. The average patronage of public transport is 21 per cent, with 12 percentage points for buses and 9 for rail connections. Taxis account for a higher share than the average public transport share. In the majority of case studies, their importance has increased over time. Taxis are particularly important for tourist and leisure travel connections to airports.

Transport demand by workers is of particular importance to the connectivity of larger airports. Round Table 121 discussed strategies to improve commuter travel. They are of great importance to airports, with tens of thousands of employees often commuting at peak hours, competing with customer travel and adding to road congestion. The share of private car use by commuting workers is large, regardless of the type of airport or its geographical location. It appears to increase with the distance from major metropolitan areas. To give an example, private car use was the commuting mode of about 75 per cent of all employees at Heathrow airport in 2001, compared with 99 per cent at Stansted.

Developments in the airport network, observed in recent years in Europe, do not suggest an endogenous trend towards greater multimodal connectivity. The increasing share of point-to-point flights by low-cost carriers is connected with the use of smaller airports further away from metropolitan centres, or even metropolitan areas. The growing importance of smaller airports in the overall airport network will therefore heighten not only the land transport intensity of air travel but also the road transport intensity of the surface transport deriving from air travel.

In the US, deregulation has helped to make multimodal transport commercially more viable, based on the natural synergies between local road services and trunk rail and water transportation. However, the types of goods transported by air do not appear to be those for which rail transport has a broad comparative

advantage over other modes. Moreover, the emergence of smaller airports specialising in freight transport means that it is unlikely that the density of freight transport to and from airports will make rail more competitive than other modes.

As the case studies discussed at the Round Table have shown, the road sector's share is increasing endogenously, even for the larger airports close to metropolitan areas with good public transport connections. Changes in the market structure of the airline industry in Europe, with growth in the relative importance of point-to-point connections and regional as well as local airports, will reduce average airport size and further increase the share held by the road subsector.

4. POLICY CONCLUSIONS

In Europe at least, there appears to be a widespread consensus that airport connectivity should be multimodal. An initial reason for this is that road transport is seen to be associated with social costs in terms of environmental damage, accident risks and congestion costs, which are higher than for other modes and not reflected in private costs, or rather in the cost calculations behind the travel decisions made by airport service customers. As a result, the level of road transport is higher than socially desirable. If transport policy accommodated the resulting volume and structure of transport demand by providing the requisite infrastructure, it would potentially add to the distortions caused by the external costs of road transport.

A second reason for promoting airports with multimodal transport connections relates to the need to contain the level of air transport in order to avoid its particularly high external costs in terms of pollution, noise and land use. Rather than extending the capacity of airports to cater for more national or regional flights, the aim is to establish competing high-speed rail services to meet at least some of the current and future demands on these distances (European Commission, 2001).

The extent to which the perceived problems behind multimodalism as a policy objective for airport connectivity are real has to be analysed for each individual airport. In many cases, one suggestion on the grounds of efficiency and the inclusion of all social costs might be to improve the supply of non-private car transport in connecting airports to surface transport.

The concrete policy steps which need to be taken depend to a large extent on the institutional environment in which policymakers make decisions on airport location, design and connectivity. That environment may make airport-related decisions subject to feasibility constraints, which in turn require forecasts as to which higher-level policies will be implemented (Sen, 1996).

4.1. Pricing and taxation

The social costs of transport, like environmental costs, accident risks and so on, should in principle be outside the domain of airport planning and implementation. Transport policy should, in general, try to internalise congestion costs so that no special measures are required for particular types of infrastructure, such as road connections to airports. Environment policy should combine factors such as pollution and noise with general measures which will help transport policymakers and infrastructure operators to take

decisions with a given level of internalisation regarding the more general, rather than airport-specific, external costs of transport. Only if general policies to internalise external costs are *not* implemented, will measures be required to contain the external costs of the various modes when designing the connectivity of airports, so as not to create further distortions.

In a sense, this is also true of safety and security issues. Whether complementary safety and security measures are required depends on the state of the relevant insurance markets, as this shapes individual safety and security behaviour in response to insurance costs. All insurance systems will, however, be imperfect in the sense that they cover only some of the safety and security risks. Remaining disparities in the external costs of different modes should, in many cases, lead to support for a modal shift from private car use to public transport and rail connections.

The internalisation of external costs might adversely affect the European trend towards more low-cost, point-to-point flights, which are handled by smaller airports. An increase in the share of this type of air travel is particularly dependent on road accessibility and would therefore suffer from measures to contain the external costs particularly associated with road transport. On the other hand, roads to smaller airports are much less likely to be congested.

4.2. Deregulation of public transport

As pointed out in the Round Table discussions, some of the external costs resulting from the private car dominance of airports do not result from deregulation but from overregulation. This is particularly true of the taxis and buses serving airports. Deregulating entry into the taxi industry should, in some cases, increase the share of taxi transport to the detriment of private-car use, which would in turn cut environmental and congestion costs, thanks to higher occupancy rates per vehicle.

Similar effects are to be expected from a rationalisation of bus regulation. One major area of intervention would be market entry, while others would include the restrictions on a differentiation of the bus services connecting airports: in some countries, mini-buses and shuttle services with high occupancy rates account for a large share of passenger connections to airports, while, in other countries with similar social and economic conditions, they are non-existent due to restrictive regulatory policies.

4.3. Airport design and organisation

As is evident from the discussion on development of the airport network, decisions on airport location and size have a strong impact on the opportunities for multimodalism. The smaller the airports and the greater their distance from major trunk transportation lines, the harder it will be to contain or reduce the predominance of private cars in connecting air and land transport. This is because other modes depend on a high level of activity, given their high fixed costs and economies of scale.

Relatively short distances to major agglomerations are also required, to make the most of economies of density on specific bus routes and, in particular, rail lines. If economies of scale and density are to be exploited for railways, airports should serve as an interface not only between air and land transport but also between rail and road transport. This shift to airports as multimodal terminals would seem to be a key way of increasing the share of freight not transported by road.

To minimise the unit costs of multimodal facilities, location policies and land-use planning should be co-ordinated with transport policy planning. The substantial land requirements of airports and airport facilities, compounded by their external effects such as air pollution and noise, make planning and implementation complex, while the costs involved in co-ordinating so many players are high.

Regulatory measures are required to change the current incentives offered to airport developers: at present, most airport operators have an interest in maintaining or increasing the high share of private car use in overall airport connections. The greater the use of private cars, the more rents there are to be earned by airport operators in the form of parking fees, charges for access to all or parts of the airport area, and even returns from the retail facilities linked to the "kiss-and-fly" traffic to and from airports.

Co-operation by airports (and airlines) with public transport authorities can help to reduce the disadvantages of the latter with respect to the costs of switching between air and land transport. Through-ticketing and improved luggage handling, for instance, can do much to make public transport more attractive than private car use. The fact that taxis account for a large share of overall airport connections for leisure travel suggests that the reintroduction of separate luggage services could make bus and rail more competitive.

To reduce private car use in commuter travel, airports should adopt plans to promote the use of public transport with transfers corresponding to the investment saved on parking areas, for instance, or access facilities for private car use by workers. As such initiatives would also reduce the external costs of commuter travel, (local) governments might find it useful to support them with subsidies.

A final area of discussion concerns measures to change the modal split of airport connections, mainly by basing the allocation of infrastructure investment funds on modal split targets rather than expected demand. Even if welfare costs are disregarded, the acceptability of such policies appears to be limited: a shift to bus and rail transport which increases the switching costs incurred by customers is likely to undermine the competitive position of the airport concerned. After the deregulation of the European air transport market, a substantial rise can be expected in the cross-price elasticity between fares for national hub services. An increase in the monetary or non-monetary costs incurred by customers in arriving at their destinations via a national hub could easily divert traffic to other European hubs.

4.4. Institutional reforms

Institutional mechanisms need to be identified to improve the efficiency of an integrated airport and land transport network. Multimodal solutions for airport connectivity suffer from two major failures in co-ordination:

- First is the big divide between airport policy and airport planning, on the one hand, and public transport policy, on the other. Again, airports might have a commercial interest in favouring road transport and, in particular, private car use. To promote co-operation between the different modes, governments should offer reward mechanisms which foster co-operative behaviour on the part of the agencies involved. With the high mobility of airlines between airports, the ensuing airport competition could make local air transport markets extremely volatile and encourage wasteful investment in airport connectivity.

– Secondly, competition between regional authorities has, to some extent, fostered the emergence of the low-cost carrier subsector in Europe. Some of the cost advantages of low-cost carriers draw on the surplus or subsidized capacity of regional and local airports. This spare capacity in regional airports is, in many cases, the outcome of local authorities competing to attract business and the attendant tax revenues.

To avoid wasting public-sector resources, investment decisions require either greater centralisation or mechanisms for co-operation on transport infrastructure policies between local authorities which would otherwise be in competition.

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LIST OF PARTICIPANTS

Prof. José Manuel VIEGAS **Chairman**
Professor of Transportation and Senior Consultant
CESUR - Instituto Superior Tecnico
Av. Rovisco Pais
P-1049-001 LISBOA CODEX
PORTUGAL

Mr. Kenneth BUTTON **Rapporteur**
Professor of Public Policy
School of Public Policy
George Mason University (MS 3C6)
FAIRFAX, VA 22030
ETATS-UNIS

Dr. Sean BARRETT **Rapporteur**
Trinity College
Department of Economics
25 Westland Row
DUBLIN 2 IRL
IRLANDE

Professor Renato PICARDI **Rapporteur**
Logistica et Organizzazione dei Trasporto Aereo
Politecnico di Milano
Dipartimento di Ingegneria Azrospaziale
Via La Masa 34
I-20156 MILANO
ITALIE

Mr. Alastair DUFF **Rapporteur**
Heathrow Strategy, 2nd Floor
Heathrow Point West
234 Bath Road
GB-HAYES, Middlesex UB3 5AP
ROYAUME-UNI

Mr. Cesare BERNABEI
European Commission - Unit F2
Directorate General for Energy and Transport
24 rue de Mot
B-1040 BRUXELLES
BELGIQUE

Monsieur Arnaud CHI
Laboratoire d'Économie des Transports (LET)
Université Lumière Lyon 2
MRASH
14 avenue Berthelot
F-69363 LYON Cedex 07
FRANCE

Dr. Nigel DENNIS
Universty of Westminster
Transport Studies Group
35 Marylebone Road
GB-LONDON NW1 5LS
ROYAUME-UNI

Mr. Hans FAKINER
Fraport AG
VTM-LV
D-60547 FRANKFURT/MAIN
ALLEMAGNE

Dr. Hans KRAMER
Ministry of Transport, Public Works and Water Management
AVV Transport Research Centre
PO Box 1031
Boompjes 200
NL-3000 BA ROTTERDAM
PAYS-BAS

Mrs Olga KRISTOFIKOVA
Ministry of Transport and Communications
Transport Policy, International
Relations and Environmental Department
P.O. Box 9
Nabrezi Ludvika Svobody 12
CZ-110 15 PRAGUE 1
REPUBLIQUE TCHEQUE

Mr. Jon Inge LIAN
Head of Department
Institute of Transport Economics (TOI)
Postboks 6110 Etterstad
N-0602 OSLO
NORVEGE

Monsieur Andres LOPEZ PITA
Universidad Politecnica de Catalunya
Jordi Girona 1-3 B-1 D-211
E-08034 BARCELONE
ESPAGNE

Mr. W. F. LYTHGOE
University of Leeds
Institute for Transport Studies
36 University Road
GB-LEEDS LS2 9JT
ROYAUME-UNI

Madame Rosario MACARIO
CESUR - Instituto Superior Tecnico
Av. Rovisco Pais
P-1049 001 LISBOA CODEX
PORTUGAL

Professor Jorma MÄNTYNEN
University of Technology
Institute of Transportation Engineering
Department of Industrial Engineering and Management
POB 541
FIN-33101 TAMPERE
FINLANDE

Mr. Alessandro MERLO
Universita di Genova
Dipartimento di Economia e Metode Quantiativi (DIEM)
Via Vivaldi 2
I-16126 GENOVA
ITALIE

Monsieur Herman NEUKERMANS
Vice-Président Strategy
Brussels International Airport Company - BIAC
Aéroport de Bruxelles National
B-1930 ZAVENTEM
BELGIQUE

Dr. Tae Hoon OUM
University of British Columbia
Faculty of Commerce and Business Administration
Operations and Logistics Division
2053 Main Mall, Henry Angus 452
CND-VANCOUVER, BC,V6T 1Z2
CANADA

Prof. Marco PONTI
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TRT Trasporti e Territorio SRL
Via Rutilia 10/8
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ITALIE

Mr Markus RADL
Federal Ministry for Transport, Innovation and Technology
Department K6 / EU-Affairs
Radetzkystrasse 2
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AUTRICHE

Mr. Giuseppe RIZZO
European Commission
Directorate F - Air Transport - Unit 3 - Airport Policy
Directorate General for Energy and Transport
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B-1040 BRUXELLES
BELGIQUE

Dr. Philippe ROTH
École Polytechnique Fédérale de Lausanne
Institut des Transports et
de la Planification
EPF - Ecublens
CH-1015 LAUSANNE
SUISSE

Prof Andrzej RUCINSKI
University of Gdansk
Faculty of Economics
Armii Krajowej 119/121
PL-81-824 SOPOT
POLOGNE

Monsieur Michel SAVY
Professeur à l'IUP et l'ENPC
Université Paris XII Val de Marne
IUP
Immeuble La Pyramide
80 avenue du Général de Gaulle
F-94009 CRETEIL CEDEX
FRANCE

Mr. Hans Christian STIGAARD
Vice-President
Copenhagen Airports A/S
P.O. Box 74
Lufthavnboulevarden 6
DK-KASTRUP
DANEMARK

Prof. Siri STRANDENES
Norwegian School of Economics and Business Administration
Center for International Economics and Shipping
Department of Economics
Helleveien 30
N-5045 BERGEN
NORVEGE

Mr. Henrik SYLVAN
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ATKINS
Transport Planning
Pilestraede 58
DK-1112 COPENHAGEN
DANEMARK

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PRINTED IN FRANCE
(75 2005 03 01 P) ISBN 92-821-0339-0 – No. 53941 2005