Airport planning in a liberal setting: methodologies for appropriate airport provision

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AIRPORT PLANNING IN A LIBERAL SETTING
- METHODOLOGIES FOR APPROPRIATE
AIRPORT PROVISION

By

Robert Edward Caves

A Doctoral Thesis

Submitted in partial fulfilment of the requirements for the

award of

Doctor of Philosophy of the

Loughborough University of Technology

July 1993

 Supervisor: Dr. D. Gillingwater

Department of Transport Technology

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To my wonderful family,

Emma, Ben and Anna,

without whose dedicated
support over many years
this interest would not
have been fulfilled.
Many people have contributed to this study. Some have helped without realizing it, some will have helped without my knowledge, and some have given identifiable and invaluable support.

My thanks and gratitude are offered to all those people. In the latter group are the staff and students at the Department of Transport Technology who have helped me to a better understanding of the air transport system. My particular thanks to David Gillingwater, my Supervisor, and Norman Ashford, my Director of Research for their guidance and understanding, to David Pitfield, Patrick Ndoh, Andrew Brooke and Henrique Gennari for their invaluable discussions and friendship. I am also most grateful for the use of CAA survey data for the calibration of many of the models used in this research. Finally the dedicated assistance given by Vivien Grove and Anna Caves has made possible a task which often must have seemed endless: my most grateful thanks.
SYNOPSIS

The thesis uses a comprehensive case study of the UK airport planning process to generate hypotheses to be tested. The hypotheses are that the use of more formal planning disciplines to the expansion of the London area airports would have allowed a more appropriate solution than those apparently preferred by the government; further, that this change in the planning process would only be beneficial if accompanied by changes in the framework for airport planning. It is seen to be necessary that the ground rules are known and that the interactions between all affected groups and the decision processes are transparent if the final result is to bear a strong resemblance to the project as planned. A possible solution is developed in the case study by using elements of this alternative methodology, resulting in a proposal for an extra short runway at Heathrow.

These hypotheses are then subjected to a more formal theoretical analysis in the body of the thesis. Part I develops the context for the study, analysing air transport systems and the implications of a liberalised and privatised setting. Part II examines in turn the make-up of the important participating groups and their preferences. Attention is given to passengers’ choice of airport compared with trends in airport market share, the factors controlling airlines’ choice of network, the identification of air transport costs and benefits, available aircraft technology options, and the economic characteristics of airports. Theoretical frameworks for planning are also examined, particularly in the areas of evaluation, participation and decision processes.

Part III begins the process of developing improved methods to allow airport managements in particular, and air transport as an industry, to predict and control the pressures which form their setting, taking the initiatives far enough to establish the feasibility of the methodologies and to identify the next round of research needs. Hierarchical airport market share models are developed, together with a methodology for establishing evidence of the influence of supply on demand.
A notional application of a full societal evaluation of air transport indicates policy options which have synergistic benefits to users and non-users and which offer an incremental and low risk path to a high traffic future. A voluntary Aviation Infrastructure Forum is proposed, to provide a 'shadow' of the real planning process, to pre-empt as much of the process as possible by negotiation, mediation and bartering.
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PART I

The system

planning context
CHAPTER 1: INTRODUCTION

THE NEED FOR EFFECTIVE AIRPORT PLANNING

Historically, the air transport system's economics have been dominated by the operating cost of the airlines and particularly, by the direct operating cost of the aircraft. The cost structure of the UK air transport industry in 1990 is shown in Table 1.1. Annual expenditure by airports was only 13 per cent of total system costs, the airlines' costs explaining 82 per cent of the total. On the other hand, the UK airlines' assets, when averaged over time, have been approximately equal to the combined book assets of the airports and the Civil Aviation Authority (CAA). Whereas almost 100 per cent of the airport assets and 85 per cent of CAA assets are non-transferable, some 80 per cent of the airline assets are in their fleets. Thus the UK airlines own about 50 per cent of the total net assets in the system, but only about 20 per cent of the non-transferable assets.

Recently, capital has become scarce and often also expensive, especially for those parts of the system which have been publicly owned or have had a poor profit record. This imbalance of escapable capital and operating costs between the airlines and the airports, and the parallel differences in objectives associated with public/private status and investment horizons, have lead to difficulties in funding the expansion of infrastructure capacity.

It would be instructive to compare the UK system cost structure with the world average, but the data for most airports are unavailable. The International Civil Aviation Organisation (ICAO) Contracting States scheduled airlines' total assets in 1988 were $US 178 billion of which nearly half were in aircraft and 30 per cent were current assets, UK airline assets amounting to about 2 per cent of the ICAO net value. The total ICAO airline expenses in 1988 were $US 157 billion (ICAO, 1990). If the ratios were the same as in the UK system, worldwide airport assets would be approximately $US 130 billion. A 'heroic' estimate of $US 100 billion for total world investment 1990-2000 (Wheatcroft, 1990) shown in Table 1.2 is almost certainly too low: it implies
TABLE 1.1: THE UK SYSTEM COSTS

<table>
<thead>
<tr>
<th></th>
<th>Total Net Assets (£ million)</th>
<th>Expenditure (£ million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAA ('89/'90)</td>
<td>2563</td>
<td>456</td>
</tr>
<tr>
<td>Other airports ('89/'90)</td>
<td>537</td>
<td>252</td>
</tr>
<tr>
<td>CAA ('90/'91)</td>
<td>315</td>
<td>408</td>
</tr>
<tr>
<td>Airlines ('89)</td>
<td>2530</td>
<td>5437</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5945</strong></td>
<td><strong>6553</strong></td>
</tr>
</tbody>
</table>

*Sources: CIPFA 1991: CAA 1991a: CAA 1991b*

TABLE 1.2: A HEROIC ESTIMATE OF REQUIRED INVESTMENT

<table>
<thead>
<tr>
<th>AIRLINES</th>
<th>North America</th>
<th>Europe World</th>
<th>Rest of World</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft</td>
<td>137</td>
<td>92</td>
<td>46</td>
<td>275</td>
</tr>
<tr>
<td>CRS and other</td>
<td>68</td>
<td>46</td>
<td>23</td>
<td>137</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>205</td>
<td>138</td>
<td>69</td>
<td>412</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>INFRASTRUCTURE</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Airports</td>
<td>50</td>
<td>30</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>ATC</td>
<td>8</td>
<td>5</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>Security</td>
<td>-1</td>
<td>0.6</td>
<td>0.3</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>59</td>
<td>35.6</td>
<td>23.3</td>
<td>118</td>
</tr>
</tbody>
</table>

| INDUSTRY TOTAL                  | 264           | 173.6        | 92.3          | 530    |

*Source: Wheatcroft 1990*
that only 20 per cent of new investment would go into infrastructure, hence substantially reducing the likely present 50 per cent contribution of infrastructure to total system assets.

There seems to be little doubt that air transport demand will continue to grow at some five per cent per annum in Europe (Boeing, 1993), given sufficient capacity. Industry analyses (AEA, 1987; SRI, 1990) clearly show that many airports in Europe will reach capacity before the year 2000 unless urgent action is taken to expand them or build new airports, as shown in Table 1.3. The authorities at the 80 airports with more than one million passengers and the other 460 or so airports which receive commercial air service in Europe are already planning to spend some $US 45 billion in the 1990s (Ashford, 1990), compared with the $30 shown in Table 1.2. Heathrow and Gatwick are two of the most affected airports. Yet they and many other congested airports are finding difficulties in implementing their plans for expansion. There is a real possibility that demand will be seriously constrained as the ratio of infrastructure to airline assets falls and congestion rises. The demand which does reveal itself will be distributed through the system in a way that will be determined by the availability of capacity rather than by the best interests of users or society. The evolution of the European air transport system will be dictated by default: piecemeal decisions on expansion of capacity will be taken at a local level. It is not possible, without considerable research, to judge the extent to which the resultant decentralised planning will allow the system to evolve in a way that complements the objectives of the single market. Planning methods need to be developed to allow appropriate airport expansion, or, at least, to evaluate the impact on society of limiting the expansion.

THE QUALITY OF AIRPORT PLANNING

The Annex to this thesis presents, as a case study, a detailed review of the evolution of airports in the UK. An attempt is made to assess the effectiveness of the system in meeting the needs of the users and to identify the aspects of
## TABLE 1.3: CAPACITY PREDICTIONS AT EUROPEAN AIRPORTS

<table>
<thead>
<tr>
<th>AEA Medium Growth reached capacity in:</th>
<th>Airports Constrained by 2000 under SRI Medium Growth Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Terminals</td>
</tr>
<tr>
<td>Vienna</td>
<td>1994</td>
</tr>
<tr>
<td>Brussels</td>
<td>1993</td>
</tr>
<tr>
<td>Helsinki</td>
<td>-</td>
</tr>
<tr>
<td>Paris Orly</td>
<td>1993</td>
</tr>
<tr>
<td>Paris CDG</td>
<td>1993</td>
</tr>
<tr>
<td>Marseille</td>
<td>-</td>
</tr>
<tr>
<td>Lyons</td>
<td>1993</td>
</tr>
<tr>
<td>Frankfurt</td>
<td>-</td>
</tr>
<tr>
<td>Dusseldorf</td>
<td>1998</td>
</tr>
<tr>
<td>Munich</td>
<td>1996</td>
</tr>
<tr>
<td>Hamburg</td>
<td>-</td>
</tr>
<tr>
<td>Stuttgart</td>
<td>1986</td>
</tr>
<tr>
<td>Athens</td>
<td>-</td>
</tr>
<tr>
<td>Budapest</td>
<td>1996</td>
</tr>
<tr>
<td>Dublin</td>
<td>1999</td>
</tr>
<tr>
<td>Rome</td>
<td>-</td>
</tr>
<tr>
<td>Milan</td>
<td>1986</td>
</tr>
<tr>
<td>Luxemburg</td>
<td>1993</td>
</tr>
<tr>
<td>Amsterdam</td>
<td>-</td>
</tr>
<tr>
<td>Porto</td>
<td>1995</td>
</tr>
<tr>
<td>Copenhagen</td>
<td>1990</td>
</tr>
<tr>
<td>Oslo</td>
<td>1986</td>
</tr>
<tr>
<td>Madrid</td>
<td>1999</td>
</tr>
<tr>
<td>Palma</td>
<td>1989</td>
</tr>
<tr>
<td>Malaga</td>
<td>1997</td>
</tr>
<tr>
<td>Barcelona</td>
<td>1986</td>
</tr>
<tr>
<td>Zurich</td>
<td>1996</td>
</tr>
<tr>
<td>Geneva</td>
<td>1998</td>
</tr>
<tr>
<td>Heathrow</td>
<td>1993</td>
</tr>
<tr>
<td>Gatwick</td>
<td>1995</td>
</tr>
<tr>
<td>Stansted</td>
<td>2000</td>
</tr>
<tr>
<td>Birmingham</td>
<td>1989</td>
</tr>
<tr>
<td>Glasgow</td>
<td>1986</td>
</tr>
<tr>
<td>Manchester</td>
<td>-</td>
</tr>
<tr>
<td>Stockholm</td>
<td>-</td>
</tr>
</tbody>
</table>

Sources: AEA, 1987; SRI, 1990
the total planning process which might have been responsible for any lack of effectiveness.

The conclusion drawn from the case study is that, despite some rudimentary attempts to rationalise the process, UK airports have evolved in a disjointed and incremental manner. The resulting set of airports is not as appropriate as it might be for the needs of its users or, as far as the implicit nature of government policy allows any judgement to be made, for the wider needs of society at large. It is further concluded that the airports would have developed in a more appropriate way if they had been regarded as an interactive system so that their roles could have been more clearly defined, if the process of evaluating solutions had been more inclusive of concerned interests and operational consequences, if the decision-making process had been explicitly recognized as part of the planning process and if the whole planning/decision/implementation process were managed more interactively rather than being seen as discrete and sequential steps. The Annex demonstrates some of these shortcomings by a detailed examination of the possibilities for, and consequences of, various options for a third runway at Heathrow. The viability of the options requires much deeper analysis over a much wider socio-economic horizon than is currently being undertaken by the government working parties on runway capacity in the South East (RUCATSE) if the most appropriate option for Heathrow is to be compared with options at other sites and if the most appropriate site option is then to be successfully implemented. The full set of concerned actors, as depicted in Figure 1.1, must develop a mutual understanding and consensus if the implementation and use of the airport is to be reasonably predictable.

Certainly the British Airports Authority (BAA) feels the present system of airport planning in the UK to be inappropriate. "The planning challenge, I would suggest, is to find some new, more rational, more equitable and, above all, more efficient way of balancing legitimate interests" (King, 1990).

Yet, just at the time when the western world has been
FIGURE 1.1: PRIMARY AIR TRANSPORT ACTORS AND RELATIONSHIPS

1. Regulators extend beyond aviation interests.
2. Airports relate to others in a system.
3. Communities relate to wider political entities.
4. Airlines extend from based operators to foreign registration.
5. Other interests, e.g. aircraft manufacturers and other transport modes, may have powerful interests.

N.B.
moving towards liberalisation and privatisation of air transport operators and airports, so, at least in the UK, there has been a move away from central planning of the airport systems. The reason for this may be that it is too difficult to predict the required infrastructure, or it may be the belief that the individual airport authorities can plan adequately without government help. Any such belief may be ill founded on at least three grounds: that there would have to be almost the certainty that the project would pass through the governmental planning process, that private capital is concerned with short term payback and that the interactions between optional proposed projects could result in excessive expectations for each project and consequently a substantial waste of resources. In addition to these difficulties which face the entrepreneur, it could be objected that a major successful project would itself be making national policy by default.

THE FUTURE SETTING FOR AIR TRANSPORT IN EUROPE

A regulated air transport industry tended to produce orderly growth. Airport competition was in the hands of the predictable route licensing regulators. The airport management function was seen as a demand-reactive provision of service and facilities, thus minimising the risks of overprovision. The public purse was expected to cover the remaining risk in the interests of continuity and the wider value of an adequate air transport system. The consumer had to accept the regulators’ judgement of the necessary costs of providing a safe, regular and semi-social service, together with the limited choices which were deemed suitable. Communities around airports, and the wider community of environmentalists, tended to have to defer to supporting economic expansion by the provision of transport capacity on demand.

The setting in which air transport has to function in the western world is now very different. The liberalisation of the economic regulation of airlines, allowing the industry to set its own fares and frequencies, as well as to enter and leave routes at will, opens the possibility of a major
restructuring of the air transport network and of much
greater perturbations in the service at any point in the
network. The new opportunities for airlines to compete on
price and quality of service imply considerable changes in
the quantity and distribution of revealed demand, the demand
being more driven by the desires of the consumers themselves
than by the consumers’ needs as perceived by regulators.
These changes make it more difficult for airports to predict
the demands to which they should react. Parallel tendencies
towards the privatisation of the airports and to the
increasing power of the environmentalists have created on the
one hand, a greater desire to compete and expand yet, on the
other hand, increased difficulty in achieving the necessary
planning approvals.

Within the EEC, the UK has had the longest and deepest
commitment to the liberalisation of air services. The Civil
Aviation Authority (CAA) firmly believes that competition is
the best way to ensure that users have the widest choice of
products, the best quality of service and cost-related
fares; it also believes that competition is an incentive to
efficient operation and the sound allocation of resources
(CAA, 1988a). Even so, the UK has not adopted unconditional
deregulation in all markets. Domestically, the CAA retains
some control over route entry to allay fears among the
smaller carriers that their services might be of interest to
British Airways (BA), while lack of capacity at Heathrow
denies them access to BA's Heathrow routes. Loose control is
also exerted over tariffs to ensure that they are cost-related and not predatory. Internationally, the UK
authorities are willing to give complete freedom on fares and
route access, subject to double disapproval, if the other
country reciprocates. In fact, many other countries do not
reciprocate. The UK also generally allows the development and
operation of airports subject to the normal laws of industry
and commerce, with the exception that the BAA airports and
Manchester have imposed on them an upper limit on the annual
increases in their charges.

Thus the EEC has a good model for the liberalisation which
in theory governs intra-EEC air transport since 1st January
1993; indeed, the UK attitude to liberalisation seems in many respects to have been taken as the model by the EEC Transport Commission. The model should be sustainable in many respects: in considering how much liberalisation is possible; in how to negotiate with less liberal regimes; in what forms of residual control, other than the courts, are required; in the likely consequences for traffic and industry development. In this latter respect, the model drawn from UK experience, and therefore more appropriate than the US experience of deregulation, indicates a different and relatively smaller impact of regulatory freedom (Caves and Higgins, 1993).

Even so, the UK and US experience suggests that European airport entrepreneurs will face increased risk from three main uncertainties:

- user demand as satisfied by the airlines in a competitive setting

- capacity and cost implications of environmental protection

- refusal of planning permission after lengthy preparation, or duplicated permission leading to over capacity.

Brief introductions to each of these issues are necessary to explain the nature of the concern. In addition to these issues, the airports' fortunes will be determined by regulatory attitudes with respect to competitive behaviour and to non-EC route licensing.

DEMAND AND SUPPLY

Table 1.4 illustrates the considerable stability of the traffic on the main routes out of London, in that most increased by a factor of 4.5 to 6.3 between 1958 and 1984 and by a factor of 1.5 and 2.0 between 1984 and 1992. Their ranking has changed very little if the growth in charters to the holiday destinations is taken into account. Nothing like this stability is seen among smaller provincial airports.
Table 1.5 analyses the recent history of the smaller regional airports, showing both the greater growth rate and the greater variability of the smallest class of airports. The traffic through this smallest class of airports in the UK is dominated by charters on the one hand and by scheduled domestic routes on the other hand: there is relatively little use of these airports for scheduled international services. The history of individual lower density routes shows an even greater variability over time, often making their use for revealed demand studies rather dubious, even where the data are readily available. These airports' faster growth has been due to the strong trend towards regionalising the holiday charter services.

The variability of revealed demand over time at the smaller airports is reflected in the scope and connectivity of the network served. The scheduled airlines more than doubled the number of airports served between 1952 and 1972, almost trebled the number of direct links and improved the frequency per link while increasing both the aircraft speed and size, as indicated by Table 1.6 (OECD, 1977). By 1977, there were 75 airports with significant traffic in the 19 European Civil Aviation Conference (ECAC) countries connected by 340 international routes providing at least five return flights per week. For the EEC group of nine, this was equivalent to 296 routes flown, as indicated in Table 1.7 which compares the routes flown with the potentially available linkages in each of the airport-pair categories (EEC 1983), where Category One airports are effectively the national capital airports.

The Institut de Transport Aerien organisation undertook a similar study in the European Conference of Ministers of Transport (ECMT) countries, but based their examination on the principal city/provincial city. They found 164 cities served by non-transfer scheduled international services in 1975. By 1980, 21 cities had ceased to receive service and 24 others had joined the network. There was a consistent history of improving service at all levels of the network in terms of linkages and frequency. However, frequencies appeared to be increasing faster on non-primary and non-stop routes. On the
TABLE 1.4: PASSENGER TRAFFIC ON TEN TOP SCHEDULED ROUTES BETWEEN LONDON AND THE CONTINENT (thousands in plus out)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Paris</td>
<td>3510</td>
<td>462</td>
<td>1.53</td>
<td>4.96</td>
</tr>
<tr>
<td>Amsterdam</td>
<td>2058</td>
<td>218</td>
<td>1.67</td>
<td>5.65</td>
</tr>
<tr>
<td>Frankfurt</td>
<td>1250</td>
<td>77</td>
<td>1.60</td>
<td>10.1</td>
</tr>
<tr>
<td>Brussels</td>
<td>1089</td>
<td>223</td>
<td>1.99</td>
<td>2.45</td>
</tr>
<tr>
<td>Zurich</td>
<td>961</td>
<td>119</td>
<td>1.68</td>
<td>4.80</td>
</tr>
<tr>
<td>Geneva</td>
<td>822</td>
<td>76</td>
<td>1.72</td>
<td>6.30</td>
</tr>
<tr>
<td>Rome</td>
<td>739</td>
<td>63</td>
<td>1.94</td>
<td>6.05</td>
</tr>
<tr>
<td>Milan</td>
<td>677</td>
<td>62</td>
<td>1.74</td>
<td>6.29</td>
</tr>
<tr>
<td>Copenhagen</td>
<td>674</td>
<td>59</td>
<td>1.92</td>
<td>5.95</td>
</tr>
<tr>
<td>Dusseldorf</td>
<td>631</td>
<td>87</td>
<td>1.51</td>
<td>4.79</td>
</tr>
</tbody>
</table>

Sources: Derived from Edwards 1969, BAA 1985, CAA 1993

TABLE 1.5: DIFFERENTIAL GROWTH RATES AT UK REGIONAL AIRPORTS

<table>
<thead>
<tr>
<th>Terminal passengers</th>
<th>No in class*</th>
<th>1984/1979 growth</th>
<th>1992/1984 growth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in 1984</td>
<td>average</td>
<td>max</td>
</tr>
<tr>
<td>More than 1 million</td>
<td>6</td>
<td>1.27</td>
<td>1.82</td>
</tr>
<tr>
<td>0.5 million - 1 million</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0.2 million - 0.5 million</td>
<td>6</td>
<td>1.19</td>
<td>1.78</td>
</tr>
<tr>
<td>0.1 million - 0.2 million</td>
<td>7</td>
<td>1.31</td>
<td>2.18</td>
</tr>
<tr>
<td>5000 - 100,000</td>
<td>3</td>
<td>2.63</td>
<td>8.69</td>
</tr>
</tbody>
</table>

Notes:
1 Liverpool was excluded because 1979 traffic was abnormally heavy.
2 Belfast Harbour was excluded because it only opened in 1983.
3 Taken over 1981 - 1984; many airports in this category did not start reporting until 1981.
4 No in class = Number of airports in class.

NB: Excluding Manchester, Aberdeen, Prestwick, Sumburgh, the Scottish Highlands airports and the Penzance/Scilly Isles airports.

Source: Derived from CAA 1985b, 1993
### TABLE 1.6: CHANGE IN THE EUROPEAN NETWORK COVERAGE OF EARB AIRLINES

<table>
<thead>
<tr>
<th></th>
<th>1952</th>
<th>1962</th>
<th>1972</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airports with services</td>
<td>70</td>
<td>134</td>
<td>162</td>
</tr>
<tr>
<td>Direct Links</td>
<td>234</td>
<td>418</td>
<td>664</td>
</tr>
<tr>
<td>Links per airport</td>
<td>6.6</td>
<td>6.4</td>
<td>8.2</td>
</tr>
<tr>
<td>Return flights per week</td>
<td>7.5</td>
<td>8.6</td>
<td>9.7</td>
</tr>
<tr>
<td>Seats per aircraft</td>
<td>31.8</td>
<td>70.6</td>
<td>107</td>
</tr>
<tr>
<td>Average speed (km/hr)</td>
<td>264</td>
<td>433</td>
<td>717</td>
</tr>
</tbody>
</table>

*Source: OECD, 1977*

### TABLE 1.7: EEC REGIONAL SERVICE INITIATIVE

<table>
<thead>
<tr>
<th>Route Category</th>
<th>Applicable to Legislation</th>
<th>No of International Links</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Possible</td>
</tr>
<tr>
<td>1-1</td>
<td>No</td>
<td>64</td>
</tr>
<tr>
<td>1-2</td>
<td>No</td>
<td>179</td>
</tr>
<tr>
<td>1-3</td>
<td>Yes</td>
<td>552</td>
</tr>
<tr>
<td>2-2</td>
<td>Yes</td>
<td>115</td>
</tr>
<tr>
<td>2-3</td>
<td>Yes</td>
<td>719</td>
</tr>
<tr>
<td>3-3</td>
<td>Yes</td>
<td>996</td>
</tr>
</tbody>
</table>

*Total eligible routes: 2382, 135*

*Source: EEC, 1983*
primary network between the 21 principal cities, there were nine new direct routes, three new stopping pairs and 10 stopping pairs were made direct. Progress on the thinner provincial/provincial routes was greater than on the primary network but much more erratic, with the 87 routes in 1975 gaining 35 links but losing 19 links by 1980. Thus the changes were almost as numerous as the unchanged links, the majority of continuing links being over water. All of the trends noted in the ITA study appear to have continued. As an example of the principal/provincial category, Milan had 19 such links in 1986 compared with 15 in 1980 and 11 in 1975. Regional airlines operating into or within Germany served 65 routes in 1985, of which 46 were international, compared with a total of 15 in 1977 and 31 in 1981.

Thus even in the era of fully regulated services there were very considerable perturbations in the traffic at smaller airports, even though the linkages were predominantly to larger cities. Table 1.5 suggests that, since the beginning of UK - Europe liberalisation, the growth at airports with less than 0.2 million passengers per annum (mppa) has slowed relative to the larger airports, whereas previously they had prospered. In both time periods the smaller airports' traffic has been very volatile, with a tendency for the volatility to increase as they become subject to a more competitive environment.

The most recent UK government forecasts (DTp, 1991a) admit to considerable uncertainty in likely UK traffic levels in 2005, but do not reflect any of the indicated volatility at individual smaller airports. Their estimates of growth to 2005 from a base of 1989 have ranges for domestic traffic from 85% to 149% for London airports and from 93% to 169% for regional airports: the corresponding values for international traffic are 60% to 134% and 97% to 167% for the London and regional airports respectively. The expectation from these forecasts appears to be that the regional airports will grow faster than the London airports but that the uncertainty about their growth is less than that about the London area growth. However, a considerable part of the regional demand is met by Manchester, which would certainly regard itself as
a world-regional, rather than a UK-regional airport. The Department of Transport (DoT) forecasts do not attempt to account for individual airline behaviour, but do presume certain route start behaviour associated with predicted route demand.

In view of the volatility even in a regulated era, the individual airport entrepreneur certainly cannot presume an average traffic growth in return for investing in expansion. The utilisation of new capacity will depend crucially on the decisions of the airlines and their users, ie the very factors deliberately avoided in the DTp forecasting. These same factors cannot be ignored by the airports in the London area, either in terms of the distribution of traffic within the London system or in terms of competition between London and other major continental hubs.

AIR TRANSPORT AND SOCIETY

When the feasibility of an airport expansion programme has been established technically and financially and brought forward for local public examination, the debate turns on the issues of the environmental disbenefits and the economic benefits - assuming that the expansion is not in an area where the economy is overheated. The debate is usually well informed on environmental impact, not least because it is now necessary in law for an Environmental Impact Analysis to accompany any significant development. That is not to say that the predictions of impact are accurate, since so much depends on the aircraft fleets operated and the destinations served, but at least a substantial body of technical research exists to support the discussion and the usefulness of the indicators is well understood. The economic impact, on the other hand, is still assessed on dubious indicators and its quantification tends to ignore the crucial aspect of the stimulation of the economy which is frequently the prime concern of the decision-makers and of the funding agencies when appeals are made for development funds.

The balance of benefits and disbenefits will always need to be decided locally, but the decision will be much influenced
by wider aspects of the system. The fleets and routes will be largely predetermined by the major airlines and the rules governing operations at the major airports. The legislations on aircraft noise and emissions certification are established internationally. The eventual decision will be taken by a Secretary of State who will take account of national and international ramifications of the decision.

Since aviation growth has substantial national policy implications, it must therefore direct itself not only to the ultimate user but also to policy makers. Society as a whole must see the need for growth if the policy makers are to be persuaded to allocate the resources required to support further growth. Furthermore, society, as well as the local communities around airports, must be persuaded that the need is worth the full social costs which will accrue from the further growth.

The industry has recognised the need to strike a realistic balance between the costs and benefits of airport development. The International Air Transport Association's Infrastructural Action Group Director said: "In many cases it will be necessary for additional capacity and genuine environmental concerns to achieve an acceptable and cost effective trade-off responding to local requirements. Solutions can only be found if we respect environmental needs, in particular the genuine concerns caused by aircraft noise and emissions. Equally, airport authorities will need support in explaining the economic benefits that the air transport industry can bring to their areas." (Meredith, 1991) This view was endorsed by the Director General of the European Region of the Airport Associations Council International (AACI) at their Airport Capacity Conference (Yates, 1992).

The balance that must be struck between the benefits and the costs of expanding the aviation industry will strongly influence the nature and extent of the expansion that will be possible. The AACI is aware that "what is required is a measured assessment of all transport modes in order to determine sensible and achievable methods of further reducing
the inevitable impact of transport on the environment" (AACI, 1992a). The view of the European Commission and some of the European Governments is that the balance is currently in favour of aviation and against the environment (Koppert, 1992).

THE PLANNING FRAMEWORK

The critique of the UK airport planning process in the Annex suggests that the application of the formal techniques of systems planning might have produced a more appropriate set of airports, especially if the plans could have been more fully implemented by a less obstructive and more transparent evaluation and decision framework. Yet there is a tendency to withdraw from central planning, which means that, for an individual airport to fulfil its most appropriate role in a European set of airports, each airport will have to develop, or afford to buy in, skills in system planning or take very risky investment decisions. Even so, each competing airport will not be able to influence the important external factors which could be changed by united representation from an airport lobby. The industry’s own representative organisations, like the Airports Council International (ACI), can, of course, perform a valuable lobbying function, but the outcome will always be uncertain for each individual airport.

The UK experience is used as a focus when considering the planning methodologies which the EEC Commission might adopt if it involves itself in ensuring the provision of appropriate infrastructure. However, transferring the analysis to the EC setting must allow for the fact that, in the UK, air transport liberalisation has occurred in a setting which has also seen changes in other linked areas. Trends can be detected in the ownership of the industry as well as of the status of planning in general and of the application of systems analysis in particular. The airline industry has, with the privatisation of BA, ceased to have a publicly owned component. Similarly, BAA is now privatised, with the government owning only a single 'golden share', so that there is now less public control of the country's largest airports than there is of the medium sized airports.
The latter are obliged to be registered under the Companies Act as Public Limited Companies (plcs), but control is mostly still exercised by the local authorities through their majority share holdings. Many have, however, become commercially minded, more because of limited public borrowing limits than of the reconstruction of their boards of directors. The trend to commercial orientation is set to continue with sales of majority shareholding into private, and perhaps foreign, hands. There is even discussion of the privatisation of the National Air Traffic Services (NATS) element of the CAA: it has long been possible for aerodromes to provide their own air traffic services.

The EC, if it wishes to ensure an improvement in the capacity situation while remaining firm in completing the liberalisation of air transport, will be faced with trying to plan in a similar environment to that in the UK, yet faced with a diverse set of national airport ownership and planning policies. In the hope that some clues can be uncovered which might benefit both the UK and the EEC governments in improving the quality of planning, Chapter 9 attempts to understand the UK airport planning process and compare it with processes adopted in other countries and also with developments in planning theory. Particular attention is paid to the rise and fall of systems analysis, as a tool both to help structure the planning process and to understand the elements of the air transport system and their relationships. An existential view of the evidence is adopted, with the objective of constructing an improved planning methodology.

The central question to be addressed here is whether individual airports can plan adequately without the aid of national-level strategic planning, ie can roles, and the competition for them, be resolved through numerous and independent planning studies of a market which may only become known 10 years later? On the other hand, could national-level strategic studies give sufficiently accurate guidance on roles while not unduly constraining local initiatives. Indeed, can sensible strategic planning be attempted at all in a liberalised environment whose very
ethos is innovation at the level of the individual firm?

THE THESIS INTENTIONS AND FORMAT

In the light of the understanding obtained from the annexed case study of UK airport planning, it is hypothesised that a concerted attack on the application of formal planning methods, on the techniques required to understand and model individual elements of the air transport system and the interaction between the elements, on the decision and implementation processes, and indeed the modelling of the decision process within the overall system planning framework, could allow the development of a set of airports which would meet the needs of the industry and society, even in the turbulent setting of a privatised and liberalised industry.

The thesis sets out to investigate the validity of the hypothesis by a systematic study of the elements and the processes. There are three substantive parts to the main body of the text:

Part I, chapters 1-3, describes the context for system planning

Part II, chapters 4-9, examines the state of the system elements and the methodology of its planning

Part III, chapters 10-13, develops the state of the art of understanding the elements and the planning process and draws conclusions on the necessary further improvements in methodology.

Thus the remainder of Part I devotes Chapter 2 to systems analysis. It considers the general make-up of systems and their behaviour. It then discusses some of the necessary characteristics of transport systems before examining some examples of the application of system planning to national and regional airport systems. Part I then goes on to examine the evidence of the impact of liberalisation in Chapter 3. The conflicting evidence from the US experience of
deregulation is reviewed before the more relevant effects of early attempts to liberalise in Europe are analysed. The analytical and operational context are thus set for the study of the state of the art of understanding the system elements and their interactions.

The consideration of the system elements in Part II begins with the ultimate users in Chapter 4, since the application of a 'market forces' philosophy should make their needs the most important determinant of system performance. The primary focus is on the consumer's choice of airport and routing, though some attention is also paid to trip generation and choice of mode. The users can only respond to the transport they are offered, so the behaviour patterns of the airlines are considered in Chapter 5. The focus in this case is on the determinants of network shape and size, and on the strategies with respect to competition. The local and national reactions of environmentalists and society at large will provide arguments for the alternative use of resources and the imposition of the rule that the user pays for pollution. The costs and constraints of environmental protection are examined in Chapter 6, as are the arguments for economic benefits of infrastructure expansion. The balance of the costs and benefits will depend in the future on the aircraft available and the way they are operated, so aircraft technology options are examined in Chapter 7. The generality of aircraft/airport compatibility is examined, in order to determine those technologies which might offer synergistic advantages across a range of problems. Chapter 8 focuses on the financial viability and managerial options available to the airports themselves in defining an appropriate role, leading to the goals, objectives and criteria essential to the application of a systemic approach to planning. Formal planning and evaluation methodologies are themselves examined in Chapter 9, together with consideration of their application: it is seen that these methodologies themselves affect the design and use of the resulting systems.

Part III draws on the existential evidence of the state of understanding of the system elements and their planning
framework to develop initiatives for improving that understanding. Chapter 10 develops methods of understanding and predicting the behaviour of airline users. It also suggests ways in which airlines might respond to European liberalisation. Chapter 11 develops a methodology for analysing causality of the relationship between the supply and demand for air transport and also presents a notional rebalance of air transport benefits and costs which emphasises the industry's ability to reoptimise itself around new constraints. Chapter 12 develops a framework for planning which avoids the problems which have plagued the disjointed incremental approach.

Chapter 13 draws conclusions on improvements still required in understanding the system behaviour, on the viability of the suggested evaluation and decision methods and therefore on the extent to which the hypothesis has been substantiated. At least by this stage the essential acceptance of the importance of the linkages within the system and the need to allow them to be apparent at an early stage of the planning process will have become apparent.

In a study over many disciplines the value rests in this understanding of the linkages. Progress has, however, been made in the understanding of the individual elements as well as in the nature of the interactions. This is so particularly in modelling the areas of airline and airport costs, airport choice and market share. The linkages on which some light is thrown include the causal relationships between demand and supply, the implications of hubbing for airport master planning, the limitations imposed by airport capacity on liberalisation initiatives, the effect of aircraft technology on the efficiency and acceptability of the system to non-users, and, most importantly, the relationship between the planning process and the degree to which the linkages are recognised and allowed to influence the outcome.

The planning methodologies and air transport policies developed here are intended to be notional examples of the application of a systemic analysis of the air mode and its
relationship to its setting. It is recognized that the application of the methodology by the actual concerned actors would probably produce different potential solutions.

It is recommended that the Annex be read before the main text. It is an essential element of the thesis, not only because of its role in developing the hypothesis but also because it demonstrates the power of the linkages and some of the consequences of adopting a planning process which does not give them explicit recognition or which implicitly pre-weights the importance of some system elements and linkages over others.

The work reported in this thesis has itself been an iterative process of understanding which has developed over many years. It is original work by the author in that all the research was either performed personally or initiated and supervised by the author.
CHAPTER 2: THE PLANNING OF AIRPORT SYSTEMS

INTRODUCTION

The case study of the planning of the UK airport system, presented in the Annex, concludes that the approach has been pragmatic in the extreme. Except at the individual airport level, formal planning studies either have not been attempted or their conclusions have been rejected. The planning methodology has been implicit, vague and very reactive. The prime reasons for the rejection of the plans, and for the inappropriate provision of much of the UK’s airport capacity, appear to be:

1. best planning practice was not followed, with too much reliance being placed on local planning inquiries

2. too narrow a view of the problem was taken, not only spatially and temporally but also in terms of economics and politics, ie a system-wide analysis was seldom performed, nor was the discipline of systems thinking applied to the planning process itself.

Airports were therefore often left to create their own individual perceptions of their markets and their roles, without the benefit of the large team of multi-disciplinary skills required to perform the wide-ranging studies necessary for a full understanding of the interactions involved or to set their airport in an overall systems context.

It might be argued that a single national airport authority might be better able to produce a consistent policy for all the individual airports under its ownership. Actually the situation has moved in the opposite direction, towards local and privatised ownership. It is true that the BAA is the major employer, but it is seriously restricted by competition law from coordinating its developments across its groups of London and Scottish airports. Any similar block ownership in other parts of the country might make good operational sense but would have to be equally strictly controlled by the regulators.
Competition is therefore supposed to flourish between many relatively small airports, yet in many important ways they are not in control of their own future. The chapter attempts to assess the extent to which the adoption of more formal techniques of planning and of systems analysis could assist in the process of defining an appropriate role for an airport and hence minimise the risk of development. Firstly the formal discipline of systems analysis and its application to planning is reviewed in the context of sets of airports. Then various attempts to use this approach are examined in outline. Some of the more important factors and interactions are identified. Finally, the deficiencies in conventional system planning are noted from the UK case study and the international comparisons. This preliminary survey of the applications of systems concepts is intended to form the basis for the analysis in Chapter 9 of the changes in planning methodology which will be required for the coming turbulent liberalised free market.

SYSTEMS BEHAVIOUR

A systems approach to planning begins with a formal acknowledgement of the elements of a system and of the inter-actions between those elements. The approach has little value if the interactions are in insignificant, if their nature is not understood or if the boundaries are drawn round the system so tightly that the most influential interactions are considered to be outside the brief of the study. A considerable degree of familiarity with the functioning of the system within the general socio-economic setting is, therefore, implicit in a decision to adopt this sort of approach. Systems analysts usually probe deeply into the workings of a system in order to clarify its scope and function, (Open University, 1983) asking questions like:-

- Can you give it a name?
- What decides whether a thing is part of it?
- What interactions with wider systems:
  - money
  - input, output
  - constraints?
- Are there functional sub systems?
- How are conditions controlled at each stage?
- What measures the efficiency of the process?
- What people, groups and what are their powers and how do they interact?
- How have chance events affected it?
- What relevant external changes might there be?
- What are the main objectives - can the achievement of these be measured?
- What are the main conflicts?
- How can changes be implemented?
- Whose values determine what is desirable?
- On what criterion can one decide what change is desirable?

In the planning of airports, many important decisions about the understanding of the interactions and the multidimensional boundaries of the exercise must be faced, the decisions being influenced by considerations of the inevitable compromise between scale and accuracy. Should the study be confined to a single airport location, major airports in a region, all airports in a region, major airports within a nation, major airports within a subcontinent? Should it include local airspace constraints, enroute air traffic control consequences, aircraft operating limitations, compromises between aircraft and airport technology? Should it respond passively to demand estimates or should it have to meet economic criteria? Should the economic criteria be in terms of rate of return or loss minimisation; should they be for the single airport, the set of airports, the air transport system, the transport system of the economy of which the airport is only one derived part? Should the timescale be set in relation to the ability to forecast, to the time constraints for technical obsolescence or political will, to the time when the effects of the discounted cash flows are made negligible by the discount rate, to the time to build the planned facilities? Should the approach to the analysis be "top-down", "bottom-up" or be combined into some sort of iterative and dynamic process? Can a systems planning exercise derive its own realistic objectives or must these be given before the exercise can
The number of ways in which the scope of a system involving airports can be defined is almost infinitely large. The situation can be formalised in the three non-orthogonal dimensions of:

- spatial scale
- transport system elements
- sectors of the economy

as depicted in Figure 2.1. Systems which are very large are usually incapable of a meaningful analysis because the nature of some of the interactions is inadequately understood, eg the effect of political intervention on demand. On the other hand, a too narrow system boundary can miss out areas which are ultimately more important than the areas being studied, eg the effect of the provision of more flights on a regional economy, or the effect of changing aircraft technology on airport size.

Systems are usually dynamic: static equilibrium is usually difficult to achieve, because of unsynchronised changes in the variables influencing the system and also because of the tensions which exist between the various interested parties, or 'actors'. In the case of airports, examples of the changing variables are population distribution, technology, other modes of transport, passenger travel behaviour and political regimes. Some of the typical areas of tension are between consumer needs and supply capability; national and local interests; air transport, private and military users; consumers and non-users. One could argue that a primary reason for airport system planning is to recognize formally and resolve as many of these conflicts as possible prior to implementation, even more than to harmonize standards (eg of safety and reliability) and to produce an economically efficient system.

Successful systems achieve dynamic stability by closing the input/response loop with negative feedback. In airport systems also it is necessary to recognize the inevitable and
FIGURE 2.1: THE PROBLEM OF SYSTEM BOUNDARIES

NUMBER OF AIRPORTS (SPATIAL SCALE)

Complete system

1 Level

1 Hub

1 Airport

TRANSPORT SYSTEM ELEMENTS

Aircraft production

Air system

Airports

Transport

Economic

Social

Political

SECTORS OF THE ECONOMY
necessary dynamics, and control the system by monitoring.

The difficulties raised by the above questions have led many organisations to take a passive and/or isolated approach to airport planning. This attitude has also been encouraged by the perceived need to run airports as independent competitive businesses. Yet, for many observers, there is an indisputable need for a systems view which recognises that the elements of the air transport system are interdependent with each other and with other sectors of the economy. An a priori case for airport national planning has been made on the grounds of the need to make efficient use of the scarce resources of land and capital, to assist in rationalisation to reduce the number of loss-making airports and because local planning draws its boundaries too tightly to reflect the interests of all those affected by aircraft (Sealy, 1976).

The Federal Aviation Agency (FAA, 1989) makes another a priori case for state airport planning on the grounds that there is competition for funds to maximise the contribution to the State's goals and objectives and that airports are the contact points between society and the whole air transport system. Studies have demonstrated quantitatively how the systems view can be expanded to national planning across all relevant modes of transport (de Neufville, 1972; Caves, 1976).

Aviation-centred planning studies normally have drawn system boundaries around transport, and have not considered explicitly the two-way dynamic interaction between the transport investment and the socio-economy within which it is set. A substantial survey of South East Asian Regional Transport suggested that airports be used as economic growth poles, but did not present evidence of the effectiveness of such policies: this survey used very broad geographical and political boundaries, but otherwise tended to consider each element of each mode in isolation, and used very simplistic trend forecasting (Little, 1972).

Such omissions are usually excused by inadequate
understanding of the interaction mechanisms and by the fact that this exclusion leads to a pessimistic evaluation of viability. It is certainly apparent from earlier studies that the broadening of the boundaries of systems models can only realistically be based on an extended iterative learning process, and furthermore, that this broadening must not be at the expense of ignoring the micro-economics and constraints which exist at the operational level. However, as long as planning remains within narrow spheres of interest and authority, there is the danger that evaluation may be distorted and that the advantages of the mode may not be maximised. The stimulation to the regional economy may far outweigh the direct benefits to the users or the environmental costs to the community. The failure to plan for political intervention, environmental regulation and legislation of route traffic and pricing may reduce the air mode's unique advantage of flexibility. The failure to match airport facilities and aircraft technology may lower air transport cost effectiveness relative to other modes.

CONVENTIONAL PLANNING METHODS

An excellent example of the systemic approach to planning is embedded in the FAA's advice on State Airport System Planning, (FAA, 1989), shown diagramatically in Figure 2.2. It encompasses the official recommendations for Airport Master Planning (ICAO, 1987; Ashford and Wright, 1992), but extends them to the treatment of systems of airports. There are problems at each stage of this planning process. Some of these problems are noted in Figure 2.3. Perhaps the most important area is policy formation. In a deterministic, unidirectional process, if the first step is not correct it is unlikely that the other stages can be completely successful; the feedback in the diagram is intended to make it a continuous ongoing adaptive process, rather than to correct large scale errors in the original premises.

Policy formulation requires goals, objectives and criteria to be established. It is not the recommended role of a systems analyst or planner to generate the goals and objectives. However, one goal would normally be the satisfaction of
consumer needs within the constraints of available financial and other resources. It is not an easy task to find out what are the consumers' real needs. Revealed demand studies tend to imply that the users are satisfied with the present system, which has evolved usually through a demand/capacity approach to planning. They also usually ignore the non-user, since data collection on even the users is time consuming and expensive. Stated preference methods presume that real needs can be elicited in a hypothetical situation and that the present population can speak for future passengers. Yet if the needs are not understood, it is unlikely that the system will be used in the way it was envisaged.

Two objectives which might flow from the above goal are adequate safety and adequate accessibility. The corresponding criteria might then be risk per flight over the whole network equal to the best trunk line practice and equal opportunity to access scheduled air transport, although most
current systems fail to meet either of these criteria.

Transport planners in other areas have worked not only with access to a network, as in the UK with motorways (Fullerton, 1975) and in the USA with airports, but with the much more relevant concept from a behavioural standpoint of access to a necessary destination (Dalvi and Martin, 1976). Even more relevant to aviation studies is the concept of a space-time geography within which the individual traveller is constrained by a time budget, illustrated in Figure 2.4 (Hägerstrand, 1987). This can be thought of as the ability to make day-return trips.

Another goal which might be adopted would be to minimize the disparity in wealth between regions by minimizing the disparity in accessibility between regions, thus attempting to reverse the spiral of spatial disadvantage which tends to build up when transport investment merely follows revealed demand (OECD, 1977). Thus more investment would be channelled to regional airports according to a criterion which might be stated in terms of allowing equal opportunity to access given destinations. This type of policy might reduce the disparity in propensity to fly between the London area and the UK regions, which is much greater than the disparity in the general propensity to travel, as shown in Table 2.1.

In most airport system planning studies, goals have been implicit, objectives have often been contradictory and criteria have seldom been assigned. The planners have had to adopt their own inferred criteria: all too often, it has been most expedient (and profitable, when the planner has belonged to the team of consulting engineers who will have the development contract) to use a demand/capacity approach, subject to some financial test.

When this method is adopted, the planning process can start with an inventory of the present facilities, the demands on it and the achieved productivity. The productivity will vary greatly with the setting, and questions arise as to the design criteria which should be used in the future when the base year productivity is low by Western standards. The
required increase in capacity depends on the base year utilisation of capacity, the base year productivity in a capacity situation, the expected changes in productivity and acceptable levels of service, and on the demand forecasts. Demand analysis and methods of prediction are dealt with in Chapter 4, in the context of establishing user preferences. It is necessary here only to note that no forecasts are accurate, that the degree of inaccuracy depends on the budget (particularly for survey work) and that techniques are available for dealing with uncertainty (Khan, 1989). In one way or another, it is possible to predict future desire lines, i.e., traffic flows defined by trip origins and destinations (ODs). These are illustrated by Figure 2.5 from a study of a long term air transport plan for Libya (Frederic R. Harris, 1983).

The future demand has to be met by some presumed development of the base year supply network. Assumptions have to be made
### TABLE 2.1: PROPENSITY TO TRAVEL IN THE UK REGIONS

<table>
<thead>
<tr>
<th>Economic planning regions</th>
<th>Population (thousands)</th>
<th>Propensity to fly</th>
<th>Propensity to travel</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>3293</td>
<td>3097</td>
<td>0.163</td>
<td>0.570</td>
</tr>
<tr>
<td>Yorks &amp; Humb.</td>
<td>4811</td>
<td>4855</td>
<td>0.208</td>
<td>0.533</td>
</tr>
<tr>
<td>North West</td>
<td>6747</td>
<td>6406</td>
<td>0.261</td>
<td>0.735</td>
</tr>
<tr>
<td>W.Midlands</td>
<td>5122</td>
<td>5136</td>
<td>0.258</td>
<td>0.505</td>
</tr>
<tr>
<td>E.Midlands</td>
<td>3390</td>
<td>3807</td>
<td>0.226</td>
<td>0.504</td>
</tr>
<tr>
<td>E.Anglia</td>
<td>1686</td>
<td>1865</td>
<td>0.211</td>
<td>0.435</td>
</tr>
<tr>
<td>S.West</td>
<td>3792</td>
<td>4326</td>
<td>0.208</td>
<td>0.503</td>
</tr>
<tr>
<td>S.East</td>
<td>17289</td>
<td>16729</td>
<td>0.540</td>
<td>1.811</td>
</tr>
<tr>
<td>Wales</td>
<td>2724</td>
<td>2790</td>
<td>0.179</td>
<td>0.459</td>
</tr>
<tr>
<td>Scotland</td>
<td>5217</td>
<td>5131</td>
<td>0.186</td>
<td>0.984</td>
</tr>
</tbody>
</table>

**Notes**

1. Propensity to fly is the number of flights per head of population per year.
3. GLC and Metropolitan Area 2.098
   Remainder of South East 0.769
4. Trips more than 40km, 1976
5. Will include some commuting to work in London.

The figures for Greater London are 24 all modes and 20 by car.

**Sources:** CAA annual statistics; Department of Trade, 1976; UK Census, 1981; Langdon, 1983
on the criteria for minimum frequencies, aircraft purchasing policies, allowable load factors and policies for starting new domestic and international routes, new airports and international gateways, before the network can be analysed as illustrated in Figure 2.5. Assignment of traffic to the network may be simplistic, eg all-or-nothing on the basis of minimum generalised cost to the passenger, or using airport and route choice models (see Chapter 4). Terminating and transfer traffic at each airport can then be determined directly, as can the air transport movements (ATM) and fleet requirements. In this way, the whole system can be planned to a consistent set of assumptions, and there is no possibility of the demand being double-counted by competitive and non-collusive attempts by individual airports or operators to expand beyond their natural role. It would, however, be prudent to explore alternative means of meeting the predicted demand, as was done in Spain (de Andres, 1980). In the Spanish study, natural development of the base year network was compared with a fully connected network on the one hand and a minimally connected (regional hubbing) network on the other (Figure 2.7). The latter solution was found to give minimum infrastructure and user cost, and the facilities were planned on that basis.

For each alternative system plan, the required facilities have to be sized and phased, again in accordance with level of service criteria. This process is illustrated in Figure 2.8, for each airport in the system, including the requirements of all users. It is not usual at this stage to take into account the design problems of each individual site. Average unit estimates of space, staff and costs are considered sufficiently accurate for a system study: these would be considerably more refined in a master plan for any single airport, when the budget will usually be larger than that for an entire system plan. The land take, staffing requirements, equipment, capital and operating costs for each airport can then readily be calculated.

Evaluation usually centres on choosing a preferred alternative, rather than on a build/no build decision. Since demand has usually been presumed not to vary between
FIGURE 2.5: PREDICTED DOMESTIC TRAFFIC FLOWS BETWEEN ZONES IN THE YEAR 2000 IN SOCIALIST PEOPLE'S LIBYAN ARAB JAMAHIRIYA

Source: Frederic R Harris Inc, 1983
FIGURE 2.6: NETWORK PLANNING PROCESS

Domestic O-D between zones plus international to airports.

Zones with no current airport reallocated.

Airport terminating pax. including international transfer.

Direct service = f(historic pattern, 10,000 pax/year min).

Sector traffic: Domestic transfers (including transits).

Frequency load factor, fleet mix constraints.

Reallocate non-direct traffic

Domestic fleet size, aircraft utilisation, average block speed, distance, flights per week, etc.
FIGURE 2.7: ALTERNATIVE AIR NETWORKS IN SPAIN

Source: de Andres, 1980
FIGURE 2.8: STRATEGIC AIRPORT PLANNING PROCESS
alternative schemes, evaluation of the preferred option has often been based on cost minimisation, rather than rate of return or some other financial criterion. Sometimes, as with the Roskill study, factors other than monetary cost have been included in the cost minimisation analysis (Button and Barker, 1975). More recently, weighted or non-weighted variations of Planning Balance Sheets (Litchfield et al 1975) have been used to attempt to deal with the uneven distribution of costs and benefits across and within the groups of actors, and Environmental Impact legislation often makes it essential to generate and compare alternative schemes. These matters are considered further in Chapter 9.

Despite this apparently sensible approach to planning, the record of implementation of the plans for either individual airports or systems of airports is not good. All the planning effort is, of course, wasted if only part or none of the plan is implemented. The Annex shows this to have been a common result in the UK. Other countries’ national airport planning methods are now examined briefly, to gain some further understanding of the extent to which formal planning techniques have been used and how successfully they have been implemented.

NATIONAL AIRPORT SYSTEM PLANNING EXPERIENCE

USA

This is the country with the widest planning experience. The origins of federal involvement in the airport system are to be found in the anti-depression programme of the early 1930s. Then followed a strong military effort and the Federal Airport Act in 1946 to develop and improve public airports. Thus, as with France, the plan developed from a need to give direction to a decision that public money should be devoted to maintaining an adequate set of airports. Added impetus was given to the programme by the disparity between airport development and that in the private sector (ie the airlines).

Many of the planning methods were initially developed by individual States, but the FAA (Federal Aviation
Administration) began to formulate federal methods when it was
given responsibility to administer the aviation Trust Fund in
1970. In 1984, the FAA produced the National Plan of
Integrated Airports System (NPIAS) to replace the earlier
National Airport System Plan (NASP) of 1978, and updated it

The main objective of the NPIAS was to ensure that each
community had access to a safe and adequate airport. To this
end, 3243 existing airports out of a total of some 16,000
landing areas were included in the 1986 plan and a further
466 were proposed. The emphases within the system are shown
in the Table 2.2:

**TABLE 2.2: AIRPORTS IN THE US NPIAS 1986-1995 PLAN**

<table>
<thead>
<tr>
<th>Airport classification</th>
<th>Number of airports</th>
<th>Cost(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Existing</td>
<td>New</td>
</tr>
<tr>
<td>Commercial service</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- primary</td>
<td>278</td>
<td>4</td>
</tr>
<tr>
<td>- other</td>
<td>272</td>
<td>11</td>
</tr>
<tr>
<td>Reliever</td>
<td>244</td>
<td>64</td>
</tr>
<tr>
<td>GA</td>
<td>2449</td>
<td>387</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3243</td>
<td>466</td>
</tr>
</tbody>
</table>

Note 1: total cost to federal, state, local authorities and
private investment.

*Source: FAA 1987*

11 per cent of the $24.3 billion was to be spent on
maintenance, 18 per cent on renovation and updating and the
remaining 71 per cent on adding capacity in terms of both
flow rate and airport size. The new airport at Denver was
expected to account for 11 per cent of total NPIAS costs. In fact, the expected total airport development spend by the FAA was $886 million in fiscal 1991, only a few of the major projects having survived local planning decisions.

Public Airports are mostly owned by cities and counties, but some are tied to old Federal interests. Primary Airports (278) are those Commercial Service Airports having more than 0.01 per cent of total US enplanement.

General Aviation (GA) Airports are in two categories:

Basic Utility - for most singles, many twins, making up about 95 per cent of the GA fleet.

General Utility - for all aircraft with < 12,500 lb. AUW.

Reliever airports expand capacity in metropolitan areas. There is a minimum of 10 per cent of Airport Improvement Program (AIP) funds reserved for these airports, but noise has increased due to jets and the increased level of activity so that the provision of this capacity is being hindered by legal battles over noise abatement, despite the provision of federal funds.

The classification above is very useful to disburse funds by airport function. Another classification is used to examine the integrated planning needs of state, metropolitan and local planning: this is based on the hub, or demand pole concept as shown in Table 2.3:

TABLE 2.3: US CLASSIFICATION OF AIRPORT HUBS

<table>
<thead>
<tr>
<th>Hub classification</th>
<th>Number of hubs</th>
<th>% of total domestic passengers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large (L)</td>
<td>24</td>
<td>1% and more</td>
</tr>
<tr>
<td>Medium (M)</td>
<td>39</td>
<td>0.25%-0.99%</td>
</tr>
<tr>
<td>Small (S)</td>
<td>61</td>
<td>0.05%-0.25%</td>
</tr>
</tbody>
</table>

Source: FAA 1987
Each large hub handled more than 2.78 million enplanements in 1982; each non-hub handled less than 139,000 enplanements. The system has been stable at the large and medium sizes, but the number of small hubs fell by a third between 1978 and 1984. However, the new trend to airline hubbing is rapidly altering the situation.

The NPIAS was intended to be revised every two years. Its role is to support the needs of civil aviation, defense and the postal service with a safe, efficient and integrated system. It should relate each airport to:

- the local transport system
- forecasts of aeronautical technology
- developed forecasts of other modes.

The federal goal was to provide public access to national air transportation, the criterion being a 30 minute road time to an adequate airport, paying attention to the diverse needs across the nation. 97.3 per cent of the population in 1984 was within a 20 mile drive of a NPIAS airport and 70 per cent of these had commercial service. Thus entry to NPIAS was based on adequate access and on commercial viability, where this latter criterion was deemed to be met by 10 based aircraft, or, for Commercial Service airports, more than 2,500 scheduled boardings per year. Entry to the GA category was also influenced by the mail service and military activity. The conditions for the rapidly expanding reliever category were also carefully controlled.

The FAA provides financial support for the planning function as well as the implementation from NPIAS through the Planning Grant Program.

The federal plan is coordinated and updated through the regional offices of the FAA. The State input comes via Joint Planning Conferences. The emphasis is on collaboration with all interested parties, eg the Air Transport Association being consulted on navaids.

Most airports are common to both NPIAS and the State plans,
although there are inevitably some differences in entry criteria, time frames and views on border problems.

Other important elements of the integrated planning process are:

- Joint Planning Conference with relevant Airport Managers, tower staff, airlines, airport tenants, city planners

- Intermodal Planning Groups set up by the Department of Transportation in each of 10 Federal Planning Regions

- Citizen Involvement at each stage of the planning process

- the need for an Environmental Impact Statement (the 1978 one is deemed to be still valid)

- there are specific federal funds for noise compatibility planning.

The airport accessibility objective should be seen in relation to the support of air services to isolated communities. This is provided by the Department of Transportation, via the Essential Air Services Program, for those communities which are more than 90 minutes driving time from a scheduled air service.

The NPIAS is continually monitored by governmental agencies, eg the General Accounting Office, the Congressional Budget Office, the Office of Technology Assessment.

In summary, the NPIAS methodology is reaching down to the lowest levels of demand and is particularly concerned with access. It has rigid rules for the quality of planning, the degree of federal involvement in funding and the level of facilities which can be provided at a given level of activity. It is integrated with local and regional economic and transportation plans. It is intended to be continuously monitored, both in terms of content and effectiveness. It
gives guidance and assistance for state system planning, but has no power over a State to produce a plan. The role of reliever airports is rapidly assuming major importance in allowing regional aviation to perform its dual primary roles of feeding the national system and providing efficient local transport.

All the excellent planning methodology has still produced a system with many problems, even at the larger airports, as listed in Table 2.4. Also, some larger airports question the value of being a part of the federal planning process, due to the resulting lack of flexibility in managing their own affairs. The fear that unilateral action by airports on charges and on noise control will result in 'de facto' national planning has led to calls for clear federal airport policies to pre-empt these actions. The system is subject to substantial delay in bad weather despite flow control and slot rationing at the major airports. There is also a widespread consumer feeling that levels of service and punctuality have fallen since deregulation, and that delays

**TABLE 2.4: PROBLEMS AT 41 US HUBS**

<table>
<thead>
<tr>
<th>Problems</th>
<th>No of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inadequate reliever airport capacity</td>
<td>30</td>
</tr>
<tr>
<td>Potential closure of major GA airport</td>
<td>17</td>
</tr>
<tr>
<td>Air carrier terminal congestion</td>
<td>32</td>
</tr>
<tr>
<td>Noise land use conflicts</td>
<td>32</td>
</tr>
<tr>
<td>Ground access to air carrier airports</td>
<td>23</td>
</tr>
<tr>
<td>Inadequate air carrier runway capacity</td>
<td>22</td>
</tr>
</tbody>
</table>

*Source: FAA, 1987*
and cancellations have greatly increased. The traffic forecasting methodology developed during the regulatory period has proved incapable of handling the rapid creation of new hubbing points. The FAA has responded to the situation with proactive and longer term planning studies, but these rely very much on the existing planning methodologies. There is no sign that the links within the Department of Transportation, or between it and Congress, will change markedly. Also, it is interesting to note that the strategic planning process which the FAA expects to adopt is to function only within the confines of the aviation community, and only the aviation community were consulted on the planning.

US State System Plan: Alaska

The state of Alaska is, of course, not typical of most states in the USA. Not only is it isolated, but in 1983 it had 70 times the air taxi flying hours, 16 times the number of aircraft, and eight times the number of pilots per capita than the average state. The State System Plan includes 1,000 airfields and lakes, of which the state operates 250 (Robart, 1983; State of Alaska, 1986).

The discipline of systems analysis is strongly embedded in the planning methodology, with special attention given to studying the forces on the system and their implications. An inventory is taken and the facilities are classified, taking account of the population and the level of service. The present demand is measured and future demand is estimated. The capacity and facility requirements are calculated and the programmes needing support are identified. A large range of alternative designs, their operating policies and schedules of implementation is presented to users, the public and various governmental agencies for evaluation.

Two special issues related to the low density settings are fuel availability and navaid coverage. Where a road is available, the state role in fuel supply is limited to a management, coordination and communication role: otherwise the State flies fuel in by the barrel. The State funds all
navaid provision, but there is only 27 per cent of the USA average coverage and more is needed, particularly at low altitude. A particular requirement is for approach aids where the quality/reliability trade-off is brought into focus by comparing a state-wide bill of $3m for an NDB system with $60m if ILS were to be provided. MLS would cut the ILS bill substantially, but would need a significant commitment by users.

The system is based on hubbing to Regional Airports and to larger Regional Centre Airports. It costs $298,000 per year to run 11 of the former and $471,000 for 10 of the latter airports. They could be taken over by the local communities, but they would have to be responsible for costs. The State could not afford to see these airports close because they are essential to the proper functioning of the system.

Canada

The federal authority, Transport Canada, owns 168 airports. It operates 108 of these, with the provincial or municipal authorities operating the remainder. A further 301 airports are both owned and operated by the provinces or municipalities. Another 600 airports are owned and operated privately.

The airports in the federal plan are classified primarily by the nature of the air routes operated:

1. Eight International Airports.
2. 11 National Airports.
3. 46 Regional Airports giving direct access to classes 1 and 2, having collected local traffic.
4. Local Commercial Airports used by airlines but not meeting other criteria.
5. Local Airports, ie not served by airlines.

These airports are also sub-classified by their importance to the community (as measured by originating passengers), level of aviation activity and the importance of the airport to operators (as measured by the operating and maintenance
expenditure).

The system in general is funded via Transport Canada through parliamentary appropriations from a general fund. The fund is supplied by the pooled revenue from the Budgetary Airports supplemented from other sources. There are 23 larger Non-budgetary Airports which are funded from their own revenue plus support from an Airport Revolving Fund. The government wishes to see a greater degree of cost recovery (Canadian House of Commons, 1985).

In the special case of the Arctic Region, a Task Force was set up in 1973 to provide, maintain and operate the air transport facilities to the minimum standard required to enable the operation of reliable air services to communities in the Yukon and North West Territories. After taking the views of carriers, users and government agencies to determine the policies, the Task Force developed a five year implementation programme costing $69m (Courtney, 1977).

The system presupposed a hub and spoke system where Class C (Community) airports would feed Class B (Area) airports which would in turn feed Class A (Regional) airports, where qualification for each class depended on population, the national and regional value of the community's function and the type of air service provided. A general qualification for all classes was that no other means of regular transport was available. Any community of over 100 people could have a Community airport suitable for Twin Otters. Any growing community of over 400 people with a regular air service which either provided an area administration or a resource development role could have an Area airport suitable for F 28 aircraft. If, in addition, the community had regulated air carrier service and performed a regional administrative role, it qualified for an airport suitable for 727 aircraft. There is also provision for seaplane bases.

In fact, as the system evolved, the assumed hub and spoke links did not always function. Some A class airports have reduced in importance while B and C classes have become more predominant, due to more direct linkages being established
than had been envisaged. This may be due in part to the fact that the Territories are now responsible for B and C class airports even though Transport Canada still operates some of them while local personnel are trained in situ.

The level of facility provision at the C class airports is broadly similar to those which give 97 per cent reliability in the NorOntair network.

France

France is highly centralised and nested both in administration and planning. Paris has 18.5 per cent of the population, 26 per cent of GDP and 56 per cent of passengers. Another 24 per cent of the passengers board in the five main regional centres of Marseille, Nice, Lyon, Toulouse and Bordeaux. The remaining 20 per cent of passengers (5 million boardings) pass though the other 25 regional airports (Toepel, 1986).

Aeroport de Paris and Basle/Mulhouse are public entities. The national authorities own the other 30 largest airports as well as some smaller ones. They issue operating concessions to the local Chambers of Commerce but retain technical control.

National plans have been drawn up, and in general put into practice, since 1922. Recent plans have been the result of national transport demand modelling, with the application of modal split modelling to derive air traffic demand between towns, modified by regional socio-economic objectives.

The creation and expansion of airports requires a national airport plan, a regional airport plan and an airport master plan, the latter two plans being made by the region and submitted to the Minister for approval. There must also be a declaration of public use if land has to be expropriated. After ministerial approval has been given, individuals do not have the right to oppose the decision.

The national plan classifies airports into four categories by
function, ie long range, medium range, feeder/charter and aero club, with appropriate levels of facility provision.

There is now a move towards decentralisation, with transfer of property from the national to the regional authorities. This will make it easier to market regional gateways, but the regions will have to contribute to the provision of nav aids, lighting, fire and rescue facilities.

**Germany**

In contrast to France, Germany is much more evenly balanced both in population and in airport traffic. All the eight main airports serve regions with some 7 per cent of both population and GDP. However, Frankfurt has some 37 per cent of the passengers. This relative strength is due partly to the central location of Frankfurt and also to Lufthansa's decision to move there from Hamburg when the first generation jet aircraft demanded greater runway length. The long-haul service required a progressively stronger feeder network, which is now being provided partly by rail (Toepel, 1986).

The federal authorities are ultimately responsible for airport planning, but delegated this function to the States in 1961 thus avoiding conflict with the existing State practices. The setting of system goals is therefore also left to the States - Bavaria, at least, lays emphasis on access to civil aviation for each of its 18 regions. The States also assumed responsibility for the construction and supervision functions. The federal authorities were initially major shareholders in the airport operating companies, but with minority participation, thus helping to resolve any State/Federal conflicts. They have since withdrawn from many airports, but are becoming more active in national transport system planning with coordinated forecasts, uniform capacity calculations and air/rail cooperation. Meanwhile, the emphasis on State planning has not proved an adequate solution to the environmental debate.
Italy

Here the relationship between passengers, GDP and population is more correlated. Special laws are needed to create or alter airports. All airports are owned by federal authorities and operated by local companies or authorities. Alitalia is often one of the shareholders. Airport-based technical supervisors report directly to federal government (Piccardi, 1986).

Japan

The air transport system is, as in the USA, dominated by domestic traffic with 40m passengers per year compared to 3m international passengers on Japanese airlines. Five year airport system plans are drawn up by the Ministry of Transport. There are, incidentally, also five year plans for tourism, rail and shipping, but not for Air Traffic Control. The fourth plan, adopted in 1987, stresses improvements in road, rail and air infrastructure to a system which will allow nationwide day-return between any major city pair. This implies a move towards jets and away from commuter sized airports. The capital requirement is largely met from an Airport Implementation Special Account managed by the Ministries of Transport and Finance and funded by passenger charges and fuel tax.

The airports are classified from 1 to 3 by runway length, class 1 having more than 3,000 metres. There are 13 class 1, 20 class 2 and 44 class 3 airports in the plan. The Special Account funds all the large airports except Haneda and Kansai, 75 per cent of the medium and 50 per cent of the small airports. The central government also makes up any annual deficit on all but the small airports where cross-subsidy is hard to justify (Ohta, 1989).

Norway

The salient feature here is the Norwegian government's goal to give all communities relatively easy access to the capital, Oslo. To this end it has set up a system of STOL
airfields (and heliports) along the North coast. These airfields are very well equipped to accept Twin Otter aircraft which provide feeder services to jet service at regional hubs (Strand, 1983; Wilson and Neff, 1983).

Brazil

The airport planning system in Brazil is very much a question of 'horses for courses'. The large nationally-important airports are planned by specially instituted short-life commissions managed by committees drawn from the various federal, state and municipal bodies who provide the funds. An exception was ARSA which, until recently, managed the Rio de Janeiro airports on a continuous basis. Historically, other airports have been planned on an individual ad-hoc basis by municipalities and/or states. The planning effort at all levels has been supported by an organ (CECIA) within the Directorate of Civil Aviation, working under contract to the relevant planning authority. Since 1981, CECIA has been jointly responsible with the States for developing State Airport System Plans, though curiously these exclude the state capital airports.

The small airports are administered by the relevant municipal or state authority, the large ones by a federal agency (INFRAERO). This agency has now been reorganized into seven regional administrations one of which has taken up the former responsibilities of ARSA (Menezes, 1989). This leads to some conflict, because a state tends to have to subsidize an airport during a growth phase; then, when a position of financial viability is reached, INFRAERO takes over and the profits go to central government.

HUB FRAGMENTATION

The second type of airport set concerns those described as hubs in the US NPIAS, ie a set of airports serving a single metropolitain area, usually owned by a single authority. These occur because airports age through changes in technology and land use and because they are outgrown by traffic growth. This growth is often overheated by airline
hubbing. Even with the best use of new methods to increase capacity and control environmental pollution, it is necessary to find a site for a replacement or an additional airport. Many cities now have multiple airport hubs; among these are Montreal, New York, Los Angeles, San Francisco, Washington, Sao Paulo, Rio de Janeiro, Paris and London. Population forecasts indicate that many more major cities will face this problem during the remainder of this century.

London now has two main airports, both owned by the BAA Plc, plus Luton and Stansted. It has already seen problems in fragmenting services between Heathrow and Gatwick and now needs to fragment further due to runway capacity problems. Land use and airspace limitations preclude any new close-in airports with the exception of the small London City Airport, so it is being forced to fragment further among the airports at its disposal. It seems that London follows a general rule of an airport for every 8 million originating passengers per year (de Neufville, 1984), though the implication that it will soon need another major airport is hard to visualise.

The choice of how to plan and operate a fragmented hub system is difficult to make, depending on transfers, international politics, the availability of cross-subsidy and the way the costs fall on the operating airlines. Some secondary airport uses are given in Table 2.5. There are immense difficulties to be faced in creating a viable scheduled airline operation at a secondary airport which is usually sited more remotely than the primary airport. Unless there is rigorous enforcement of route rights favouring the secondary airport, it is better either to close down the earlier site as at Munich, limit its use as in Sao Paulo, or expect low cost or freight services to be the initial users, as at Gatwick or Newark. However, despite the apparent diseconomies, fragmentation can occur naturally in the air transport system when airlines seek new markets as in the Californian corridor, but planners must foresee the trends and use them. Much of the annexed case study of the UK airport planning experience is concerned with the London hub. The analysis is not repeated here. Hubbing and fragmentation are considered in Chapter 5.
### TABLE 2.5: SOME INNOVATIVE AIRLINES ASSOCIATED WITH SECOND AIRPORTS

<table>
<thead>
<tr>
<th>Metropolitan region</th>
<th>Second airport</th>
<th>Airline</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York</td>
<td>Newark</td>
<td>People Express</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Federal Express</td>
</tr>
<tr>
<td></td>
<td></td>
<td>World Airways</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>Ontario</td>
<td>United Parcels</td>
</tr>
<tr>
<td></td>
<td>Burbank</td>
<td>Pacific Southwest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Air California</td>
</tr>
<tr>
<td>London</td>
<td>Gatwick</td>
<td>British Caledonian</td>
</tr>
<tr>
<td></td>
<td>Luton</td>
<td>Tour Operators</td>
</tr>
<tr>
<td>San Francisco</td>
<td>San Jose</td>
<td>Pacific Southwest</td>
</tr>
<tr>
<td></td>
<td>Oakland</td>
<td>World Airways</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Federal Express</td>
</tr>
<tr>
<td>Chicago</td>
<td>Midway</td>
<td>Midway Airlines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Air One</td>
</tr>
<tr>
<td>Washington</td>
<td>Baltimore</td>
<td>World Airways</td>
</tr>
<tr>
<td>Dallas</td>
<td>Love Field</td>
<td>Southwest Airlines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Muse Air</td>
</tr>
<tr>
<td>Houston</td>
<td>Hobby</td>
<td>Southwest Airlines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Muse Air</td>
</tr>
</tbody>
</table>

*Source: Australian Department of Aviation, 1985*

### OTHER AIRPORT SYSTEMS

A third set of airports, which is given little attention, is that used by General Aviation. Centrally planned systems usually have a GA airport category, but otherwise these airfields are considered to be the unique responsibility of the local communities. Yet there are grave issues of access
from these small airfields to the national hubs, and of lack of official guidance for the inexperienced local officials who have to manage local conflict. This topic cannot be given here the attention it deserves, but Table 2.6 classifies the types of GA and some of the planning issues.

TABLE 2.6: GENERAL AVIATION PLANNING CLASSIFICATION

The constituents of General Aviation

<table>
<thead>
<tr>
<th>Transport</th>
<th>Industrial</th>
<th>Training</th>
<th>Leisure</th>
</tr>
</thead>
<tbody>
<tr>
<td>3rd level</td>
<td>Agricultural</td>
<td>Commercial</td>
<td>Private</td>
</tr>
<tr>
<td>Corporate</td>
<td>Inspection</td>
<td>(schools)</td>
<td>Flying clubs</td>
</tr>
<tr>
<td>Air Taxi</td>
<td>Survey</td>
<td>P.P.L.</td>
<td>Gliding</td>
</tr>
<tr>
<td>Private</td>
<td>Field support</td>
<td>(clubs)</td>
<td>Hang gliding</td>
</tr>
</tbody>
</table>

Equipment types

<table>
<thead>
<tr>
<th>Business jets</th>
<th>Powerful singles</th>
<th>Light twins</th>
<th>Singles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twin Turbo-props</td>
<td>Light helicopters</td>
<td>Singles</td>
<td>Un-powered craft</td>
</tr>
<tr>
<td>Helicopters</td>
<td>and light singles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Twin piston engines</td>
<td>Medium twins</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piston singles</td>
<td>Heavy twins</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>and helicopters</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Airfield type and location

| Substantial          | Rudimentary      | Usually     | Rudimentary |
|                      | often improvised | co-located  | rural       |
|                      | sites in rural   | with transport | location    |
|                      | or isolated      | activities.  |             |
|                      | areas            |             |             |

Adverse environmental impacts

<table>
<thead>
<tr>
<th>Take-off and landing noise</th>
<th>Disturbance of rural environment</th>
<th>Unsocial hours</th>
<th>Unsocial hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ie similar to transport</td>
<td>Low altitude circuits with power changes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
POSSIBLE IMPROVEMENTS IN AIRPORT SYSTEM PLANNING.

This brief review of airport system planning, together with the examination of the UK approach in the Annex, has shown that airport systems have evolved in some cases from completely laissez-faire policies and, at the other extreme, from rigid central planning, some countries having adopted very narrow planning and others having tried to integrate airports into the rest of the transport and local planning sectors. Some countries have planned statically while others have built rolling plans and incorporated feedback loops.

Frequently airport system plans have been made without consideration of the airline route structure. This has lead to problems with feeder service access to hub airports, partly because of a tendency to plan national hub airports in isolation from the other airports. Where the air transport system has been planned in an integrated fashion, the airport role has often been wrongly identified because of insufficient understanding of how passengers make choices, how airlines manage their business and how, as a consequence of these decisions, hubs develop and decay. Except when they are constrained by government intervention, airlines plan their network development very differently from the way a government agency or private entrepreneurs would plan a system of airports. The main reasons for this are the mismatch of planning horizons and the different objectives of the actors involved. A particular example of the determination of network structure by airlines attempting to achieve their market share objective is the trend in the liberalised US airline industry to form hub and spoke networks based on one or more 'fortress hubs'. The fortress allows the carrier a local monopoly and the opportunity to raise local fares in order to compensate for lower yield per mile for transfers across the hub. It is difficult to enforce anti-trust laws in these situations. The economic and level of service advantages of hubbing were apparent in the 1930s, in long haul with Imperial Airways operating a mail hub at Alexandria and in short haul with proposals for a hub (Maybury) near Manchester (Frater, 1987). Post-war, BOAC operated a mini-hub at Prestwick. In theory, the airline
obtains economies of scale with larger aircraft and better utilisation; the passenger gains with better frequency, more destinations and lower fares. The technology has to be reliable and the system cannot afford congestion, hence airlines will open new 'by-pass' hubs when congestion looms. The role of major based airlines in the shaping of facility requirements and route structures is often underestimated, if not completely ignored. An attempt is made to examine the bases of airline behaviour in Chapter 5, and to predict some of the consequences in Chapter 10.

Very few airport plans are embedded in plans for other sectors of the economy. On the other hand, airports have been developed with the express role of avoiding constraints on economic development or because of pressure from local and powerful politicians. The level of understanding of the relationships between airports and these other factors is usually too low to allow more formal integration.

Most airport systems seem to have evolved with no firm objectives other than to provide capacity to match revealed demand. Some have simple concepts of access to a network (eg USA). The only plans which explicitly use the concept of time-space accessibility appear to be those of Norway and Japan. Objectives other than accessibility are seldom treated on a basis of quantified criteria. Factors like safety and reliability are usually only treated in a reactive way.

There is often an undue emphasis on demand forecasting, based on revealed demand. Some attention is paid to changes in aircraft and technology, operating practices, the regulatory setting and macro changes in national and international socio-economy as they might affect demand, but the forecasting of these factors is rudimentary and their interactive effects are usually ignored. These deficiencies frequently prevent the plans from being implemented, if they have not already been disrupted by environmental concern, by tactical or operational difficulties, political differences at national and local level or by financial problems.

Monitoring of all these external as well as internal factors
is essential for successful plan modification. It can only occur if suitable performance indicators can be devised which relate meaningfully to the criteria used to plan the system. The indicators should be designed to monitor the efficiency, i.e., some measure of input divided by output, the effectiveness, i.e., achievement of objectives and the economy, i.e., a comparison of input costs with expectations (UK Treasury, 1987) of the system. Other than some budgetary control, the only continuous monitoring actually taking place appears to be on the delay criteria which should trigger new investment in the US. The UK CAA have recently started to monitor delays.

The problems noted above have resulted in imperfect infrastructure provision, even in the relatively calm and predictable setting of a regulated industry.

It is said that "the good system scientist or philosopher is both reductionist and holist" (M'Pherson, 1974). In other words, only examining the elements of a system risks losing important information about the higher levels of complexity associated with the linkages and a system's self-adaptive capabilities, while a purely holistic analysis risks a wrong understanding of the capabilities of the parts. Therefore, the thesis proceeds by examining the system actors individually, and also the organisational setting within which they must operate and plan their activities. Chapter 3 considers the implications of liberalisation in Europe. The chapters in Part 2 explore the options of the major actors in the system and the tools available for predicting their behaviour before returning to give a more formal critique of systemic planning in Chapter 9.
CHAPTER 3: EFFECTS OF EUROPEAN LIBERALISATION

THE DEVELOPMENT OF ECONOMIC LIBERALISATION

The world of aviation regulation has come a long way since the Edwards Committee (Edwards 1969) took the view that scheduled air services should be regulated in the 'public interest'. Within a decade, the US had deregulated first its air freight and then its domestic passenger aviation, and was crusading for a similar philosophy to be applied in international air transport: it signed a liberal bi-lateral Air Service Agreement (ASA) with the Netherlands in March 1978, followed rapidly by 22 others (Dresner and Trethaway, 1992). The fall of regulation seems to be as inevitable as its rise, both trends being logical in their own era.

Regulation of US domestic service was prompted in the 1920s by concerns for safety, lack of funds for infrastructure, poor financial viability of carriers and no means of providing them with subsidy (Wolfe and NewMyer, 1985). The deregulation movement had its origins in the feeling that air transport had developed to the point where its anti-trust immunity was no longer justified. The cost of retaining the protection of carriers' routes and capacity began to seem too high relative to the benefits to inter-state commerce which flowed from guaranteed service under the public convenience and necessity licences granted to the trunk and local carriers. Less regulated intra-state and commuter carriers were seen to offer lower fares without compromising service standards or safety. Fears were expressed over the ability to transfer the results of intra-state carriers to the inter-state market, the development of an oligopoly situation, the lack of security for the traditional revenue bond method of airport financing, the loss of service to small communities and hence of feed traffic to the trunk carriers (Taneja, 1976). Despite these fears, and those of most of the carriers that their level of service would fall as they responded to competition, control was progressively relaxed in the latter half of the 1970s, starting with cargo services. The Civil Aeronautics Board, as the regulating authority, had to phase itself out, hand over its residual
responsibilities, and declare its own ‘sunset’ in 1984. Support actually came from some airlines, who could see that they could adopt more efficient route structures. The hub concept allowed passenger and cargo carriers to retain feed and protect themselves from local competition: this is examined in more depth in Chapter 5, where the evidence for changes in fares, levels of service and market concentration is presented. Here, it is sufficient to note that an oligopoly certainly has developed, giving serious barriers to entry. Even so, airline finances have not improved, strain has been thrown on system capacity at those main hubbing points which have constraints on development, airport traffic levels have become more volatile, and the evidence of benefit to the users is sufficiently conflicting that the only conclusion which can be drawn is that there have been winners and losers. Some communities have gained service, others have lost it. Some passengers pay higher prices, others pay less. Some airlines have gone into bankruptcy (either permanently or into Chapter 11); others have prospered, some relatively, others in an absolute sense.

In the international arena, there is some evidence, from a sophisticated paired comparison of liberal and regulated routes, with assumptions of Bertrand (profit-maximising) behaviour on the former and collusive behaviour on the latter, that although normal economy fares were not affected, discounted fares fell by 35% after the liberal US bilaterals were signed (Dresner and Trethaway, 1992). It is not, however, clear if this resulted in corresponding traffic growth.

Many other countries have since taken the same path with their domestic transport, including Australia and Chile. Internationally there has been less movement. However, the EC has been preparing for the 1993 single market by encouraging the breakdown of the economic regulation in intra-EEC air transport since their 1979 report, “Air Transport: a Community approach”. That approach has been to begin with the relatively uncontroversial area of inter-regional air services using non-Category 1 airports (EEC, 1983b) and then gradually relax the controls on route entry,
capacity and fares (Barrett, 1991), culminating in the adoption in June 1992 of the 'third package' to be implemented on 1 January 1993 (van Hasselt, 1992). Within the first two months of 1993, 14 services were started or announced which relied on the new freedoms, either of cabotage or fifth freedom (Avmark, 1993). There are some waivers on the immediate implementation of the third package, and clauses which allow national government control over access to scarce capacity. There is also uncertainty, as there was in the US, as to the way which the residual regulation is to be effected, ie monopoly abuse, anti-competitive practices, market access, non-EC relations. It should be noted that a majority of European passenger km, namely those on charter airlines, have always enjoyed de facto deregulation; there will no longer be a distinction between scheduled and charter airlines. There are similarities with the US process of deregulation in the experiments with sections of the industry, notably the cargo services which from February 1991 were allowed to set their own rates and to operate unlimited third, fourth and fifth freedom services within the Community. It is also of interest that the primary consumer pressure came from comparisons of scheduled fares with those of European charters and US domestic carriers, both comparisons being hard to justify, particularly with regard to the quality/price relationship.

It is clear that the potential response of the industry to liberalisation and its residual regulation must be understood if the preferred role of individual airports in Europe is to be inferred. The structural changes which might occur in the industry are examined in Chapter 5. This chapter analyses the direct European evidence which can be derived from the UK experience as one of the nations who have acted as champions for airline competition.

The UK has been allowing competition on domestic trunk routes for a long time, though only since 1982 has the main carrier been subject to head-to-head competition on these routes from London Heathrow. Although there was an initial increase in the traffic of perhaps 7% in the first year of competition on
the routes to Glasgow, Edinburgh and Belfast (LAE, 1984), in the following years the growth was lower (by perhaps 5%) than 'control' routes with little or no competition (Poole, 1986). The stimulus for the initial growth may well have been the greater capacity, leading to lower spill rates, i.e. turning away of passengers and to the greater use of yield management techniques. Further, once the situation had settled down, there was little evidence that published fares had fallen relative to the 'control' routes: this holds for discounted as well as full economy fares. The main effect of 'competition' appears to have been that the ratio of Air Transport Movements (ATM) to passengers has increased much more quickly than on the control routes. Other analysis, using UK - Europe scheduled traffic as the control, shows even less conclusive evidence of either temporary or lasting effects on traffic or fares from competition on domestic trunk routes (CAA, 1987).

Attempts by the UK Civil Aviation Authority (CAA) to open up the thinner domestic routes to competition have been aborted because of industry protests that open route access would have allowed the major airlines to challenge for traffic on cross-country routes, while the small carriers would have no compensating rights to the thick routes because of the ban on new airlines at Heathrow. Thus competition on the thick routes has, by stimulating extra ATM at Heathrow, helped to deny competition on thinner routes without apparently producing major benefits for consumers. It could be argued that there have been significant second-order benefits: the choice of airline per se; increased frequency; improvements in cabin service and airport lounges; punctuality (though this has been affected for all airlines by Air Traffic Control capacity problems). However, unless these benefits can be seen to have stimulated extra use of the services, they must have accrued as consumer surplus, particularly since there has been relatively static competition from rail during the period under investigation.

The UK has taken a lead in European bilaterals similar to that taken by the US, though without the same threat of action in the domestic courts for those who refused to
conform: the US forced a two-tier version of IATA into being with its insistence that foreign carriers "show cause" why their collusion on fares to/from the US should not conform to antitrust legislation.

An examination of the history of the newly liberalised routes between the UK and the continent of Europe from the above points of view is undertaken here, in the hopes of establishing the value of competition for the consumer as well as providing a basis for estimating the impacts of further EEC-induced liberalisation on traffic and route structures.

The ethos of competition is that industry will become more efficient and further, that it will pass the benefits of that efficiency on to the consumer at least to the same degree that they accrue to the industry's shareholders. The indicators of the beneficial impact of competition of the consumer would be:

- increase in use of the service as increased efficiency causes the 'price' to fall and release new demand (assuming the traditional demand/supply relationship)

- reductions in fares relative to less-competitive markets, assuming that the carriers judge that the consumers are interested to some extent in price per se rather than only in improved quality of service

- improvements in quality of service

- more choice of airline and of routes: one of the main freedoms sought by the industry and by the consumer is the right to operate new routes.

THE LIBERAL AIR SERVICE AGREEMENTS (ASA)

A summary of the agreements is given in Table 3.1. There were many points of detail in the ASAs which are not pertinent to the present study and are therefore not noted. It can be seen that the liberal agreements mostly extended
the route access provisions of the EEC's Regional Air Service Directive to give all resident airlines access to all routes. The main difficulty here is that, as with the UK domestic routes, access to the most desirable points is in practice denied by the lack of availability of runway slots at the busy periods of the day. Multiple designation access is also sometimes denied temporarily on these routes where prior protection had been offered to the entrepreneurial airline. The EEC directive itself had already been responsible for 10 new services which would not otherwise have been able to start, despite the many restrictions embodied in the Directive (EC, 1986). The 1987 Directive applicable to all EEC airlines and all routes (EC 1987), embodied the objective of multiple designation on all routes by 1993, with an initial validity on routes with more than 250,000 passengers per year.

The liberal agreements allowed complete freedom in sharing capacity on a route, whereas most old type bilaterals required 50/50 sharing. The EEC 1987 Directive again proposed a gradual transition to complete freedom in 1993.

On tariffs, the UK negotiators made less progress than in the other areas. The most liberal agreements allowed fares in all classes to be proposed by the operators; they were to be applied subject only to disapproval by both the relevant governments. In the least liberal bilaterals (Italy, France), all fares still needed positive approval, while the more moderately liberal agreements (Germany, and later the EEC) only allowed double disapproval of discount fares and also limited the depth of the discounts.

By 1989 there was a substantial history of the after-effects of all these ASAs which range from the most liberal possible to the continuation of the old style of protectionist bilateral. It should therefore be possible to derive the effects of liberalisation from comparative analysis, rather than relying solely on time series analysis. The latter is inevitably subject to the criticism of there being no counter-factual state. The comparative analysis may also be challenged on the basis of not comparing 'like with like', but is judged to be the lesser of two evils.
<table>
<thead>
<tr>
<th>Country</th>
<th>Date</th>
<th>Route access</th>
<th>Capacity</th>
<th>Tariffs</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Netherlands</td>
<td>June 1984</td>
<td>Open on all routes to all resident airlines</td>
<td>Airlines decide for themselves</td>
<td>Originating country to approve, other airlines can match</td>
<td>DTP Press notice No. 281, 1984 Double disapproval of fares, May 1985</td>
</tr>
<tr>
<td>Germany</td>
<td>Dec. 1984</td>
<td>Ditto</td>
<td>Ditto</td>
<td>Ditto, but for discounts only</td>
<td>DTP Press Notice No. 564, 1984 Discounts limited to 33%</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>March 1985</td>
<td>Ditto</td>
<td>Ditto</td>
<td>Double disapproval</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>Sept. 1985</td>
<td>Ditto</td>
<td>Neither country to exceed 55% of London-Paris seats</td>
<td>Approval still needed for all tariffs</td>
<td>DTP Press Notice No. 399, 1985 Effective from Summer 1986</td>
</tr>
<tr>
<td>Switzerland</td>
<td>Dec. 1985</td>
<td>Ditto</td>
<td>As Netherlands</td>
<td>As Germany</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>March 1986</td>
<td>A few new route licences</td>
<td>No change</td>
<td>No change</td>
<td>DTP Press Notice No. 122, 1986</td>
</tr>
<tr>
<td>Ireland</td>
<td>April 1986</td>
<td>As Netherlands</td>
<td>As Netherlands</td>
<td>Double disapproval</td>
<td></td>
</tr>
<tr>
<td>EEC</td>
<td>Dec. 1987</td>
<td>Multiple designation on the thickest routes</td>
<td>Some inequality</td>
<td>Some promotional fares</td>
<td></td>
</tr>
</tbody>
</table>
Changes in Demand and Supply

The growth in monthly traffic between the UK and a selection of the EEC countries (and also the traffic between London and the major continental cities) is shown in Figure 3.1 relative to the traffic in January 1980. This time span allows a preliberalisation state to stabilize and also gives several years after the ASAs for the situation to develop. The data throughout the study are taken from CAA monthly statistics and the ABC World Airways Guide. Full information on the responses of operators to regulatory opportunities on the routes are chronicled elsewhere (Caves and Higgins, 1991). Table 3.2 summarises the frequency of daily return flights on the main scheduled routes at the beginning and end of the period studied, while Table 3.3 gives the annual growth rates of traffic for the countries as well as for the main city pairs.

Taking those countries with the most liberal ASAs first, the main link with the Netherlands in 1980 was Amsterdam/London. This was already unusually liberal, in that the independent airline BCAL was allowed to compete with BA, though from Gatwick. Since then, Amsterdam has had a variety of new services, both from Heathrow and also from all the other airports serving London, at least some of which have entered the market with low openly available fares. Despite these changes the traffic growth between the UK and the Netherlands has been substantially less than that to Luxembourg and Ireland, though on a par with Belgium. The growth in traffic to Luxembourg has been achieved with no new entrants. The high growth on the route had been established during 1983, well prior to the liberal ASA.

The history of the Irish route operations is similar superficially to the Netherlands route, with a proliferation of services to most of the London airports. However, there were profound differences in market characteristics which resulted in extraordinary decisions by the airlines. The strong growth started at the same time as the ASA, though it may well have been precipitated by the 1983 Directive. It is particularly significant that the initiative broke the trend...
FIGURE 3.1: FARES AND TRAFFIC GROWTH, ON A BASE OF JANUARY 1980

A Netherlands

B Ireland
C  West Germany

D  France
TABLE 3.2: CHANGES IN DAILY RETURN FLIGHTS

<table>
<thead>
<tr>
<th>Route</th>
<th>1980 Flights</th>
<th>1980 Flights per carrier</th>
<th>1989 Flights</th>
<th>1989 Flights per carrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amsterdam¹</td>
<td>16</td>
<td>5.3</td>
<td>40</td>
<td>5.7</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>2</td>
<td>1.0</td>
<td>3</td>
<td>1.5</td>
</tr>
<tr>
<td>Dublin</td>
<td>15</td>
<td>5.0</td>
<td>36</td>
<td>7.2</td>
</tr>
<tr>
<td>Brussels</td>
<td>12</td>
<td>6.0</td>
<td>23</td>
<td>5.8</td>
</tr>
<tr>
<td>Frankfurt²</td>
<td>7</td>
<td>3.5</td>
<td>15</td>
<td>5.0</td>
</tr>
<tr>
<td>Paris</td>
<td>12</td>
<td>6.0</td>
<td>27</td>
<td>9.0</td>
</tr>
<tr>
<td>Rome²</td>
<td>8</td>
<td>2.7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NB 1 Excluding London City
    2 Excluding substantial fifth freedom services.
of several years of negative growth - which perhaps reflected BA's apparent lack of interest in the route. There appear to have been two major differences which succeeded in stimulating growth. Ryanair's high frequency, low fare jet competition, even though operating at Luton, together with Aer Lingus's decision to enter a fare war, were both initiatives unique to the Dublin route. On the other hand, it does not appear that the extra choice provided by British Midland's entry caused much extra stimulation in 1989, any more than their entry increased the total Amsterdam traffic significantly in 1986. The CAA (CAA, 1990a) points out that the Irish route is a special case with few charters, strong ethnic links, a high proportion of price-sensitive repeat traffic, shortage of capacity at certain times and a substantial "but, by all accounts, ill-served" surface market. These factors go some way to explaining the large stimulation in traffic, the small response to the British Midland entry and BA's subsequent decision to leave the route.

The Belgian route has achieved only a low growth rate. The traffic history of the route does not suggest any strong impact from the relatively low capacity or rather temporary market entries at Luton and Gatwick.

Of the countries with less liberal ASAs, Germany had the most liberal ASA, with even double disapproval of discount fares. France still maintained control of capacity shares, while Italy also retained control over route starts. The major German route is London - Frankfurt. Frankfurt is different from the liberal routes reviewed so far, not only because of the terms of the ASA but also the large number (17) of carriers with fifth freedom rights. Not all the rights are used, but in 1988 Pan Am flew 143,000 passengers compared with BA's 174,000. The response of new entrants has therefore been marginal, presumably because the fifth freedom carriers have been able to cater for the low fare market. When Dusseldorf is examined, in order to avoid the complications of Frankfurt's fifth freedom traffic, its traffic is seen to follow closely the total German pattern.
There is a striking similarity between the German and French route traffic growths and growth in frequency, despite the differences in their ASAs, their stage lengths and the near absence of fifth freedom rights into France. An OECD study purports to show that French traffic grew faster than Netherlands traffic before the ASAs and slower afterwards (Barrett, 1991a), but this is not borne out by Table 3.3.

Italy had very few relaxations in its ASA, yet the growth of traffic between it and the UK exceeds that for France or Germany as well as for Belgium and the Netherlands. Again BA and Alitalia matched each other's services and prices throughout the decade, with only competition from Air Europe in 1989. Again there has been significant fifth freedom traffic; eight airlines other than BA and Alitalia carried passengers in 1988.

The traffic growth of the three most protectionist EEC countries are shown in Table 3.3c, i.e. Greece, Spain and Portugal. The histories of Spanish and Portuguese scheduled traffic are almost tied together, with steady growth from 1984 giving a growth over the decade which is only surpassed by Luxembourg and Ireland. In winter months Greek traffic has not grown at all; on summer peaks, there is considerable variation from year to year but little overall growth. These countries can add little to any comparative analysis because the situation is clouded by the changing fashions for holiday destinations, by the much greater charter traffic, by the use of inclusive tour packages on scheduled flights and by the increase in direct charters to Greek islands diluting the scheduled traffic through Athens.

The data on a final group of countries is shown in Table 3.3d. These are the non EEC Austria and Norway, together with Denmark which is a special EEC case because of its joint ownership of SAS. The fares per mile to Scandinavia have always been high. The growth is correspondingly very slow and even. The end result, however, is that even their growth over the decade matches that of Belgium and the Netherlands i.e. those with the most liberal ASAs on the mainland, though admittedly with more powerful ground competition because of
### TABLE 3.3: ANNUAL AVERAGE GROWTH RATES, PER CENT

<table>
<thead>
<tr>
<th></th>
<th>(1) 1980-89</th>
<th>(2) 1980-84</th>
<th>(3) 1987-89</th>
<th>(4) (3)-(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a) Most liberal EEC countries</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td>6.7</td>
<td>1.0</td>
<td>7.5</td>
<td>6.5</td>
</tr>
<tr>
<td>Ireland</td>
<td>9.5</td>
<td>-2.7</td>
<td>22.7</td>
<td>25.4</td>
</tr>
<tr>
<td>Belgium</td>
<td>6.6</td>
<td>1.5</td>
<td>8.8</td>
<td>7.3</td>
</tr>
<tr>
<td>Luxembourg(1)</td>
<td>11.6</td>
<td>5.3</td>
<td>4.5</td>
<td>-0.8</td>
</tr>
<tr>
<td><strong>b) Less liberal EEC countries</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>7.6</td>
<td>1.4</td>
<td>8.6</td>
<td>7.2</td>
</tr>
<tr>
<td>France</td>
<td>5.6</td>
<td>1.0</td>
<td>16.7</td>
<td>15.7</td>
</tr>
<tr>
<td>Italy</td>
<td>6.8</td>
<td>0.1</td>
<td>13.6</td>
<td>13.5</td>
</tr>
<tr>
<td><strong>c) Non-liberal EEC countries</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greece</td>
<td>2.4</td>
<td>1.5</td>
<td>8.5</td>
<td>7.0</td>
</tr>
<tr>
<td>Portugal</td>
<td>8.4</td>
<td>0.0</td>
<td>14.9</td>
<td>14.9</td>
</tr>
<tr>
<td>Spain</td>
<td>9.0</td>
<td>2.2</td>
<td>14.9</td>
<td>13.7</td>
</tr>
<tr>
<td><strong>d) Non EEC countries</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Austria</td>
<td>8.4</td>
<td>4.4</td>
<td>7.8</td>
<td>3.4</td>
</tr>
<tr>
<td>Denmark(2)</td>
<td>5.1</td>
<td>2.9</td>
<td>8.8</td>
<td>5.9</td>
</tr>
<tr>
<td>Norway</td>
<td>6.0</td>
<td>5.4</td>
<td>6.1</td>
<td>0.7</td>
</tr>
<tr>
<td><strong>e) Major cities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amsterdam</td>
<td>7.8</td>
<td>3.8</td>
<td>8.3</td>
<td>4.5</td>
</tr>
<tr>
<td>Dublin</td>
<td>7.5</td>
<td>-0.1</td>
<td>23.4</td>
<td>23.5</td>
</tr>
<tr>
<td>Brussels</td>
<td>6.3</td>
<td>3.1</td>
<td>10.5</td>
<td>7.4</td>
</tr>
<tr>
<td>Dusseldorf</td>
<td>4.6</td>
<td>1.2</td>
<td>11.1</td>
<td>9.9</td>
</tr>
<tr>
<td>Paris</td>
<td>4.5</td>
<td>1.8</td>
<td>17.2</td>
<td>15.4</td>
</tr>
<tr>
<td>Rome</td>
<td>4.6</td>
<td>0.1</td>
<td>19.8</td>
<td>19.7</td>
</tr>
</tbody>
</table>

(1) Luxembourg's greatest growth came during the regulatory changes.

(2) See text on Denmark.
their proximity to the UK. Austria is very unusual. Not only has its traffic been growing since 1980, but its particularly high summer growth gives it an overall growth for the decade equal to the best of the others, despite having no special ASA and no EEC Directive status.

Clearly the comparative interpretation of the holiday-oriented destinations is too fraught with difficulties to be valuable. The remainder of the analysis concerns itself only with those countries and cities within the EEC with reasonably common characteristics.

Inspection of Table 3.3 shows that over the decade there does appear to have been a small extra growth in the traffic to the more liberal countries, if the high growth of the non-liberal main holiday destinations is taken to be influenced by the liberal charter setting. The most recent history, ie 1987-1989, only bears this out for the comparison between the less liberal EEC countries and the non-EEC countries; it certainly is not the case when comparing the most liberal with the less liberal EEC countries. When the relative changes between the early static state at the beginning of the decade and the most recent history is examined in the final column of Table 3.3, both these effects become more pronounced, ie the non-EEC (and least liberal) countries have had the least improvement in growth rate, but the less liberal EEC countries have increased their growth more than those which negotiated the most liberal ASAs with the exception of Ireland, whose unique characteristics have already been noted.

The overall growth rates over the decade to the major cities also do not vary a great deal, but the most liberal routes do show perhaps 2.5% to 3.0% greater annual growth. However, the difference in growth rate over time, between the stable pre-liberalisation period and the period of rapid growth shared by most routes after 1986, shows an inverse correlation with the increase of liberalisation. The exception proving the rule is again Dublin. In all cases, the result is due to the predominance of the growth in the final three years of the decade: the ranking of the routes by
growth rate is the same for that period as it is for the difference between it and the earlier period.

Clearly an analysis which concentrates solely on output is not only missing many of the supposed advantages of liberalisation, but is probably failing to compare like with like. Some attempt is now made to cover these omissions.

FARES

Some of the difficulties in carrying the analysis any deeper immediately become apparent when fares are considered. It is not possible to know the extent to which airlines may have taken the opportunity given by the ASAs to compete on discount fares. Yields are not reported, and there is no evidence as to whether one seat or half a plane-load were offered for sale in any of the multitudinous fare categories quoted in the ABC World Airways Guide.

None-the-less, fare reductions in real terms are expected to be one form of benefit from liberalisation. The lowest available non-restricted fare is therefore taken as an indicator of the airlines' desire to compete on price. Only airlines on routes to the Benelux countries and Ireland could compete on these non-discounted fares without double approval. The history of these fares is given in Figure 3.1 for the trunk routes. Since it might be expected that response of traffic to fare changes would be almost simultaneous, a detailed monthly analysis was carried out. The seasonal trend for each route was averaged over the 10 years, then each year's monthly traffic was compared with the average. In the case of the Netherlands, there was a substantial fall in fares some 2 years after the ASA, due to the start of services to Maastricht by Virgin. The large effect on that local traffic tends to explain the relationship between total growth to the Netherlands and growth on London/Amsterdam. The service was short-lived. The British Midland competitive entry in 1986 does appear to have stimulated some extra demand in a one-off sense, though the only strong effect shown in a detailed monthly analysis was growth from March 1985, nearly a year after the ASA and
with no significant fare change. The steady growth seems not to have been affected by the return to more normal fare levels: probably the London European Airlines capacity out of Luton was not very significant.

The earlier Irish no-growth situation appears to have been transformed by the reduction of fares, that reduction and the traffic growth coinciding with the ASA to the nearest month. The high growth in a very seasonal market continued through 1989, despite some recovery in fares. The earlier fare rises were steeper than to the Netherlands, the later history being quite similar.

Prior to the ASA, fares to Dusseldorf rose at the same pace as those to the Netherlands. The small and short term reduction in fare at the time of the ASA did not appear to affect the traffic, even on a monthly analysis. The traffic continued to grow, despite continued small fare rises. The overall growth in fares from 1980 to 1989 is substantially higher than on the more liberalised routes. This may have more to do with rates of exchange than with a protectionist policy, the fare being indicated in current pound sterling.

The French case is clouded by what appears to be an abnormally low fare in 1980. If this is ignored, the fare growth over the decade rose steadily by 60%, rather similar to the German case. There is no discernable effect of fare changes on traffic, other than the small temporary one just prior to the ASA. Unlike the German ASA, no freedom was given to the airlines to set even their own discount fares. In both cases, the temporary fare reduction near the time of the ASA must have been approved through the normal negotiating process.

The Italian fare growth is again similar in character to the German and French cases, until the substantial fall in 1988, the latter taking place despite continued regulation. Apart from some stimulation of summer traffic, probably associated with inclusive tours, there was almost no growth in traffic until the ASA. It is difficult to understand how the small changes to the ASA (BCal being allowed to fly Gatwick/Milan,
BA to fly Manchester/Milan-Rome etc) would cause substantial new growth. However, fares in pounds sterling were held almost constant for some five years. The fare reduction associated with the Air Europe entry on Gatwick/Rome does seem to have produced substantial traffic growth from September 1989. There is a similar amount of traffic growth from September 1988 following the previous fall in fare, even though it was only returning to the levels of six months earlier.

Even though it is necessary to assume that the quoted fares were actually available, it is interesting to compare the fare behaviour. Table 3.4 shows that, over the decade, there is no clear relationship between fare movements and the degree of liberalisation, any more than the above examination of the detailed histories has detected much apparent time-dependent relationship between the signing of ASAs and the fares charged. It may, of course, be that the picture is distorted by previous anomalies in fare levels being repaired. Allowing for a natural reduction of fare per mile as the stage length increases, the only obvious anomaly in the relatively regulated atmosphere of 1980 was the cheapness of the fare to Dublin. Paris had been much cheaper in 1980, but the 1981 fare has been used in Table 3.4. By 1989, the Frankfurt fare (in pounds sterling) had become relatively expensive, the Dublin fare less cheap and the Rome fare relatively cheap. Thus the Dublin anomaly had been partially corrected. The percentage increase would otherwise have been lower, suggesting that, compared with Paris, the very short haul route fares have been held down by the competition fostered by liberal ASAs. On the longer routes, however, Rome seems recently to have offered good value without this aid. Even the Frankfurt fare growth is substantially less than the 92% rise in the UK Retail Price Index.

Fares on liberalised routes may have been lower, but their availability is called into question by the limited effect they appear to have had on traffic. This impression, gained previously from a visual examination of Figure 3.1, is confirmed by the results of a regression analysis given in Table 3.5. A high correlation would not be expected: the
TABLE 3.4: CHANGES IN LOWEST UNRESTRICTED FARE PER MILE
(current pence)

<table>
<thead>
<tr>
<th>Miles</th>
<th>Pence per mile</th>
<th>% increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amsterdam</td>
<td>217</td>
<td>28</td>
</tr>
<tr>
<td>Paris*</td>
<td>220</td>
<td>25*</td>
</tr>
<tr>
<td>Dublin</td>
<td>288</td>
<td>17</td>
</tr>
<tr>
<td>Frankfurt</td>
<td>396</td>
<td>20</td>
</tr>
<tr>
<td>Rome</td>
<td>898</td>
<td>17</td>
</tr>
</tbody>
</table>

* 1981

NB UK Retail Price Index grew 92%, 1980-1989

sensitivity of the analysis is increased by an order of magnitude over normal regressions of traffic on fares by regressing annual growth rates. Even so, the fit is very poor. Note that Dublin in 1989 suffered a fare increase of 40% but traffic grew by 20%; also the Paris 1981 fare increased 50% with 5% traffic growth.

What evidence there is suggests that the fare elasticities were only -0.2, assuming other variables had no effect, except for the most protected route. This might have meant that there was a greater latent demand on the more protected routes, if the statistical fit had been better. As it is, it is clear that the traffic growth has been dominated by factors other than fares. This is so, even though unrestricted fares have tended to grow more slowly in liberalised markets and though restricted discounted fares have become cheaper: discounts relative to lowest unrestricted fares increased from 15% in 1983 to 50% in 1988 to Amsterdam; the corresponding figures for Frankfurt were 4% to 21%. 
TABLE 3.5: RELATIONSHIP BETWEEN TRAFFIC AND FARES

<table>
<thead>
<tr>
<th>Location</th>
<th>m</th>
<th>n</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amsterdam</td>
<td>-0.20</td>
<td>7.94</td>
<td>0.22</td>
</tr>
<tr>
<td>Dublin</td>
<td>-0.13</td>
<td>8.78</td>
<td>0.05</td>
</tr>
<tr>
<td>Dusseldorf</td>
<td>-0.30</td>
<td>6.19</td>
<td>0.11</td>
</tr>
<tr>
<td>Paris</td>
<td>-0.15</td>
<td>7.64</td>
<td>0.06</td>
</tr>
<tr>
<td>Rome</td>
<td>-0.57</td>
<td>7.66</td>
<td>0.30</td>
</tr>
</tbody>
</table>

where m and n are constants defined by \( y = mx + n \)
where \( y = \% \) annual growth of passengers
\( x = \% \) annual growth of fares

INCOME

Following the normal econometric approach to demand prediction (eg DTP, 1991a) the other most likely determinant of traffic should be income. The UK government, among others, uses trade as the appropriate indicator, at least for business travel.

The peaks and troughs of trade growth almost always coincide with those of passenger growth, while fare growth shows no obvious relationship with the other two variables. Further, there is a strong similarity in the shapes of all the trade curves over time. The data are dominated by a deep reduction in trade in 1986. The patterns over the decade for all routes of both trade and passengers are generally similar. This strong similarity in the pattern of traffic growth over time suggests again that there is a much stronger determinant than liberalisation working in the market. The similarly common pattern of trade growth over time suggests that this might be the determinant. However, there was little passenger growth when trade growth was strong at the
beginning of the decade whereas there was strong passenger
growth when trade was again strong at the end of the decade.
It is therefore not surprising that multiple regression of
traffic growth against trade growth and fare growth, shown in
Table 3.6 is not very successful, though, except for Dublin,
the fare elasticities become more normal. Comparison with
Table 3.5 shows that the addition of trade improves the
explanation relative to the use of only fares, particularly
on Amsterdam and Paris, but only on the former are the 't'
statistics satisfactory. At average values of the growth
rates, the constant is considerably more important than the
trade or fare contributions, suggesting a strong autonomous
growth independent of trade or fares; i.e. there remains a
strong latent demand on both the liberalised and restricted
routes. However, the constants' own 't' tests are only
positive on Amsterdam. There is certainly no clear
indication that trade has influenced traffic on liberalised
routes more than on the more protected routes.

**TABLE 3.6: RELATIONSHIP BETWEEN TRAFFIC, FARES AND TRADE**

<table>
<thead>
<tr>
<th></th>
<th>m</th>
<th>n</th>
<th>c</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amsterdam</td>
<td>-0.29(-2.57)</td>
<td>0.46(1.73)</td>
<td>7.06(2.88)</td>
<td>0.59</td>
</tr>
<tr>
<td>Dublin</td>
<td>-0.07(-0.28)</td>
<td>0.33(0.36)</td>
<td>6.85(0.68)</td>
<td>0.06</td>
</tr>
<tr>
<td>Dusseldorf</td>
<td>-0.44(-1.32)</td>
<td>-0.11(-0.24)</td>
<td>9.84(1.31)</td>
<td>0.26</td>
</tr>
<tr>
<td>Paris</td>
<td>-0.72(-1.32)</td>
<td>0.37(0.89)</td>
<td>5.78(0.73)</td>
<td>0.39</td>
</tr>
<tr>
<td>Rome</td>
<td>-0.57(-1.63)</td>
<td>0.25(0.41)</td>
<td>5.25(0.57)</td>
<td>0.36</td>
</tr>
</tbody>
</table>

where m, n and c are constants defined by \( y = mx + nz + c \)
where \( y \) = % annual growth of passengers
\( x \) = % annual growth of fares
\( z \) = % annual growth of trade
( ) are 't' statistics
ANOMALIES IN PROPENSITY TO FLY

It is possible that anomalies existed in the absolute level of traffic on the routes prior to the ASAs, the correction of which through autonomous growth has influenced the traffic growth rates. This is difficult to analyse with any accuracy, because differences would be expected in propensity to fly to/from the UK, caused not only by influences which could be more easily quantified (eg the generalised cost of ground competition, ethnic links, supply characteristics) but also by more difficult factors like community of interest, racial characteristics or cultural tastes. The propensity to fly (ptf) between the UK and the other countries in the EEC per head of the country concerned is shown in Figure 3.2, as a function of GDP per capita and of population. It is clear that Ireland has a special relationship with the UK, but it is not possible to conclude that its traffic is closer to saturation than the other countries' traffic. The other countries with particularly high ptf are holiday destinations whose traffic is predominantly charter. Of the countries of interest to this analysis, the Netherlands has a relatively high ptf for its GDP per capita and population, perhaps indicating that its traffic is closer to saturation. If this is so, compared with France it would have needed a stronger stimulus to produce a similar growth rate. It did, indeed, have a greater stimulus from fares, but it also suffered from lower trade growth resulting in a much smaller change in growth rate after the ASAs were signed. If the same argument were applied to Denmark, also with a rather high ptf, it would imply that its relatively low growth rate of traffic, previously explained by a restrictive ASA, would also have to be interpreted as due to approaching saturation.

ROUTE ENTRY

Most of the ASAs, as well as the EEC 1983 Directive, give freedom to start new routes, only the Italians not allowing this freedom. The extent to which this has happened is shown in Table 3.7. In all cases except Belgium the number of cities served from London has increased to perhaps the
FIGURE 3.2: PASSENGERS TO AND FROM THE UK PER THOUSAND CAPITA OF THE FOREIGN COUNTRY IN 1986

A) Effect of GDP per capita

B) Effect of population
maximum for which there is viable traffic. The experience of Maastricht shows the potential overspill from some of the prime routes, but also the unstable nature of the marginal airlines and their traffic. Belgium's connectivity with London has actually declined, perhaps for this reason.

The UK regions are now served by a reasonable number of services from those countries with liberal route rights in their ASAs, again with the exception of Belgium - BA was hoping to change that anomaly with its planned Brussels/Sabena hub. Despite the liberal nature of its ASA in this respect, Germany has some way to go in serving the UK regions directly. Its main hub, Frankfurt, has almost no more links than in 1980, the growth coming mainly from Dusseldorf and Munich: clearly Berlin will soon augment this trend. In contrast, most of the services to UK regions from France come from Paris and Dutch ones from Amsterdam, their main hubs being less congested than Frankfurt. Only the Irish and French connections grew substantially soon after signing the ASA. It has been claimed that the UK/Irish bilateral stimulated the Irish services, where the EC Regional Services Directive failed because it limited services to aircraft with less than 70 seats into non-Category 1 airports and barred routes which competed indirectly with established routes (Barrett, 1991). Also, the deregulated charter carriers penetrated the UK regions more effectively than the scheduled carriers. It seems that, although the trunk carriers wish to protect their hubs and will not dilute their own traffic by starting regional services too early, the poor record of new entrants using regulatory freedom in this way may be due to the traffic not being there or, perhaps, to the equipment not being available. It may be that these routes can only reach their potential when 50 seat jet aircraft are introduced.

It was presumably hoped, by the bilateral and EEC policymakers, that the route entry freedoms would not only give the consumer the opportunity to fly direct from the regions, but that this would reduce the concentration of traffic at the hubs and relieve some of the congestion pressure. Table 3.8 shows this not to have happened, in the most liberal of
TABLE 3.7: CHANGES TO THE NETWORKS

<table>
<thead>
<tr>
<th></th>
<th>1980</th>
<th>1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Number of cities with scheduled links to London</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Ireland</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Belgium</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Germany</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>France</td>
<td>15</td>
<td>21</td>
</tr>
<tr>
<td>Italy</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>b) Number of routes to UK regions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Ireland</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>Belgium</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Germany</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>France</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>Italy</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

environments. Though the number of links has gone up considerably, the traffic has concentrated on the hubs. This is symptomatic of the known economies of density and the more hidden economies of scope (CAA, 1990a) which have lead to such a concentration of traffic in the US deregulated setting. With maximum regulatory freedom an airline can and will only operate if it can achieve economic viability and the passengers will only choose the alternative which will maximise their utilities.

Since the outcome of liberal ASAs has been to concentrate traffic more on London, the liberalisation presumably served to allow the carriers to make London more attractive, ie competition at London should have increased choice and lowered fares. Certainly the previous analysis has shown this to be the case with Ryanair on Luton/Dublin. Amsterdam/London also had only small increases in fares, though not necessarily lower than other less liberal routes
TABLE 3.8: CONCENTRATION OF TRAFFIC

<table>
<thead>
<tr>
<th></th>
<th>1980</th>
<th>1989</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a) UK - Netherlands</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i) % of UK traffic at Amsterdam to:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>London</td>
<td>64.5</td>
<td>68.6</td>
</tr>
<tr>
<td>Manchester</td>
<td>7.9</td>
<td>8.0</td>
</tr>
<tr>
<td>Birmingham</td>
<td>3.2</td>
<td>4.4</td>
</tr>
<tr>
<td>ii) % of Netherlands traffic at London to Amsterdam</td>
<td>83.9</td>
<td>87.9</td>
</tr>
<tr>
<td><strong>b) UK - Ireland</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i) % of UK traffic at Dublin to:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>London</td>
<td>64.4</td>
<td>70.2</td>
</tr>
<tr>
<td>Manchester</td>
<td>10.1</td>
<td>6.8</td>
</tr>
<tr>
<td>Birmingham</td>
<td>8.9</td>
<td>8.9</td>
</tr>
<tr>
<td>ii) % of Irish traffic at London to Dublin</td>
<td>75.9</td>
<td>72.3</td>
</tr>
</tbody>
</table>

from the point of view of tariffs. It might be expected that there should be a relationship between the number of airlines, shown in Table 3.9, taking up the route-entry freedoms and the fares charged. The table indicates that the number of airlines is now determined largely by the traffic density, allowing for fifth freedom carriers.

At least some of the economies of density must be diluted by the reduced density per carrier. The dilution would inevitably affect the airlines' ability to reduce fares. This is why British Midland only entered the market when guaranteed enough frequency to collect significant traffic. It is not surprising that any low fare new entrants only appear at the lower cost secondary airports. The table does, however, show that greater choice of airline product is now available on all the liberalised routes, even though with some joint ownership. There is also more choice of airport
within London, due much more to the congestion at Heathrow than to a deliberate search by the airlines for a new market within London.

**TABLE 3.9: NUMBER OF AIRLINES SERVING LONDON**

<table>
<thead>
<tr>
<th></th>
<th>1980</th>
<th>Traffic (millions)</th>
<th>Airlines 1990</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Airlines</td>
<td>1989</td>
<td>1990</td>
</tr>
<tr>
<td>Amsterdam</td>
<td>3</td>
<td>1.91</td>
<td>7(1)</td>
</tr>
<tr>
<td>Dublin</td>
<td>2</td>
<td>2.24</td>
<td>6</td>
</tr>
<tr>
<td>Brussels</td>
<td>2</td>
<td>0.99</td>
<td>4</td>
</tr>
<tr>
<td>Frankfurt</td>
<td>2</td>
<td>1.29</td>
<td>2(2)</td>
</tr>
<tr>
<td>Paris</td>
<td>2</td>
<td>3.36</td>
<td>7</td>
</tr>
<tr>
<td>Rome</td>
<td>2</td>
<td>0.63</td>
<td>3(3)</td>
</tr>
</tbody>
</table>

Note: (1) Only 3 are fully independent, Eurocity being associated with British Midland; KLM wholly own Netherline, and have 40% of Transavia and 15% of Air UK

(2) 17 other airlines have fifth freedom rights

(3) 8 other airlines have fifth freedom rights

**CONCLUSIONS**

Despite inevitable accusations of failing to compare like with like, the study does show that few of the positive effects of the liberalised ASAs which were expected by the policy makers had been achieved by 1989. Certainly more airlines have taken up the opportunity to serve the densest routes. Also more regional links have been established, though this has not necessarily resulted in a decreased concentration of traffic at the hubs. It is not possible to show that fares are relatively cheaper in liberalised markets. The comparative analysis between liberal and non
liberal routes is valuable here, because all fares have fallen relative to the Retail Price Index. Perhaps a lack of a similar 'control' case for comparison makes some of the positive conclusions from the US domestic experience misleading. Even a before and after study of deregulation, allowing for effects of fuel price changes and increased circuity of passenger routing, shows that real fares per trip have risen since 1978 in the US (Dempsey, 1990). The lack of positive fare effects agrees with a simple comparative study between 'liberal' and 'conservative' European and Asian countries' fares to the US (Feldman, 1988), and at least partly with a more sophisticated study (Dresner and Trethaway, 1992). A further study of appropriate methodologies for the analysis of the effects of deregulation reports similar conclusions (Dionne and Gagné, 1988).

The greatest disappointment is that, whatever extra choice has been generated by the UK's attempt at liberalisation in Europe and domestically, there is no clear evidence that the market has seen enough benefit in that choice to make extra use of it. The traffic, with the noticable exception of Ireland, has not categorically increased more rapidly on liberalised than conservative routes. Further, there do not appear to be extenuating circumstances to explain the relative lack of growth in terms of market saturation or weakness of the economy. This view is shared by later commentators (Lucking, 1993).

Undoubtedly there is a problem overhanging the whole analysis, in that Heathrow has been close to capacity throughout the decade. The first choice of those operators wishing to take up route freedoms has mostly been denied them. However, there is no evidence that, when the freedom has been exerted at Heathrow, it had resulted, up to 1989, in greater traffic growth than that generated from Gatwick or Luton (admittedly at lower fares). Meanwhile, the maintenance of frequency per airline at Heathrow in a more competitive situation only worsens the Heathrow capacity problem. It appears that a true test of competition could only be made if Heathrow had sufficient capacity to allow new low fare entrants.
The problem of airport capacity, compounded by based airline domination, is only one of the barriers to contestability in a liberalised market. The other problems are predatory pricing, ground handling monopolies, State aids, bias in Computer Reservation Systems (CRS), price collusion, anti-competitive mergers and thin route monopolies (Barrett, 1991; R.B. Associates, 1992; TRB, 1991). To these should be added the growing problem of route exit, in that runway slots are now so precious due to capacity problems that they have to be used or released. At least a previous barrier to entry under regulation is now not applicable, namely the need for the new applicant to disclose its plans to any incumbent objector, while not receiving reciprocal information (Beesley, 1986).

The EC regulators have many possibilities to minimise these barriers, all of which imply further interference, though perhaps not more so than with other industries. Rules are in place to control the use of CRS, predatory prices, State aids and anti-competitive mergers. In the latter case, even though the EC Competition Directorate could not interfere in the BA-Dan Air purchase because the price was below the threshold at which their interest could be triggered, many would argue that the Commission has so far been generous in allowing the Air France-UTA-Sabena and BA-British Caledonian mergers, just as the US Department of Transport was criticised for not applying the antitrust rules with sufficient rigour in its merger decisions (Dempsey, 1990). It is widely believed that some flag carriers have been allowed government support for restructuring just before liberalisation to a greater extent than intended in the rules governing national initiatives to protect their economies. Also, more could be done to control ground-handling monopolies, and there is criticism that the double disapproval of fares will not easily prevent collusion to raise prices. Thin route monopolies can only be prevented by indirect competition, which is likely to happen under airline route restructuring (see Chapter 5).

The really difficult problem is access to congested airports where the greatest competition would naturally occur. The EC has ruled that coordination of schedules should be done by an
independent body to help ensure transparency, neutrality, non-discrimination and increased competition (EC, 1993). Unused slots are to be put into a pool, 50% of which shall be reserved for new entrants. The EC legislation is incorporated in UK law from 1 April 1993, including the Member State's right to reserve slots at fully coordinated airports for domestic routes to peripheral or developing regions under certain conditions. The CAA has stated that it does not intend to use this option, considering that there is no aviation-based reason for regulatory interference and that wider issues are the responsibility of government (CAA, 1993). The US system of bidding for slots is economically efficient (Hardaway, 1986) but requires this sort of 'ring fencing' to ensure continued access for smaller aircraft on short haul routes. The EC view is that paying for slots will increase the cost of air travel (Reed, 1992), but it seems inevitable that the industry will manage to put some implicit value on these slots, and to attempt to influence their distribution. British Midland have used their slots at Heathrow to expand profitable routes at the expense of less profitable ones, BA appear to have offered to help Virgin with their Heathrow slots in exchange for settling the 'dirty tricks' dispute, and United Airlines has only agreed to pay $14.5 million for US Air's Philadelphia-Gatwick route if the government agree to transfer the route authority to Chicago-Heathrow.

There is no doubt that the shortage of capacity at the most popular airports will have profound implications for the way in which the airline industry restructures itself. The regulators' attitude will influence that restructuring both directly through control of mergers and indirectly by their decisions on how, on the one hand to manage the expansion of capacity and, on the other hand, to manage the allocation of slots. An important issue, if slots were to be sold, would be the extent to which the revenue could be earmarked for expansion of the congested airport, or, if that airport were too tightly constrained, how the revenue could be transferred to an alternative airport. The latter option would not currently be available between Heathrow and Stansted, with the Monopolies and Mergers Commission hinting at greater
competition rather than cross-subsidy.

Meanwhile, many regional routes into Heathrow have been discontinued, and the size of the BA stake in Brymon European may be the deciding factor in the continuance of the Plymouth route or BA’s use of the slots on a more profitable route. This demonstrates some of the implications of route liberalisation, of the interrelationships between merger policy and services, and also of the interrelationships between access at congested airports and the future of spoke airports and regional development policy. The aim of the chapters in Part II is to examine in depth the characteristics of the individual actors within the air transport system and of the planning system within which they operate. Part III concentrates on the interrelationships and how an understanding of them can aid the process of planning a coherent system in a turbulent liberalised environment.
PART II

Understanding
the system elements
and processes
CHAPTER 4: DEMANDS FROM PASSENGERS

INTRODUCTION

User behaviour should become the paramount influence on the air transport system in a free-market setting. In theory, competition should mean that success can only be achieved by satisfying the customer. The airlines' customers are their passengers and their shippers. Most decisions on the operation of a route are taken on the basis of expected passenger flows, even though capacity decisions will be influenced by freight contributions. Attention is therefore given here only to the passenger behaviour on a route-by-route basis. It is on each route, rather than globally, that most competition for passengers occurs, and it is argued in Chapter 2 that specific destinations are important in satisfying passenger needs.

The traffic on a route sector will consist of local (origin-destination, or O/D) and connecting passengers. The connecting passengers may be originating, terminating or connecting at both ends of the sector. The four categories are illustrated in Figure 4.1. The size of the potential local demand will depend on the trip generation at the origin and the attraction of the destination, both generation and attraction being a combination of the size of the traffic base and the trips per unit of the traffic base. It is usual to refer, in passenger terms, to some measure of the population as the traffic base and the propensity to fly (ptf) per capita of that population. The total potential traffic will consist of passengers generated at A for B, and also passengers returning from being attracted to A from B.

The potential local demand is that which desires to travel between A and B. Not all of this potential traffic will appear on the sector. Some people will find the travel opportunities on the sector inadequate to meet their needs, ie to give them a low enough travel time or cost budget for their perceived disutility of travel to be less than the utility they would gain from the activity at the trip end. Some of these people will find that they can achieve a net
FIGURE 4.1: CATEGORIES OF DEMAND FROM AIRPORT A TO AIRPORT B
utility gain by travelling indirectly between A and B via, say C, or by an alternative mode. Of those who do travel from A to B, some will only just gain net utility, while others will gain some consumer surplus, i.e., they value the utility of the resulting activity sufficiently to gain substantial net utility from the trip. Those trips already being made between A and destinations on the network, either directly or indirectly, are said to be the revealed demand. Those trips which are desired but not made to destinations on the available network are said to constitute latent demand, while those which might be stimulated by additional network connectivity are said to be induced demand. If B were a destination newly served from A, the local traffic would be some combination of redirected revealed, released latent and newly induced demand.

DEMAND GENERATION MODELLING

Choice of models

The generation at or behind point A can be simply counted if one is fortunate enough to have access to survey information on the traffic through A. Otherwise, it is necessary to predict the trips generated by some new development, or for the future, by some appropriate combination of techniques. The methods are widely described in the literature (Ashford and Wright, 1992; Doganis 1991; ICAO, 1985; Kanafani, 1983), and by the author (Caves, 1991a).

The choice of method primarily revolves around its complexity and scope. The complexity should depend on the time stability of the situation being analysed, the availability of a data base and the budget for the study: the scope depends on the last two of these and also on the time-horizon to be studied. The more temporally stable and shorter term forecasts can usually be met adequately with quite simple trend models which may not need to be unduly concerned with causality and uncertainty. Forecasts of a long-term and/or less temporally stable nature, if they are to succeed at all, must concern themselves with causality, with events outside the close ambit of the air system and with inter-
relationships which may result in divergent tendencies and the possibility of catastrophic changes. Wherever on this spectrum of complexity the chosen method lies, it must lead to understandable results. The British Airports Authority (BAA) put on an additional criteria that the results should be open to the informed judgement of the user.

The availability, or cost of collecting, data can be seen to be a major determinant of the type of analysis chosen. The simplest method of all, that of informed judgement, appeals because it needs very little data - indeed, too much data confuses the decision maker and slows the process down. If this method is unacceptable to the user due to its lack of formal evidence, it can be refined by the Delphi technique where a panel of experts have their judgements calibrated and combined.

It is sometimes possible to take data off the shelf, but there is usually something incompatible about it. For instance, the ICAO ticket samples which result in their published origin-destination statistics are between airports, so that they take no account of the ground access trip nor of the route taken from the origin airport. Frequently, when the available data is geographically adequate, it may well fall short in terms of its sample size or the extent of its disaggregation. Also, it is very likely to be out of date. When methods requiring much data are chosen, a prolonged and expensive data collection exercise will be necessary.

Equally, rather than using ready-made data, ready-made forecasts can sometimes be used. Again, the problem is usually one of compatibility in time, space or characteristics of the setting. However, acceptable corrections can sometimes be made to suit the study in hand. Provided that adequate checks can be made on the validity of the base forecasts, this frequently can be the most cost-effective method.

The simplest formal techniques of analysis are trend extrapolation (either in time or scale) and the "step-down" procedure from given national forecasts. Neither of these
requires a broad data-base nor any consideration of causality, though both may be modified to take account of expected variations from the base case. With the latter refinements, these are quite the most common techniques currently being used in master planning of existing airports, while analogy is widely used for prediction of traffic for new projects. Linear or log-linear trends of growth rate of passengers and aircraft with time are used for airport planning, and trends of passengers fitted to appropriate parts of a Gompertz curve are used by Boeing to forecast airline traffic in classified market sectors. The "step-down" method is very popular in the USA, with its strong national forecasts and relatively stable traffic patterns, though deregulation may well cause this method to be abandoned or strongly modified.

Econometric models

If the complexity or time-horizon makes the above methods too naive, then it is necessary to bring causality into the method. The least complicated set of causal models is called econometric. They are so called because they try to relate the traffic to underlying economic parameters or more readily available proxies for them. Usually they are calibrated by multiple regression techniques applied to time series data to give rise to elasticities of demand with respect to the independent variables. This set of methods carries a number of assumptions: ie that a satisfactory explanation is possible with only a few independent variables, that the explanation is causal rather than co-incidental, that the 'independent' variables are reasonably independent rather than suffering from multicollinearity, that there is a constant functional relationship between the independent variables and the traffic, that the independent variables are easier to forecast than the traffic itself and that there are no significant errors in the data base. Given that these assumptions can be accepted, the form of the model will depend on the particular circumstances. Linear models are well-suited to really independent variables. Multiplicative models with price, income and autonomous trend variables have been used by ICAO, BAA and Schiphol Airport as a good
compromise between complexity and intelligibility. The autonomous trend indicates the degree of latent demand, so that when the autonomous trend is zero, the level of service has risen to the point where there is no more latent demand. The multiplicative forms of the model are useful when the elasticities are essentially constant, whereas exponential models are preferable when the elasticity varies with the independent variable. Difference models are to be preferred generally when the data set suffers from multicollinearity.

The independent variables

The success in using the econometric models is determined by the ability to predict the independent variables and the factors which influence them. The socio-economic, demographic, supply and time trend factors are therefore now briefly reviewed in turn.

In the more complex and data-hungry models, gross or discretionary income tends to be the description used. Its influence on demand may be considered through category analysis, by a continuous distribution or by a proportion of the population above a nominal income level. In more macro models, Gross National Product (GNP) is normally used as a surrogate for wealth or discretionary income. Both Boeing and BAA have gone to considerable lengths to interpret government GNP predictions and to form their own views of future world events, but there is a considerable similarity of the US and Europe forecasts caused by conventional wisdom operating on common data bases. One must ask whether GNP is really any easier to forecast than traffic growth. Also one must ask whether the influence of GNP is as all-pervading as indicated by apparently impressive simple correlation analyses. The growth of traffic in Brazil suggests a more complicated relationship, with a relationship between the change in the propensity to fly and the change in GNP per capita which passes through levels of 5.5:1, zero and 3.5:1 as the economy has moved from pre-industrial through the formation of an industrial base and finally to development. Even in the UK, the record of the Treasury in forecasting the GDP has not been good (Smith, 1991).
Conventionally, air traffic increases with population, urbanisation, reduction in size of households and with younger age groups. It is generally assumed that these variables are amongst the easiest to forecast and that their relationships with traffic growth are stable. However, forecasts of the USA population in 2010 have varied since 1945 from $291 \times 10^6$ to $381 \times 10^6$ as the births per 1000 women have changed from 85.9 (1945) through 122.9 (1957) to 73.4 (1972). Again, the tendency for a much increased propensity to fly (PTF) among town dwellers may currently be explained largely by income, household make-up and job-type factors. It is quite possible that these relationships may break down, that the trend to urbanisation will change and also that this latter effect may lead to greater demand for lower density air travel. All these variables can change significantly during the 20-year time frame of airport forecasting.

At constant levels of regularity, reliability, frequency and comfort, the primary supply factors determining demand are ticket price for long haul and generalised cost (ie a combination of price and time saved) for short haul. These are determined by operating policies with respect to load factor, aircraft size, input factor costs and advances in technology. The load factor in turn depends on price so that the revenue yield per seat falls as load factor rises. Estimates of world-wide load factors suggest an increase at about 1/2 per cent per year from 55 per cent to 65 per cent by 1995. Aircraft size is expected to increase on the densest routes as most of the forecast demand is taken up by size rather than frequency in order to reduce costs in the competition for the low fare passenger and to combat the effects of congestion. In these cases, annual growth in seating capacity may be 3 per cent, so that passengers per aircraft may grow by 4 per cent to 5 per cent per year. On lower density routes, and where increasing competition is unhindered by congestion, increased frequency may well cause rather higher ATM growth rates.

Fuel is likely to dominate the changes in input factor prices. Even though real prices have changed little since 1974, a combination of shortages and the long lead times for
aircraft technology to respond to the situation has caused considerable problems for the industry. Operational changes have helped to alleviate the situation, but in the longer term large cost reduction increases will have to come from the technology when labour productivity gains have been exhausted if costs per seat km are to continue to fall. The maximum foreseen improvement before the year 2000 is a halving of fuel consumption per seat km, though there is little sign of an economic incentive to invest for this level of improvement. The combined effect of input costs, improvements in technology and in direct and indirect operating practices and changes in fleet mix may result in a total cost reduction of 1 per cent per annum.

Real air fare forecasts in Europe require a knowledge of costs and the impact of liberalisation, based on USA experience. These forecasts may then be used to estimate traffic by using fare elasticities. The derived historic elasticities may be modified as necessary to allow for changes in local conditions. It should be noted that none of these supply costs, fares or elasticities are necessarily appropriate for other situations than those for which they were derived - for example, short haul price elasticity in the USA may be as high as -2.74, (Jung and Fujii, 1976; ICAO, 1985).

Time trends depend on judging the relative acceptability of the air mode as the attributes of the mode improve and the market is educated to its value. In most parts of the world the penetration of the air mode is still quite small in terms of modal split or the proportion of the population who have flown. In Tanzania in the 1960s, the most affluent 3 per cent of the population accounted for 43 per cent of the transport expenditure; the poorest 69 per cent of rural population allocated only 0.7 per cent of their expenditure to transport; only 1.25 per cent of the population of 5 million could afford air travel producing 1.23 million domestic boardings. A Gompertz (or S) curve typifies the relationship between air traffic and development. Curves like this are used by Boeing to adjust their disaggregated airline forecasts to the characteristics of the particular
world-region market. Note that these trends are independent of the other variables discussed above, though it may be difficult to disentangle them from, for example, the decay in performance of a competing mode. It is difficult to have much confidence in the implications of apparently good fit of these curves in volatile developing environments (Jallow, 1992). It is often preferable to develop a more judgemental view of saturation levels of propensity to fly for each sector of a market, dependent on time and cost budgets and on supply constraints (Shaw, 1979), achieving consistency with the econometric modelling by massaging the price and income elasticities. Probably it is necessary to consider the saturation of demand per capita for each category of passenger, utilising the time/space budget concept indicated in Chapter 2.

Community of interest

Econometric models may be applied to gross traffic, to route traffic or to generation from a given zone. Also they may be applied to classified sub-sets of the total potential travelling population in order to avoid the gross averaging process which is otherwise applied. The variability in the supply of flights in lower density settings identified in Chapter 1 is due not only to the obvious effect of high stochastic variation in demand and costs per seat kilometre, but also to the large differences in the attraction of 'B' type destinations for the inhabitants of A (Figure 4.1). This was demonstrated by an ECAC study of potential direct air routes which was mounted in Europe to predict the likely effect of the original EC Regional Air Services package. The study (ECAC, 1978), updated later (ECAC, 1984), took account of the frequency and cost competition from interlining in the modelling of notional flows between categorised airports. The results were not very secure. There were 340 relevant routes being operated, of which 81 were not predicted by the study: on the other hand, 124 routes were predicted which were not being operated. The predictions were hardly 50% correct after allowing for the certainty of operation of the main trunk routes. There are many reasons for this, some of which have been reported elsewhere (Stauffer, 1981; AEA,
1983), but the variation in 'community of interest' will always be very large. A study of traffic flows by all modes over the English/Welsh and English/Scottish borders made this very clear.

This study used the set of Screenline Surveys carried out for the DoE in 1971 and 1972 over the Welsh and Scottish Borders (Freeman Fox, 1972). This data base is far from ideal, since it automatically deletes a large part of the travel taking place between towns with a community of interest (ie either trading, servicing, social or strategic shared interests) which give rise to the higher density routes. Despite this problem, the data was obtained and analysed to produce a series of models for inter-urban travel. A full discussion of the method and the results is given elsewhere (Caves and Parker, 1975). Because of the strategic nature of the work, the simplest possible model of total travel was required, with only population and distance terms involved. It was found that such a model of the gravity type gave a good description of the travel between large towns, and therefore appeared to give a good description for all travel when all towns were put into the same data set. However, the same model, applied only to smaller towns, gave poor results, which were improved in some cases by changes in the calibration constants. Simple attempts to include a term to describe a town's accessibility to the motorway network did not significantly improve the fit.

The data base was divided into three levels of population, giving six sets of pairing between centres. A model of the form

$$T_{ij} = e^\delta (P_ip_j)^a (d)^b$$

was applied to each data set, where

$$T_{ij} = \text{total trips each way per week between towns } i \text{ and } j$$

$$P_ip_j = \text{populations (residents) of towns } i \text{ and } j \times 1000$$
\[ d = \text{shortest-road distance between each town pair, using AA Handbook (km)} \]

\[ a, b, c = \text{are constants for each data set with values for the Welsh off-peak season averaged between social and non-social results as shown in Table 4.1.} \]

**TABLE 4.1 - DEMAND MODEL CALIBRATION COEFFICIENTS**

<table>
<thead>
<tr>
<th>Data set</th>
<th>(a)</th>
<th>(b)</th>
<th>(c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>s - s</td>
<td>0</td>
<td>-1.8</td>
<td>12.2</td>
</tr>
<tr>
<td>s - m</td>
<td>0.3</td>
<td>-1.6</td>
<td>9.5</td>
</tr>
<tr>
<td>s - l</td>
<td>0.6</td>
<td>-1.85</td>
<td>8.05</td>
</tr>
<tr>
<td>m - m</td>
<td>0</td>
<td>-2.07</td>
<td>12.6</td>
</tr>
<tr>
<td>m - l</td>
<td>1.10</td>
<td>-2.58</td>
<td>6.2</td>
</tr>
<tr>
<td>l - l</td>
<td>1.18</td>
<td>-3.03</td>
<td>8.3</td>
</tr>
</tbody>
</table>

where

- \(s\) denotes towns with populations less than 50,000
- \(m\) denotes towns with populations between 50,000 and 200,000
- \(l\) denotes towns with populations greater than 200,000

The output from these models gives an indication of the general level of present day non-holiday travel, although the small and medium-sized town travel mainly applies only between those towns with no particular community of interest. The data picks up those trips made either by direct routes or by hub-and-smoke type routes.

The increase of the deterrence function with town size indicates that smaller towns maintain their propensity to travel relatively well over longer distances. This suggests that their travel pattern is not much influenced by close links (which would normally be inside their own branch of the central place hierarchy) - a result entirely in keeping with the fact that the screenlines analysed follow the boundaries of the hierarchical structure quite faithfully.
There are certain affinities between towns, of a trading rather than of a central place nature, which raise the rate of travel well above normal. The Welsh off-peak results are notable for the links between ports.

This approach of disaggregating the data set by town size or by central place hierarchy might have produced more useful results than the ECAC modelling, had the European study adopted it and calibrated with the data collected by OECD (OECD, 1977). At least the dispersion due to community of interest would have been more apparent.

It is, then, clear that it is not possible to use average demand levels, even if corrected for frequency, to predict either the actual flows or whether an operator will attempt to serve the demand.

**Simultaneous models**

It may well be argued that generation and distribution are functions of the attributes of the modes serving a zone and that the travel choice is really a simultaneous decision, covering generation, distribution and modal split. Models have been developed which include mode attributes as well as the other variables used in the conventional travel demand forecasting process. Perhaps the best known example is the abstract mode model, which predicts these factors by including terms describing the attributes of both the subject mode and the best available value of each attribute. In this way, it is possible to analyse the likely patronage of a new mode if estimates can be made of its attributes. Alternatively, demand and supply equations may be solved simultaneously, though there may be problems of convergence. These can be overcome by iteration, as in the CAA model described in the annexed Case Study.

Although many of the above models are described as causal or behavioural, these labels can only really be justified by ‘a priori’ reasoning. There is no intrinsic proof of either effect. Probably the nearest approach to proof of causality comes from the application of Autoregressive Integrated
Moving Average (ARIMA) models to both the dependent and a chosen independent variable: cross-correlation between the residuals of the two smoothed series may then expose the leads and lags, ie the relative timing and direction of any mutual interactions. Causality is then proved, subject to the presumption that only earlier events can influence later events (Caves and Ndoh, 1990; Jenkins et al, 1981; Jones, Pitfield and Caves, 1989).

Disaggregate approaches

Attempts to increase the behavioural content of models are often made by the use of a disaggregate, or discrete, approach; this involves the knowledge and modelling of individuals' trips. Though not necessarily adding any behavioural information, this type of modelling is usually more accurate in determining responses to changing supply or choices between alternatives, because it retains the maximum richness of the available information, rather than hiding some of the variety through the aggregation process (Walmsley, 1979). Less data is needed for an adequate disaggregate model, precisely because of the increased variety.

The data for these disaggregate models is usually obtained from surveys of historic travellers; ie they are based on revealed demand. This clearly cannot account for those who have not travelled, nor for those whose travel decisions have been significantly constrained by the choices available to them: for example, charter passengers' departure airport is often constrained by flight availability. At the risk of irresponsible answers, these difficulties can be overcome by the use of 'stated preference' surveys. There are techniques for maximizing the relevance of the answers obtained, the best of which are probably budget constraints and checking against actual behaviour: the prime advantages of the technique are the cheap and rich nature of the data and the ability to consider larger scale variation in the alternatives than usually exist in historic situations (Bates, 1986; Kroes and Sheldon, 1988; Wardman, 1988).
All of the models which attempt to introduce causality require a great deal of data on the mode attributes and the demography of the potential travellers as well as more precise socio-economic information than is generally used in econometric modelling. All of them also rely on the ability to forecast the future trends of the variables used and the constant nature of the response to them. Because of these difficulties, all of the above methods suffer from errors which become greater as the time horizon increases. There seem to be four ways in which this problem of uncertainty can be approached objectively.

**Uncertainty**

The most common approach is to use sensitivity analysis on all the factors which it is felt may be in error. A rather more sophisticated approach is to assign probabilities to the forecast of the independent variables and let the output take the form of a risk analysis - in this case a preferred forecast is offered, rather than leaving the forecast open to judgement when sensitivity results are presented. The probabilities associated with the variables can be explored by scenario writing (Hirschorn, 1980; Post Office, 1976; Leemhuis, 1985; van Doorn, 1986). A third approach is the normative one of adopting policies to limit or encourage demand - in which case the models might play a role as a means of setting the levels of policy variables to adjust demand, but would not be explicitly involved in the facility planning. The last method would be to attempt to internalise the hard-to-forecast 'independent' variables, i.e. to build long term interactive models which would recognize the interdependence of all the variables - this would be more an exercise in futurology than demand analysis and the understanding of the relationships are barely at the embryo stage.

There are increasing pleas, (e.g. ASRC, 1990) for a more futurist approach to forecasting. It is quite likely that the FAA's predictions of growth of major hubs will turn out to be wrong as carriers change their strategies, following the demographic changes towards secondary cities.
Induced demand

Induced demand may well be implicit in the trend and econometric models described above, but it would not be possible to identify this element of demand separately. Indications of induced demand can be found in the relationship between propensity to fly (ptf) and the provision of air service. This has been noted by the CAA as indicated in the annexed Case Study of the correlation between ptf and distance from Heathrow and Gatwick. Also, there is a strong correlation between UK regional ptf and access to air service (Caves 1983), as shown in Table 4.2.

TABLE 4.2: THE RANKING OF ACCESS AND PROPENSITY TO FLY FOR SELECTED UK REGIONS

<table>
<thead>
<tr>
<th>Region</th>
<th>Propensity(1)</th>
<th>Access to(2)</th>
<th>Combined(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>to fly</td>
<td>nearest airport</td>
<td>access measure</td>
</tr>
<tr>
<td>Bristol</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Tyneside</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Ayrshire</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Wigtown</td>
<td>4</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Sheffield</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Cumberland</td>
<td>6</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Cornwall</td>
<td>7</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Plymouth</td>
<td>8</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Pembroke</td>
<td>8</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Hereford</td>
<td>10</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Camarthen</td>
<td>11</td>
<td>7</td>
<td>8</td>
</tr>
</tbody>
</table>

Notes

(1) Trips per 1000 inhabitants by air per year.
(2) Distance from region centroid to nearest airport (miles).
(3) Flights per week from nearest airport divided by distance from region centroid to nearest airport.
These correlations are open to the challenge that they do not necessarily infer causality. Little rigorous work seems to have been done on establishing the causality of improved air service in stimulating demand, but some evidence is reported in Chapter 6 (Caves and Ndoh, 1990). Even this cannot categorically be said to be induced rather than latent demand.

**PASSENGER CHOICE**

**Mode choice**

Particular factors which may become important in competing modes are rail improvements in short haul and telecommunications in long haul.

Some of the latent air transport from A to B in Figure 4.1 may well be satisfied by another mode until aviation offers a lower disutility than the alternatives. Indeed, the increasing but erratic provision of direct services to provincial airports noted in Chapter I often can only be justified by success in modal competition (easier on over-water routes) or by hub feed, i.e. the ‘beyond B’ category in Figure 4.1. Even the feeder traffic is subject to modal competition.

Empirical studies appear to indicate that passengers make their choice of mode on the basis of generalised cost (i.e., money cost plus value of time) and that the resulting split on routes where air transport is available gives air dominance above 400 km for business travel and 1000 km for leisure travel (Bjorkman, 1983; Paveau, 1991; Seidenfus, 1983). There is some conflicting evidence of the competitive situation between air and rail when relative fares and times are changed, from studies in France, Germany, Sweden, Japan, Spain and the United Kingdom, (A.E.A., 1983; Bjorkman, 1983; Fernandez-Diaz, 1983; Jenkins et al., 1981). Indeed, there is some evidence that there is more of a mutual benefit between rail and air than competition. The evidence from TGV competition (Gorodiche 1989) seems to suggest that, after a substantial fall in traffic, air passengers start to grow
again, possibly due to feed and access: despite the uneven playing field: it is estimated that SNCF pays less than half the full costs of infrastructure and operations (Avmark, 1992). In the UK, where the intercity rail services are much less subsidised, - there are some one million Manchester-Heathrow passengers per year of whom approximately 50 per cent are local. There is a generally accepted synergy between air and telecommunications (Goddard and Pye, 1977), so much so, that the correlation between air travel and telex messages has been used to indicate the potential for new route demand, (AEA, 1983). It must be remembered that there is also modal competition on over-water routes, which has resulted in a small tendency away from air across the English Channel. It may be that competition over water can be explained simply in terms of effective time difference, as indicated in Figure 4.2 for links between Athens and the Aegean islands.

**FIGURE 4.2: MODAL SPLIT BETWEEN AIR AND SEA**
Airport choice

The results of a small survey conducted in the East Midlands given in Figure 4.3 (Green and Caves, 1984), and of a CAA survey around Stansted Case Study reported in Figure A5 of the Annex, show the sensitivity of use of an airport to ground access. The trips indicated by the earlier generation models within any given isochrone around the airport may therefore not be converted into boardings at that airport. This was also concluded by a Norwegian study: "It is therefore not possible to presume for each airport a zone of influence whose total travel demand is fully explained by the zone's population and income per capita as is often done in more sparsely populated countries" (Fridstrom and Thune-Larson, 1989).

Traffic prediction becomes progressively more difficult as air transport regulation is liberalised, opening up the possibility for the airport's role to change, and as airport privatisation encourages airports to seek expanded roles. The difficulties are further aggravated when the airport is small and its role is determined not only in relation to the local population, but also, by interactions with other airports within a region. This is the situation facing several United Kingdom airports. The generic diagram (Figure 4.4), indicates that small local airports that wish to expand their role have to compete with larger nearby regional and national airports, and also with emerging (but currently small) airports situated close to the capital. The emerging capital city airports themselves have to compete with each other and with the capital’s major airports.

The traffic potential for Airport A in Figure 4.1 is therefore dependent on the location of other neighbouring airports and the services they offer. The factors controlling the decisions by passengers on how to use the services available to destination B at competing airports $A_1 \ldots A_2$, or how they choose between air and ground modes, can best be determined by calibrating and applying models of airport choice.
These aggregate analyses of modal split suffer from the same problems as the aggregate analyses of network flows: individual routes seldom seem to have the average characteristics implied by these analyses. A study of two potential air routes in the west of the United Kingdom using generalised cost modelling predicted the modal splits to air shown in Table 4.3, where the higher split involves a water crossing (Caves, 1983). The predicted local flow from gravity modelling was sufficient to support 6 return trips per day by BN Islander on the land route and 2 return trips per day on the water route, but no service has ever worked consistently on either route. Clearly other factors are at work in the actual mode choice decision.

### TABLE 4.3: AIR GENERALISED COST ADVANTAGE (1978)

<table>
<thead>
<tr>
<th>Trip Type</th>
<th>2nd class rail</th>
<th>Car marginal cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bristol</td>
<td>Swansea</td>
<td>Bristol</td>
</tr>
<tr>
<td>Trips cost (£)</td>
<td>7.37</td>
<td>10.61</td>
</tr>
<tr>
<td>Trip time (min)</td>
<td>219</td>
<td>335</td>
</tr>
<tr>
<td>Air cost disadvantage</td>
<td>8.52</td>
<td>4.08</td>
</tr>
<tr>
<td>Air time advantage</td>
<td>66</td>
<td>298</td>
</tr>
<tr>
<td>Value of time to use air (£/hr)</td>
<td>7.75</td>
<td>1.24</td>
</tr>
<tr>
<td>Likely modal split to air*</td>
<td>13.5</td>
<td>91.5</td>
</tr>
</tbody>
</table>

*Likely median value to time for business travellers taken as £3.00 per hour.

Source: Caves 1983
FIGURE 4.3: EFFECT OF LOCATION ON USE OF DOMESTIC REGIONAL SERVICES FOR BUSINESS

\[ X \% \text{ companies using direct domestic services} \]
\[ Y \% \text{ companies using London feeder services} \]
\[ Z \% \text{ trips using London feeder services} \]

Source: Green and Caves, 1984
The most popular model is the 'logit' model, which expresses the probability of choosing an alternative in terms of the ratio of the utility to the passenger of any one of the alternatives to the combined utility of all available alternatives, where the utility function to be maximised is a function of the attributes of the alternative and of the traveller. The logit model results in an intuitively correct S-shaped choice function, but it is constrained to equal cross-elasticities between alternatives for each attribute. The 'translog' model, with its quadratic form allows the flexibility for the elasticity to vary freely between and across alternatives, but tends to have a high computational cost. The logit model only works efficiently if all alternatives are genuinely different, i.e. it is independent of irrelevant alternatives. The constraint can be lifted either by the intractable multinomial Probit models, or, preferably, by nesting the choices and using logit models within each level of the resulting hierarchy. These techniques can be, and have been, applied to choices between
airports; routes; airlines; modes; fare classes. It is more important to use disaggregate information in their calibration stage: the application can often be satisfactory on aggregate data.

The random utility function \((U)\) is usually assumed to have a linear parameter additive form, with a representative average component \((V)\) and a random component \((\varepsilon)\) representing the deviation of individual utility from the sample average. The random component therefore accounts for all the characteristics and personal tastes of the individual and also the unobserved attributes of the choice alternatives. Since only the representative component can be measured, the choice of alternative \(g\) over any other alternative in the choice set \(G\) will occur with some probability:

\[
P_{gk} = \text{Prob} \left( \frac{U_{gk}}{U_{rk}}, r = 1, ..., G \right)
\]

where \(P_{gk}\) is the probability that individual \(k\) will select alternative \(g\). The theory underlying discrete choice models and their applicability is covered extensively in the literature, (eg Hensher and Johnson 1981).

Of the models which use this general approach, the one most frequently adopted for travel demand forecasting is the multinomial logit model. This uses a Weibull (double exponential) distribution:

\[
\text{Probability of } \varepsilon \leq x = \exp \left[ -\exp \left( a-bx \right) \right]
\]

to describe the distribution of the random utility, thus implying that the random components of utility are independent across alternatives and that they are identically distributed, ie they have the property known as the Independence of Irrelevant Alternatives (IIA). This implies that a new alternative being present is assumed not to influence the previous ratio of choice between the existing alternatives. The model, with these assumptions, requires rigorous testing before use. The general form of the model expressing the choice probabilities is then:
\[ p_{gk} = \frac{e^{V_{gk}}}{\sum_{r=1}^{G} e^{V_{rk}}} \]

where:

- \( p_{gk} \) is the probability that alternative \( g \) will be chosen by individual \( k \)
- \( V_{gk} \) is the representative component of utility associated with alternative \( g \) from set \( G \) by individual \( k \).

Parameter estimation of this class of models is usually done by the maximum likelihood method, rather than that of least squares.

Due to the CAA’s surveys, this approach has been made possible in the UK and has been used by the CAA itself in writing CAP 548, further improvements being made in CAP 570.

Ndoh and Caves attempted to apply a logit model to the choice between Stansted, Heathrow and Gatwick to near-continental scheduled destinations, using access time, frequency and fare with the 1984 CAA data, as detailed in the Annex. This exemplifies the competition between dominant and emerging capital city airports indicated in Figure 4.4. The resulting direct elasticities were as shown in Table 4.4.

**TABLE 4.4: DIRECT AIRPORT CHOICE ELASTICITIES IN THE LONDON AREA**

<table>
<thead>
<tr>
<th></th>
<th>Heathrow</th>
<th>Stansted</th>
<th>Gatwick</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access</td>
<td>- 0.962</td>
<td>- 0.701</td>
<td>- 3.423</td>
</tr>
<tr>
<td>Frequency</td>
<td>- 0.186</td>
<td>0.048</td>
<td>0.235</td>
</tr>
<tr>
<td>Fare</td>
<td>- 1.882</td>
<td>- 2.561</td>
<td>- 6.734</td>
</tr>
</tbody>
</table>

They show a high sensitivity to access time and fare but a
surprisingly low effect of frequency. It is likely that this latter effect was due to the extreme disparity in offerings between the airports: the Heathrow frequencies were so high that a change in them would hardly matter, while the Stansted frequencies were so relatively low that passengers were clearly not likely to choose Stansted if they were sensitive to frequency. The model would only calibrate well with a large dummy to represent the large additional, ie non-frequency dependent, advantages of Heathrow.

Logit models were used again on the 1983 CAA data and for short haul scheduled traffic, to describe the airport choice behaviour of those people living in the vicinity of Sheffield, but this time producing separate models for business and leisure passengers (Thompson and Caves, 1993). The resultant utility functions were:

Business: \[ U = -0.0487A + 1.595F - 0.0316f \]
Leisure: \[ U = -0.0801A + 1.546F - 0.0898f \]

where \( A \) is the access time in minutes
\( F \) is the frequency time per weekday
\( f \) is the full economy fare in Sterling.

The results show clearly that the leisure passengers are, as expected, much more sensitive to fare than the business passenger; more surprisingly, they also appear to be more sensitive to access. The leisure model predicts choice of airport more closely than the business model, which tends to assign trips away from Manchester and towards Birmingham. The addition of a new Sheffield airport into the choice set using the Independence of Irrelevant Alternatives characteristic, predicted that three frequencies per day by Dash 7 aircraft to the most popular destinations would produce viable load factors. It remains to be seen if the airlines will mount the services and if the passengers will respond in the same way as they do in choosing between more mature services.

The CAA data were also used to construct logit models to investigate the airport choice behaviour of Scottish leisure
travellers in using Prestwick, Heathrow and Gatwick to travel on scheduled services to three North American destinations (Brooke and Caves, 1993). The 1982 and 1984 surveys to calibrate a model which used access time, frequency and total trip cost, the latter taking APEX fares and allowing for value of time for the total journey. The model predicted the airport choice almost perfectly using a constant term and a logarithmic specification for the explanatory variables. The resultant direct elasticities were as shown in Table 4.5.

**TABLE 4.5: LONG HAUL DIRECT AIRPORT CHOICE ELASTICITIES**

<table>
<thead>
<tr>
<th></th>
<th>Prestwick</th>
<th>Heathrow</th>
<th>Gatwick</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access</td>
<td>- 1.52</td>
<td>- 9.69</td>
<td>- 12.50</td>
</tr>
<tr>
<td>Frequency</td>
<td>0.59</td>
<td>1.01</td>
<td>0.83</td>
</tr>
<tr>
<td>Cost</td>
<td>- 0.42</td>
<td>- 3.67</td>
<td>- 1.69</td>
</tr>
</tbody>
</table>

The higher sensitivity to the variables for the London airports is probably due to the large proportion of travellers using air to access them. The model was used to explore the effect of transferring Prestwick services to Glasgow. It was found that 50 per cent of those using the London airports would use Glasgow instead, but since 90 per cent of the sample already used Prestwick, this would only add 5 per cent to the local Scottish international departures: most of these travellers were using Scottish airports anyway, but domestically for access to London airports. At least for leisure passengers, it was clearly preferable to use Prestwick rather than the London airports.

**Route choice**

The sector AB may, as shown in Figure 4.1, carry traffic for other destinations generated at A, from other origins with final airport destination B or using the sector as part of a multi-leg journey between the two remote points. For any of these traffic categories to appear on the sector, either an individual airline would have to offer on-line transfer (or transit), usually by establishing a hub at A or B (or both),
or there would have to be an interlining facility available. The interlining may have through-ticketing, seat assignment and bag transfer, and be subject to full pro-rating of the ticket price, and take place within the same terminal between airlines with code-sharing agreement. An example of this is the hubbing activity being encouraged by the Manchester Airport management (Bowen, 1991). Particularly if the marketing links between the carriers includes their frequent-flyer programmes, and if the schedules are well coordinated, the passenger may find the level of service very similar to on-line transfers. In the worst case, the transfer may involve inconvenient connecting times, two separate full price local tickets and a change of airport.

The role of airport A, its level of emplanements and aircraft movements will all depend on each airline’s decisions as to which destinations to serve, the form of alliance they may have with other carriers serving A or B, and the location of a hub at A or B. It is therefore extremely important to understand airline strategy (dealt with in Chapter 5) and to be able to predict passenger response to the supply options which are offered. Again, disaggregate logit models provide an appropriate way of analysing that response.

Models which have used multinomial logit formulations to model passenger choice between direct and connecting services indicate a far strong preference for direct trips. A study based on US ticket data for 1985 suggested that, even where no extra distance is involved, the service over the hub would have to offer 15 flights per day on each leg to gain a 50 per cent share with a single direct flight (Hansen, 1990). In comparison, a study, based on disaggregate 1983 data from CAA surveys of trips between the UK Midlands and continental capitals and using a nested logit model (Ndoh, Pitfield and Caves, 1990), showed the marginal rate of substitution of direct flights to connecting flight frequency to be 1:7. The actual preference obviously varies route by route and with the opportunities available to travel, but the evidence suggests that very modest but well-timed frequencies on direct services will be preferred by at least 80 per cent of passengers. This is again indicated by another US study
which derives a value of scheduled delay due to low frequency at only seven per cent of the value of travel time (Morrison and Winston, 1989). These results do not necessarily mean that hubbing airlines are offering a service which fails to match their passengers' utility, since it may be that the direct service could only be offered by small, slow aircraft requiring high fares. However, as soon as some 40,000 passengers are available to support jet service, the lack of direct service must be some indication of a loss of passenger utility.

A particular difficulty in using route choice models for the prediction of an airport’s transfer traffic is that the total matrix of demand must be known, including international markets served by airlines who would not normally be party to data exchange agreements. A valuable benefit from the airline alliances considered in Chapter 5 is improved access to this type of data. No further quantification of route choice is attempted here, though. Chapter 5 considers the influences shaping airline management policies and Chapter 10 attempts an analysis of the possibilities of hub transfer markets developing in Europe. Chapter 10 also develops a method of overcoming the difficulties associated with all-embracing airport choice models which have been noted in this chapter and in the Annex.
CHAPTER 5: DETERMINANTS OF AIRLINE STRATEGY

COSTS

Infrastructure Costs

The airlines' smaller share of total system assets compared to total system expenditure explains both the historic importance of airline operating cost in the development of the industry and the recent trend expressing concern about the infrastructure. The capacity of the infrastructure has come under strain at just the time when capital has become scarce and expensive. The most serious attention must now be given to cost control, both in operations and in capital spend, particularly with the competitive pressures stemming from liberalisation.

The ICAO fleet paid an average of US$6.3 per departed tonne in infrastructure charges in 1986. This is equivalent to 3.7 per cent of its total operating cost, varying between a low of 0.1 US cents per passenger-kilometre to a high of 1.1 cents per passenger-kilometre in Europe. By 1988, this expense amounted to US$2.5 billion for IATA's international services (ICAO, 1987b).

The ICAO practice of categorising airport and en-route charges as indirect operating costs is not compatible with the fact that most fees are struck on the basis of actual use, unless, like Olympic Airways, no taxes at all are levied by agreement with the government until 2004 A.D. In fact, airport related charges contribute some 7 per cent to ICAO airlines' direct operating cost (DOC) and en-route navigation charges add another 3 per cent. These charges now appear to be under control, after having been the only items apart from fuel to show a significant percentage increase between 1969 and 1978. However, a recent ICAO study has found that additional taxes and charges, levied mainly on international traffic, adds three per cent to world average economy fares: on 500 km. sectors, the effect is between 10% and 20% in all regions except the UK and the Middle East (Costaguta, 1992).
The UK airlines have traditionally paid a rather large proportion of their total costs in charges, as shown in Table 5.1. However, the historic growth of these charges is probably not very much out of line with other ICAO airlines operating in countries which make a real attempt to recover charges. For comparison, in the USA the trunk airlines' airport related charges accounted for between 1.9 and 4.4 per cent of their total operating cost (TOC) in 1978, falling to 2 per cent or less in 1986.

Traditionally, in the USA, airlines provide many more of their own airport facilities and the average throughput of the stations is greater. Frequently, a condition of their guarantee of airport loans is that they should only pay sufficient fees to make up any deficit after all other income sources have been fully exploited. The almost full recovery of the FAA's regulatory and navigation costs is obtained from a domestic ticket tax which has varied in the recent past from 2 per cent to 10 percent, plus a percentage tax on fuel for general aviation.

The impact of system charges on individual UK airlines (Table 5.2) varies between 10 per cent and over 30 per cent.

The contribution of infrastructure to airline costs may be summed up as varying with:

- type of operation
- policy for cost recovery
- system efficiency
- utilisation of facilities.

A parametric study of air transport systems working at reasonable maximum levels of efficiency and airport utilisation gave the results depicted in Figure 5.1 for a third level system based on the Islander and a local trunk system based on the Boeing 737 (Caves 1980). With a representative number of routes using each airport, the ratio of airport-related to total system cost varied between 5 per cent and 60 per cent depending on the frequency of service and the average stage length. Aircraft indirect
## TABLE 5.1: UK AIRLINES EXPENSES - PERCENTAGE BREAKDOWN

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Flight crew</td>
<td>8.7</td>
<td>7.2</td>
<td>6.3</td>
<td>5.1</td>
<td>4.5</td>
<td>5.2</td>
<td>5.6</td>
</tr>
<tr>
<td>Maintenance &amp;</td>
<td>16.2</td>
<td>13.8</td>
<td>13.4</td>
<td>9.4</td>
<td>9.3</td>
<td>12.2</td>
<td>11.0</td>
</tr>
<tr>
<td>Fleet depreciation</td>
<td>7.8</td>
<td>6.8</td>
<td>3.9</td>
<td>3.9</td>
<td>4.1</td>
<td>4.5</td>
<td>4.3</td>
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<tr>
<td>Rental of aircraft</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.7</td>
<td>3.6</td>
<td>5.0</td>
<td>4.4</td>
</tr>
<tr>
<td>Station expenses</td>
<td>13.3</td>
<td>11.4</td>
<td>11.4</td>
<td>6.1</td>
<td>5.8</td>
<td>5.7</td>
<td>5.8</td>
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<tr>
<td>Passenger services¹</td>
<td>8.4</td>
<td>9.0</td>
<td>11.6</td>
<td>8.3</td>
<td>8.4</td>
<td>9.9</td>
<td>6.7</td>
</tr>
<tr>
<td>Ticketing, sales</td>
<td>15.4</td>
<td>13.0</td>
<td>12.7</td>
<td>13.4</td>
<td>17.6</td>
<td>14.8</td>
<td>15.2</td>
</tr>
<tr>
<td>and promotion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aircraft fuel</td>
<td>11.3</td>
<td>22.6</td>
<td>18.8</td>
<td>26.8</td>
<td>23.2</td>
<td>13.8</td>
<td>13.2</td>
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<tr>
<td>and oil</td>
<td>5.2</td>
<td>7.2</td>
<td></td>
<td></td>
<td></td>
<td>11.4</td>
<td></td>
</tr>
<tr>
<td>Landing and</td>
<td>6.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>departure fees²)</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Navigation services</td>
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<td></td>
</tr>
<tr>
<td>(Misc.</td>
<td>12.1</td>
<td>9.8</td>
<td>12.3</td>
<td>13.0</td>
<td>12.3</td>
<td>15.7</td>
<td>18.7</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

**NB** 1 includes passenger embarkation fees, except in 1989.

2 includes aircraft handling and parking fees; also passenger embarkation fees in 1989.

**Source:** Compiled using CAA 1990b
<table>
<thead>
<tr>
<th>Airline</th>
<th>Percentages of total expenses due to:</th>
<th>Average stage (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Airways</td>
<td>6.6</td>
<td>6.5</td>
</tr>
<tr>
<td>Air Bridge Carrier(^2)</td>
<td>30.1</td>
<td>18.1</td>
</tr>
<tr>
<td>Air Europe</td>
<td>13.5</td>
<td>14.8</td>
</tr>
<tr>
<td>Air UK</td>
<td>13.5</td>
<td>22.9</td>
</tr>
<tr>
<td>Britannia</td>
<td>11.8</td>
<td>14.6</td>
</tr>
<tr>
<td>B. Midland</td>
<td>21.2(^4)</td>
<td>15.9</td>
</tr>
<tr>
<td>Dan-Air</td>
<td>12.4</td>
<td>14.6</td>
</tr>
<tr>
<td>Monarch</td>
<td>10.2</td>
<td>14.9</td>
</tr>
</tbody>
</table>

2 All cargo airlines
3 Landing and departure, aircraft handling and parking fees; also passenger embarkation fees in 1989
4 Including navigation services

Source: Compiled using CAA 1990a
a. Third level Islander system

b. Second level Boeing 737 system

Return services per day

Distance (miles)

Ratio of airport to total system cost (%).
operating costs (IOC) and interest on employed capital were included in the analysis. The model clearly indicates that, with a policy of fully recovered allocatable costs, a system which operates on short stages with a low frequency of service can expect that infrastructure costs will form a major element in total system costs. For the 737 operating at 500 miles stages on three return services per day to each of five destinations (perhaps equivalent to scheduled operations out of East Midlands), the airport related cost contributes about 15 per cent to total cost.

Airline cost functions

It is now necessary to examine more closely the constituents of airline costs to understand the influences which dictate operating practices. This will allow constructive comment on some of the points of debate between airlines and consumer groups, particularly those which revolve around fare differences between routes even after a cost related approach has been taken to fare setting.

Firstly, fuel, which is currently the most important element in TOC, varied significantly by ICAO Route Group from 15 US cents per litre in North America to 32 US cents per litre in Africa in 1986. The North American fuel cost had fallen from 35 cents per litre in 1981. It then remained constant in real terms until the 30 per cent rise in 1990. Perhaps due to the falling prices, the US industry only improved fuel efficiency at 2 per cent per year, achieving 48.6 seat miles per gallon in 1989 (Flint, 1991).

The total costs per passenger kilometre on the ICAO Route Groups varied between 5.5 US cents and 14.5 US cents per pass-km in 1986 (ICAO, 1987b). The ICAO production by route is presented in Figure 5.2. It can be seen that there are envelopes of maximum unit cost formed as functions of average stage length, relative route density and the average equipment size. All three variables indicate that the American sectors consistently produce costs which are lower than the trend. The most obvious anomaly is the European Route Group in the plot of cost against route density.
FIGURE 5.2a: EFFECT OF STAGE LENGTH ON UNIT COST

FIGURE 5.2b: EFFECT OF ROUTE DENSITY ON UNIT COST
FIGURE 5.2c: EFFECT OF AIRCRAFT SIZE ON UNIT COST

FIGURE 5.2d: EFFECT OF LOAD FACTOR ON UNIT COST

Note: The numbers on the graphs refer to the following world regions:

3 North America
5 South America
6 Europe
9 Europe - Middle East
12 Mid Atlantic
13 South Atlantic
This is undoubtedly due in part to the fact that the total group production is split between a very large number of individual international routes. In terms of capacity offered, it is possible to conclude that the most important variables tending to increase unit costs are:

- decreasing stage length
- decreasing route density
- decreasing aircraft size.

It is, of course, dangerous to read too much into an empirical analysis on such an aggregate basis: there is allowance for the distribution of the important variables within each route group, nor for variations in cost efficiency caused by varying opportunities offered by monopoly situations or fare protection. However, the results are generally in line with other empirical and theoretical evidence. As in most other production processes, there are fixed and variable costs in the production of aircraft seat-kilometres. There are, therefore, economies of scale which generally apply, subject to indivisibilities of supply. They manifest themselves in route density due to spreading of fixed station costs, stage length due to spreading of fixed station costs and airport costs, and also in aircraft size due to engine and airframe efficiency and the spreading of the fixed cost of unit movement.

There are, however, two factors which tend to counteract the apparently inexorable economies of increasing aircraft size. Firstly, smaller aircraft have a much smaller absolute unproductive time than larger aircraft, ie they operate tighter patterns, turn-round faster, use shorter taxiing distances and spend less time climbing and descending. Secondly, their ratio of IOC/DOC tends to be 0.3 - 0.5, compared with about 1.0 for trunk operations. Some of this is due simply to the higher absolute DOC, but there is also an element of reduced station, ticketing and promotion costs which stem in part from the essentially local nature of their operations. Thus, as shown from the results of the hypothetical system (Figure 5.1) really short hauls are clearly more expensive than long hauls but they can be
controlled by using appropriate equipment and methods of operation.

There are also diseconomies of scale, at large values of route density due to congestion, at low values of level of service due to poor utilisation and, to some extent, at large values of aircraft size due to station processing difficulties. Very few real economies of scale should exist in terms of airline or fleet size, certainly beyond about 50 aircraft. The Edwards Committee (Edwards, 1969) found that a fleet of this size could have unit costs 14 per cent lower than a fleet of five aircraft due to aircraft and fuel purchase bargaining power, inventory costs (5 per cent spares compared with 15 per cent), increased aircraft utilisation and indivisibilities in project engineering, computer systems and simulators.

Many of the potential disadvantages of small fleets can be to some extent overcome by leasing, sub-contracting and collaborative agreements. However, there is some empirical evidence (LAE, 1985) that, over similar stage lengths, US trunk fleets do produce economies of scale. In the case of 727-200s, 55 TWA aircraft cost 32 per cent more to operate than 120 American Airlines aircraft per block hour while 100 aircraft in each of the Eastern, Delta and United fleets also cost 10 per cent more than the American fleet. Delta's fleet of 33 737-200s cost 11 per cent more than United's 48 aircraft.

Airline fleet costs are normally built up from separate consideration of DOC and IOC. The DOC may be considered to consist of the costs of crew, fuel and oil, insurance, depreciation and infrastructure fees (see Table 5.1). Effectively the only fixed element in DOC is depreciation, though there is likely to be a minor element of fixed cost in all the other elements. Depreciation is a function of accounting policy and the aircraft purchase price. In fact, with inflation and higher fuel prices, depreciation now accounts for only 7 per cent of UK airlines' DOC (Table 5.1), though extra reserve funds should really be set aside to meet replacement costs. Also, the debt charges associated with
the purchase should be added to the fixed element of the
direct cost of aircraft ownership: this is normally only
shown 'below the line'. The real replacement cost of
ownership may then rise above 20 per cent of DOC, which makes
it imperative that the aircraft should be fully utilised.
There is, however, a limit on the likely utilisation of a
fleet depending on the type of operation: it is lower for
short haul, seasonal operations with older, less reliable
aircraft.

The aircraft contribution to airline cost has now been
covered. The other main determinant of cost is the type,
rather than the scale, of operation. Three examples will
suffice to illustrate the factors at work. Firstly, a
comparison between operations and costs in North America and
Europe (Windle, 1991) has shown that in 1983 the US total
factor productivity was 19 per cent higher than in Europe,
due largely to the higher density of operations. Secondly, a
comparison between scheduled and charter operation, the so­
called Cascade studies, (British Airways, 1977) shows how the
reduction of level of service through IOC items and level of
seat access produces a reduction in TOC of up to 60 per cent
on the same leisure routes from the UK. Thirdly, the type of
route network adopted can influence the total system cost.
The empirical evidence for the control of airline-wide costs
by the choice of network strategy is now examined.

Effects of scale and density

Airline costs have been subject to a long history of analysis
in North America. These studies, their results and their
shortcomings, have been well rehearsed in the literature (eg
Gillen, Oum, Tretheway, 1990). Appropriate methodologies have
been reviewed elsewhere (Tolofari, Ashford and Caves, 1990).
It is commonly agreed that an analysis which would be useful
for policy analysis needs to separate returns to network
density (RTD) from returns to the size of a firm (RTS). This
can be done by including the number of points served as a
measure of network size. Then RTD are reductions in unit
cost as output increases for a given network size (output
attributes and input prices held constant), while RTS are
reductions in unit cost as output increases, with network size changing in proportion to output.

It is also agreed that the methodology must be flexible enough to avoid the imposition of constant returns to scale by using a Cobb-Douglas form and also to account for shifts in the cost function over time. An appropriate way to avoid these problems is to use a transcendental logarithmic (Translog) cost function; i.e., a second-order polynomial which approximates an unknown function without making any prior assumptions about the production structure of the function. The cost function can be either the total cost, which assumes that firms adjust capacity instantly to changes in input prices, or variable cost, which makes it difficult to deal with lease payments. The difference between the two functions reflects the effects of the excess capital stock which is not accounted for in the total cost model. In either case, the function is made up of: vectors of outputs, of input factor prices, of operating attributes; firm-specific dummies; a time trend variable.

Using this methodology on pooled annual data sets spanning more than a decade, it was found that the US local service and trunk airlines between 1970 and 1981 (Caves, Christensen and Tretheway, 1984); and the Canadian airlines (Gillen, Oum and Tretheway, 1990) between 1964 and 1981 both showed approximately constant RTS for the industry as a whole and for point estimates. Both studies, in contrast, showed definite RTD using the total cost function: at the mean of the data, the US RTD was 1.24 and the Canadian RTD was 1.18 on a much smaller average airline size. The US variable cost RTD was, however, only 1.17 at the mean, compared with 1.49 for the Canadian airlines. The result for Air Canada, which was the only Canadian carrier of comparable size to the US airlines, was similar to the mean US result. The study of Canadian airlines also showed Air Canada to be the only airline with less than constant return to size and to have the worst over-capitalisation: the higher mean RTD for the variable cost case showed all the airlines on average to be rather over-capitalised. Incidental findings of the Canadian study were: significant charter business did not improve
cost-efficiency; the cost functions for the small Canadian regionals was similar to the larger US carriers; the annual gain in technological efficiency was 1.7 per cent; there were no significant effects associated with particular firms, probably because the changes within each firm over time were greater than the differences between firms.

Although some confidence about the transferability of results may be gained from the close similarity of the US and Canadian results, the situation in the UK airline industry is rather different. The absolute sizes are greater than in Canada, the majority of operations are international, there are important differences in operating parameters and very different constraints exist on network development: in particular, access to the prime market of Heathrow is not open to most UK carriers. Only a cost model specific to the UK airlines (strictly for all operations into the London airports) is likely to throw any reliable light on the efficient use of those airports. A UK airline model has now been constructed (Ndoh, 1990), using a methodology essentially similar to the Canadian study on a pooled data set of eight predominantly scheduled airlines between 1976 and 1987.

The UK airline total cost function gave an RTS of 1.16, which rose to 1.24 when the firm-specific dummies were removed: the former value may be compared with approximately unity in the Canadian study. Similarly, the UK airlines' RTD of 1.21 with firm-specific effects included may be compared with 1.18 for the Canadian airlines. The total cost function results for individual airlines are given in Table 5.3. British Island Airways, Brymon and Logan Air were also included in the analyses for the years when data were available: their RTS and RTD fell between the extremes of the other airlines.

It can be seen that there are substantial differences between the UK and Canadian results. Most noticeable are the positive returns to scale still to be enjoyed by British Airways compared with the scale diseconomies of Air Canada. Equally noticeable are poor RTS of the smaller airlines without access to Heathrow, while the small Canadian carriers
TABLE 5.3:  RETURNS TO SCALE AND DENSITY OF UK AIRLINES

<table>
<thead>
<tr>
<th>Airline</th>
<th>Return to Scale</th>
<th>Return to Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Airways</td>
<td>1.25</td>
<td>1.94</td>
</tr>
<tr>
<td>British Caledonian</td>
<td>1.18</td>
<td>1.15</td>
</tr>
<tr>
<td>British Midland</td>
<td>1.03</td>
<td>1.14</td>
</tr>
<tr>
<td>Dan Air Services</td>
<td>0.71</td>
<td>1.34</td>
</tr>
<tr>
<td>Air Anglia/Air UK</td>
<td>0.77</td>
<td>1.07</td>
</tr>
</tbody>
</table>

Source: Ndoh, 1990

have constant RTS. The RTD of all the carriers is much more similar to the Canadian experience, again with the outstanding exception of British Airways' RTD of 1.94. It is likely that the further benefits to BA of increasing its network size are associated with the synergy of its Heathrow hub, both from feeder traffic and the concentration of traffic for a given number of points served which is inherent in this form of operation.

The even greater returns available from continuing to increase output within the existing network (ie RTD) are even more likely to be due to these factors. The smaller airlines, with poorly connected stations, have failed to demonstrate RTS and little RTD, probably because of an inability to compete in the prime and dense markets. British Midland, with its relatively unconstrained access to Heathrow, has been able to demonstrate a similar cost function to those of North American carriers, though its RTD since 1983 has been lower than previously. This latter characteristic is shared by the other smaller airlines, perhaps further indicating that their market opportunities have mostly been used up, other than the creation of their own hubs or greater access to Heathrow.

These results suggest that the only UK airline which could lower its costs by fragmenting its services to more than one London airport might be BA, but that it would achieve an even better return if it could expand its output by the same
amount without significant change in its network. British Airways estimated that expansion at Stansted rather than within Heathrow would require between 19 per cent and 32 per cent more aircraft and between 5 per cent and 8½ per cent increase in annual operating cost (British Airways, 1983). British Midland should definitely attempt to increase its density faster than its scale, while the smaller airlines should be attempting to increase density even at the expense of scale: their opportunity to do this could well be to expand at a secondary London airport rather than attempt to gain access to Heathrow, unless by using Heathrow, they can expand density much faster. The success of these smaller ventures is likely to be rather long term, so there are no apparent arguments based in airline costs for further fragmentation of either London's airport system or of the individual airlines' operations at them.

Effects of network shape

There are many ways in which an airline can choose to provide service to an array of airports (Pollack, 1982), a pure single hubbing network being the minimally connected option (Chou, 1990). The progressive consolidation of traffic at hubs saves on aircraft miles and movements, as well as benefiting from the lower seat kilometre (km) costs of larger aircraft. However, each passenger travels further than when using a direct link and the percentage of passengers receiving non-stop or direct service reduces as hubbing develops.

Operationally, a hubbing airline has the advantages of close control due to the frequent return of the aircraft to the hub base. On the other hand, most of the aircraft and crews have to be located at the out-stations (or 'spoke' airports), and most of the online maintenance also must be done there (Trautmann and Paran, 1988). Also, due to the necessary concentration of departures and arrivals into waves (or 'complexes') at the hub, the utilisation of runways and gates tends to fall. Some commentators feel that there are extra hub station costs due to excess utilisation of facilities during the hubbing peaks, and that the whole network is
vulnerable to any weather problems at the hub (Wheeler, 1989).

Despite these potential disadvantages, the US domestic airlines have taken advantage of deregulatory freedom to develop the concept of hubbing to an extreme degree, American Airlines now having six hubs (Horner, 1989). Not only have their original bases been strengthened, but new hubs have been established to improve geographic coverage for trips which would have required a highly circuitous routing over the earlier bases.

As shown above, operating costs per passenger km decrease as stage length, aircraft utilisation, aircraft size, load factor and route density rise. Hubbing will have a beneficial influence on the latter three items, but its effect on stage lengths and utilisation may well have adverse cost implications. Also, due to the increased transfer opportunities and to increased circuity, the total traffic will tend to grow so that, if there are economies of scale, unit costs would fall. Network density, in terms of the average traffic per station, will tend to increase but the distribution of the density through the system will be very skewed towards the hub, making it difficult to predict the overall effect of hubbing either on unit costs or, more importantly, on total system costs for a given loading on the network.

There is some evidence that hubbing provides the lowest direct operating costs for a wide variety of network situations when station costs are ignored. The numerical results for a very simple network are given in Figure 5.3, indicating how the economies of route density outweigh the effects of increased circuity for a wide range of situations. The cost relationship used, i.e.

\[
\text{Cost per seat kilometre} = 8 - 0.015/\text{km} - 0.001/\text{seat}
\]

follows the general form of a model developed for the European Civil Aviation Conference (ECAC, 1984). The operation consists of services linking a remote station 0, a
FIGURE 5.3a: RATIO OF COSTS OF DIRECT FLIGHTS TO HUBBING-
OA=100,OB=200,AB=500 TRIPS PER WEEK

FIGURE 5.3b: RATIO OF COSTS OF DIRECT FLIGHTS TO HUBBING-
DEMAND ON ALL SECTORS AT 200 TRIPS PER WEEK
small city A and a large city B. The distance D between A and B, the ratio x of the distances OA and AB and the angle Δ between links OA and AB are all allowed to vary. In almost every location of the remote traffic point O, it is cheaper to consolidate traffic at A rather than fly direct to the main city B. Another study, of the minimum network costs to link cities on the periphery of a circle around a central point (Jeng, 1988), showed that each peripheral point was best served by split routing, i.e. by hubbing to all points except those within 25° - 50° of the city's own location on the circle, those remaining points being served by direct connections.

A minimally connected network (i.e. the maximisation of hubbing) is always likely to be the cheapest way of satisfying demand when there is heavy investment in line infrastructure, e.g. rail systems. The above results show that, even when there is little line infrastructure, the operating economies of density still encourage hubbing to minimise the cost of satisfying a given demand. It is also possible to estimate the number and location of hubs required to sustain a minimally connected, minimum cost network (Chou, 1990).

In fact, airlines do not in general choose to develop minimally connected networks, preferring to retain some routing flexibility. In any case, the total network cost models reviewed above oversimplify the treatment of operating costs: the effects of out-station basing of aircraft are not considered, nor are the effects of the peaky nature of the traffic at out-stations and the hub-station. However, an indication of the practical implications of hubbing on costs can be obtained by examining the various cost studies performed on the industry in North America as it took advantage of deregulation to restructure itself. The airlines initially dropped small communities from their networks and later added larger cities (Meyer and Oster, 1987), often by the acquisition of other carriers. The traffic consequently grew more quickly than the points served, so increasing network density as well as scale.
The significant unexploited economies of density found in the above-quoted Total Cost Function studies, in both the US and Canada, appear to lead to the conclusion that "A properly designed hub and spoke system, which effectively increases the density on any given network link, could be desirable from a cost point of view" (Gillen, Oum and Trethaway, 1985, p.150). It is not, however, immediately obvious that hubbing increases network density rather than merely redistributing the same traffic (i.e. the same number of person trips) over the same points. A further warning to the smaller carriers with ill-defined market areas is the fate of the smaller trunk carriers in the US, who have been overstretched by their networks in comparison with the main trunk and local carriers (Bailey and Williams, 1988).

Another study (Caves, Douglas W. et al, 1987) attempts to measure changes in the US industry's Total Factor Productivity (TFP) prior (1970-1975) to and post (1976-1983) deregulation in comparison with that of a control group of non-US airlines over the same period. The results indicate that US industry had been improving efficiency more slowly than non-US airlines prior to 1975, but, as it grew and reorganised, strengthening its hubbing characteristics, its rate of increase of efficiency surpassed that of the non-US airlines. The same study also attempts to isolate effects of changes in operating characteristics like scale, density and utilisation, from changes in technical efficiency, the former representing movements along the cost function while the latter reflects shifts of the function. It does this by constructing a Variable Cost Function in the translog form, following the methodology of the study described previously. The results, shown in Tables 5.4, indicate that US airlines' annual rate of decrease in unit costs due to operating characteristics was improved by 0.4 per cent through deregulation, while non-US airlines worsened by 1.1 per cent, i.e. US airlines improved by 1.5 per cent relative to non-US airlines. The US rate of improvement due to technical efficiency fell by 0.1 per cent absolutely, but rose by 0.5 per cent relative to non-US airlines. Thus, the majority of the improved efficiency appears to come from operating factors, which may well be associated with increased hubbing.
TABLE 5.4a: AVERAGE RATE OF GROWTH PER YEAR OF OPERATING CHARACTERISTICS OF US AND NON-US AIRLINES

<table>
<thead>
<tr>
<th></th>
<th>Prederegulation</th>
<th>Postderegulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>U S</td>
<td>Non-U S</td>
</tr>
<tr>
<td>Output</td>
<td>4.1</td>
<td>9.9</td>
</tr>
<tr>
<td>Load factor</td>
<td>1.4</td>
<td>0.7</td>
</tr>
<tr>
<td>Stage length</td>
<td>0.6</td>
<td>2.0</td>
</tr>
<tr>
<td>Points served</td>
<td>1.0</td>
<td>0.6</td>
</tr>
<tr>
<td>Stock</td>
<td>2.2</td>
<td>8.9</td>
</tr>
</tbody>
</table>

TABLE 5.4b: AVERAGE ANNUAL PERCENTAGE DECLINE IN UNIT COSTS AND SOURCES OF UNIT COST FOR US AND NON-US CARRIERS FOR PRE-AND POST Deregulation PERIOD

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating characteristics (1)</td>
<td>1.8   3.1</td>
<td>2.2   2.0</td>
</tr>
<tr>
<td>Technical efficiency (2)</td>
<td>1.2   1.4</td>
<td>1.1   0.8</td>
</tr>
<tr>
<td>Total productive efficiency</td>
<td>(3) = (1) + (2)</td>
<td>3.0  4.5</td>
</tr>
</tbody>
</table>
However, the logic of using non-US international carriers as a control, ie as a proxy for a counter-factual estimate for the domestic US industry, could well be questioned. In 1983, European airlines were 19 per cent less productive than US domestic airlines, due largely to having a 24 per cent less dense network and 11 per cent higher costs due to government ownership, but ameliorated then by 14 per cent lower labour costs (Windle, 1991).

An attempt to isolate the effects of hubbing on unit cost has been made by McShan and Windle (1989). They constructed a variable to indicate the extent of hubbing, defined as the proportion of an airline's total departures leaving from the three per cent most utilised airports in the airline's network, the maximum feasible value being approximately 0.5. They then purport to use the same methodology as Gillen et al (1990) to estimate a Total Cost Function, though apparently ascribing 'technology' and 'airline characteristic' labels rather differently and not differentiating between route density and system density. The results are compared in Tables 5.5 with an earlier study where the hubbing element of the network characteristics was not made explicit. Elasticities are given in Table 5.5a, showing that adding points (airports) increases costs while more pronounced hubbing reduces costs. The implicit presence of the hubbing index in the points variable of the earlier study may explain its lack of significance. A one per cent increase in the hubbing index appears to cause a reduction in cost of 0.11 per cent. Table 5.5b shows this to be reflected in a greater Return to Density than had previously been estimated. Note that the inclusion of data for a longer period of deregulation also appears to have exposed some Return to Scale. Incidentally, this Return to Scale, and also the effect of hubbing, are both less pronounced when a Variable Cost Function is analysed.
TABLE 5.5: THE EFFECTS OF HUBBING ON NORTH AMERICAN AIRLINE COSTS

(A) FIRST ORDER COST FUNCTION RESULTS
(Standard errors in parenthesis)

<table>
<thead>
<tr>
<th></th>
<th>CCT 1970-81</th>
<th>CCT 1970-84 Without Hubbing</th>
<th>CCT 1970-84 With Hubbing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>.804 (.034)</td>
<td>.801 (.030)</td>
<td>.739 (.034)</td>
</tr>
<tr>
<td>Labour Price</td>
<td>.356 (.002)</td>
<td>.347 (.002)</td>
<td>.347 (.002)</td>
</tr>
<tr>
<td>Fuel Price</td>
<td>.166 (.001)</td>
<td>.174 (.001)</td>
<td>.174 (.001)</td>
</tr>
<tr>
<td>Capital - Material</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>.478 (.002)</td>
<td>.479 (.002)</td>
<td>.479 (.002)</td>
</tr>
<tr>
<td>Stage Length</td>
<td>-.148 (.054)</td>
<td>-.029 (.052)</td>
<td>.069 (.057)</td>
</tr>
<tr>
<td>Load Factor</td>
<td>-.264 (.070)</td>
<td>-.348 (.078)</td>
<td>-.302 (.080)</td>
</tr>
<tr>
<td>Points</td>
<td>.132 (.032)</td>
<td>.033 (.033)</td>
<td>.126 (.046)</td>
</tr>
<tr>
<td>Hubbing</td>
<td></td>
<td></td>
<td>-.115 (.048)</td>
</tr>
</tbody>
</table>
(B) RETURNS TO DENSITY AND SCALE
(Standard errors in parentheses)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Returns to Density</td>
<td>1.24</td>
<td>1.25</td>
<td>1.35</td>
</tr>
<tr>
<td></td>
<td>(.053)</td>
<td>(.047)</td>
<td>(.063)</td>
</tr>
<tr>
<td>Returns to Scale</td>
<td>1.07</td>
<td>1.20</td>
<td>1.16</td>
</tr>
<tr>
<td></td>
<td>(.049)</td>
<td>(.052)</td>
<td>(.060)</td>
</tr>
</tbody>
</table>

Source: McShan and Windle (1989)

The results of McShan and Windle appear to be in direct conflict with those produced in a study by Hansen and Kanafani (1989). Having distinguished between 'link economies of scale' associated with service characteristics and 'node economies of scale' associated with indivisibilities in station operations (which would create cost advantages for airlines that concentrate their flights), Hansen and Kanafani appear to show that the improvements over time are due almost entirely to 'link' rather than 'node' economies. The interpretation of their analysis is, however, complicated by the fact that one of the variables regarded by them as a 'link' characteristic, load factor, is actually directly influenced by hubbing. A US Department of Transportation study found that at the six most concentrated hubs where the dominant carrier had a 75 per cent or greater share of enplanements, the seat load factor advantage for the dominant carrier averaged over nine percentage points (Avmark, 1990). This may well be an inevitable consequence of hubbing, rather than any manipulation of traffic flows. The variability in traffic on a thin sector will always tend to be higher than if that sector traffic is augmented perhaps 400 per cent by feed from 30 other points. There will also be a frequency effect on load factor, and frequency will tend to increase with hubbing.
A fundamental difficulty with all these attempts to analyse changes in airline efficiency is that universally they use passenger miles or ton miles as the measure of output, against which they measure total cost. In fact, these output measures are automatically inflated for those airlines which increase hubbing, despite the total proportion of connecting passengers remaining constant at 25 per cent since before the deregulatory era (Villiers, 1989a). Thus, the cost efficiency per passenger journey may be much less satisfactory. The theoretical total network models reviewed earlier suggest that, in fact, hubbing does provide the minimum cost system, even when increased circuity is taken into account, but they ignore station costs. However the cost equation is resolved, it is likely that the main benefits to the airlines of hubbing are associated, not with any increased ability to control costs, but are rather to be found either in being able to create the perception of an improved product or in domination of markets and the creation of barriers to entry. The former implies a benefit to passengers while the latter implies a disbenefit.

MARKETING FACTORS

Network access

The advantages potentially beneficial to passengers which flow from hubbing are seamless single carrier service, higher frequencies, lower fares and more non-stop service. To take the last point first, since Piedmont developed its hub at Charlotte, the citizens of Charlotte have benefited from a 132 per cent rise in the cities they could visit on a non-stop flight (Avmark, 1990). By February 1991, the top 1,000 city pairs were also receiving much higher frequency than could be expected from their local traffic base.

Surprisingly, it is not only the hubs which have seen increased opportunities for non-stop flights and increased accessibility. Competition between hubs has resulted in many small spoke cities having direct service to several out-of-state hubs, rather than a single trunk service to their regional central place. Between 1984 and 1989, Bangor's
number of weekly departures remained constant, but intrastate seat miles fell 80 per cent, while interstate seat miles increased by 140 per cent (Horner, 1990). Fort Myers now has direct service to 22 out-of-state points: the strong feed to Tampa for connection to the same points has been cut back dramatically, as have regional services to the other airports providing out-of-state services. The passengers have therefore benefited in most cases by more direct service to more places on a single ticket. Moreover, they have often been compensated for any increased circuity by discounts associated with the number of miles flown - the so-called 'frequent flyer' programmes. This is borne out by recent research showing that competitive hubbing among a number of carriers has reduced the previous high spatial concentration of accessibility (Chou, 1993).

**Fares**

It is much harder to justify hubbing in terms of value-for-money fares. Earlier claims that fares have fallen under deregulation (Morrison and Winston, 1986) are challenged on the basis of faulty counterfactual comparison (Dempsey, 1990). When allowance is made for the difference in oil prices and the greater circuity, fares in real terms appear to have regained pre-deregulation levels, while the product has deteriorated, ie the discounted fares which the former analysis uses reflect purchase restrictions as well as more transfers. On the other hand, frequent flyer programmes have given additional discounts (Morrison and Winston, 1989).

It also appears that fares per mile are much higher for local boardings at a hub than for multi-sector fares across a hub - a situation defended by American Airlines on the basis of the better level of service. This differential was noticed by the US Department of Transportation (DoT) in 1989 (Ott, 1990). The eight most concentrated hubs had air fares that were on average 18.7 per cent higher per passenger mile than at other airports, some of the highest being to large cities up to 1,000 miles away. Similar results have been noticed in other analyses (Borenstein, 1989; Morrison and Winston, 1989; GAO, 1991). A Boeing study, which took more explicit account
of the effects of stage lengths by normalising the yields on the standard industry fare level, similarly found originating yields substantially greater than yields from connecting traffic at concentrated hubs (Donoghue, 1988). While the latter study principally points out only that airlines operate a form of prorating even for on-line transfers or transits, the DoT study questions why the prorating should be deeper as the hub becomes more concentrated.

**Competition and fortress hubs**

It may well be that the real attraction of hubbing for airlines is to create a barrier to entry, ie to diffuse the contestability of the market, by dominating local and regional markets (Phillips, 1987). The industry as a whole became more concentrated between 1977 and 1984. Defining a 'major' hub as one which accounts for 10 per cent or more of a carrier's total enplanements, the major hubs moved from 20 per cent of total domestic enplanements to 31 per cent and from 15.6 per cent of total departures to 24.5 per cent. Equally, there has been increasing hub domination by individual carriers such that, by 1984, the percentage of total revenue passenger miles involving interlining had fallen to 10 per cent (Phillips, 1987). Even by 1980, over 87 per cent of all passengers Eastern and Delta brought through Atlanta en-route for other destinations stayed on the same airline for the next leg (Aviation Week, 1981).

Many US carriers have achieved a high percentage of total enplanements at their hubs (Brenner, 1990). However, the hubs, in consequence, not only had more nonstop destinations but they also had more routes with competition than did non-hubs. The high enplanement percentage is usually not repeated in terms of local passengers: Delta in 1990 had 79 per cent of the enplanements at Salt Lake City, but 70 per cent of the 79 per cent were connecting; Delta only carried 58 per cent of local originating passengers (Callison, 1991). Certainly a General Accounting Office study shows that the number of non-competitive routes has grown faster than total destinations from 15 concentrated hubs (Flint, 1990), but these are generally destinations which could not otherwise
have direct service.

Hub domination appears to allow sector domination, the airlines thus establishing local monopolies. A study by Higgins and Toh (Wheeler, 1989) regressed a profitability index against a sector monopoly index and found that, for every per cent increase in the latter, profitability increased by 17.7 per cent: the profit index was the operating ratio (ie 100 times the ratio of operating revenue to operating cost) while the monopoly index was the percentage of unduplicated non-stop flights - it would probably have been better to use the unduplicated route mileage.

At the same time, a one per cent increase in the share of originations at an airport is estimated to cause an increase in share on a route of up to 0.33 per cent, depending on the share of the route that the carrier already possessed (Borenstein, 1989). Domination of both sectors and airports is then mutually reinforcing, though this local domination can only be achieved in a deregulated setting if the hub location is well chosen and the role it is to play has been correctly identified.

General route development

Much attention has been paid to hubbing and the concentration of services. Less noticeably, there has also been a strong fragmentation of air services. As shown in Chapter Three, many new services have developed between the UK and the continent, while at the same time the traffic has become more concentrated (Caves and Higgins, 1993). Although long-haul route dispersion has been a fact of life for a long time (Pilarski et al, 1983), the advent of the overwater long range twin engined aircraft has caused a dramatic increase in direct international services where bilaterals have allowed it. This is exemplified by the rapid growth in US - Asia flights bypassing Tokyo. American Airlines is so committed to long haul fragmentation and frequency that its chairman predicts it will never need a 600 seat aircraft (Aerospace, 1991): it was even prepared to fly into all three London
airports, though it has since withdrawn from Stansted due to poor loads relative to the station costs.

The Civil Aviation Authority (CAA) in the UK uses the principle of fragmentation when it models the introduction of new regional routes (CAA, 1989a), though not attempting to take account of airline strategy in that analysis. Following their experience of airline behaviour, the CAA model triggers new routes when 80 per cent or so of the city pair forecast reaches, say, 10,000 passengers per year, the remaining 20 per cent being presumed to opt for higher frequency and other perceived advantages of connecting flights. Airlines which already benefit from consolidation of traffic at a hub will tend not to start thin direct services in this way unless their hub is already at the desired frequency and they do not wish to increase their aircraft size, or unless the hub is suffering from congestion. This often may be a strong argument against the opening of routes to new international gateways where the existing gateway is the main hub for the flag-carrying airline. For example, direct charter flights to Greek islands dilute the transfer traffic at Athens and hence the domestic monopoly traffic of Olympic Airways and Olympic Aviation. Indeed, it has been suggested that non-liberalised carriers will have to influence their governments to disallow dispersion by liberalised carriers into non-hub cities in their home regions, and so avoid competition on low density routes (Levine, 1990).

Dilution of domestic traffic did not stop the introduction of new gateways in the US, where, while traditional gateways have tended to lose share, they have still increased their traffic (Meyer and Oster, 1987). The domestic system as a whole will have lost passenger-kilometres, but, since the new gateways did, and still have followed airlines' hubs, individual airlines may well have gained more feed revenue than they lost, ie the fragmented international traffic will not have been only local to the new gateway.

The domestic US market has now settled into an equilibrium state following a period when increasing concentration occurred side by side with increasing new route starts. The
unexpected benefit of new direct services being initiated to provide small city feed to new hubs means that most of the trunk airlines see little opportunity for more direct service, despite the strong passenger preference for direct flights noted in Chapter Four. At Columbus, 70 per cent of the passengers were local to the 29 hubs served and a further 10 per cent were catered for by direct service to La Guardia and Washington National (Callison, 1991). The other 19 of the top 50 destinations were non-hubs, but only an average of 37 passengers per day were reaching each of those destinations via a hub in lieu of direct service. This is much too low to justify direct service. Those destinations which might justify direct service have almost invariably already become hubs. On the other hand, other commentators believe that new direct services would be an important way of establishing a product differentiation while taking advantage of new small jet technology and avoiding hub congestion costs, the so-called 'hub busters'. Use of the national 10 per cent ticket sample to analyse the traffic between the 50 largest metropolitan areas in the US in April 1985, allowed 70 viable city pairs without non-stop service to be identified (Schwieterman and Spencer, 1986). Of the 18 cities which appeared more than three times, 14 were non-hub cities. Boston appeared nine times. The scope for an entrepreneur depends on successful direct market penetration in competition with megacarrier hubbing alternatives. At least during the current recession, the battle seems to be favouring the low cost non-hubbing recent entrants: they have been able to show profits while the majors have suffered huge losses (Nocella, 1993). A crucial factor is that they have been able to control their costs even on short sectors.

Multi-airport hubs

A special case of fragmentation is that between several airports in a single metropolitan area. Sometimes it occurs naturally as in new city pair markets because of an opportunity to serve a particular market due to ground congestion difficulties within the metropolitan areas. While there is no noticeable geographic discrimination in trip generation between Heathrow and Gatwick within the central
London area, the rationale behind the development of London City Airport has been to capture the business traffic whose origin is nearer to London City Airport than any other. Access advantages have also spurred the regeneration of other down-town sites (e.g., Chicago Midway, Toronto Island, Dallas Love Field, Belo Horizonte Cumbica, Belfast City) and the multiple route services between Los Angeles and San Francisco. Sometimes a low cost operator, again as in competing hubs, wishes to avoid head-to-head competition and takes the alternative less developed airport (e.g., Peoples Express at Newark). Product differentiation, e.g., with the low fare travellers' lack of sensitivity to access time, can often overcome the adverse effects of remoteness and Renard's theory of the relationship between frequency and market share (de Neufville, 1972).

Service by an airline to multiple points within a single city may also be part of a strategy to retain overall market share in the face of a competitor's exploitation of a secondary airport. Thus airlines in the US normally serve at least two of the New York airports at moderate frequency rather than dominating just one airport with high frequency (Caves, 1990). In London, Air France or its subsidiaries has chosen to serve all the airports; Aer Lingus and Ryanair serve two airports each as a result of Irish government policy. BA, Lufthansa and Air France are now all serving Newark daily without diluting their traffic through New York's Kennedy (Lefer, 1990). Countering this willingness to fragment is once again the desire for concentration of small carriers in order to gain a share of the major airport market, as shown by the moves from Gatwick to Heathrow by Virgin once the limitations on new entrants were removed.

**Airline and passenger behaviour**

All the above examples of fragmentation within a metropolitan area are cases of market advantages overcoming the economies of network concentration, identified earlier.

A US study (Kanafani and Ghobrial, 1985), which modelled an airline's profitability as it modified its hubbing strategy
in response to passengers' choice of routing, suggests that both airlines and passengers gain by supporting strong hubs. The routing was estimated by a multinomial logit model whose choice function was sensitive to travel time, frequency, economy air fare, aircraft size and exogenously determined connectivity dummies [the model implying that the difference between a non-stop and a connecting flight was worth about two hours of travel time: this compares with other work which suggests that one hour of transfer time is worth 2.3 hours of travel (Morrison and Winston, 1989)]. The hub was assumed to be working with a delay function which was proportional to the cube of the traffic flow. The landing fees at this hub (Atlanta) for a typical aircraft were allowed to vary from the actual $50 by the imposition of a congestion toll where $1,800 was the equivalent of a 50 minute delay. The toll was recovered by increased fares, so that fewer passengers chose to connect. Only seven new direct links were predicted in response to a 36 times increase in landing fee. The implied elasticity for hub flights was therefore only -0.148 to -0.38. Airline operating costs were predicted not to change greatly, since the load factor would rise and the frequency would fall. On the basis of this study, airlines at congested hubs should allow fees to rise to pay for capacity increases while avoiding congestion costs, though there was no apparent check on the ability of the toll to fund the required capacity.

Hansen has shown a certain amount of success in predicting airline strategies with respect to hubbing and frequency, using game theory with profit-maximisation as the goal (Hansen, 1990). He was able to do this with straightforward application of a passenger route choice model to industry fares and costs, without resorting to further calibration constants for airlines or airports. This gives some hope that airlines are not deliberately manipulating their passengers away from fragmented services when reinforcing their hubs, presumably because the direct traffic would have been too thin to justify service (the minimum size aircraft allowed in Hansen's model was a 737). However, applying a Hansen-type model to US - Asian fragmentation, it was found that there were fewer than expected flights to gateways other
than Tokyo Narita in 1985, despite congestion there (Hansen and Kanafani, 1989). If costs at Narita increased by 40 per cent, they had expected at least half of the transfer traffic to avoid Tokyo. A different approach to modelling an airline's choice of hubbing strategy for gateway services (Hansen and Kanafani, 1988) also comes to the conclusion that an airline can best maximise its market share by reinforcing its primary hub rather than by fragmenting service.

AIRLINE DEVELOPMENT STRATEGIES

Congestion and decentralisation

The development of hubbing in the US seems to have raised the frequency of service between major cities and increased direct connections from small cities to competing hubs without having cost the passenger a significantly higher fare. It has, however, caused congestion at the main hubs, which, given that most models predict that airlines, other things being equal, would be better off expanding their main hub, must be one of the reasons for the proliferation of hubs. While it appears that congestion pricing could raise the revenue for expansion without unduly inconveniencing the incumbent airlines, the system of funding for infrastructure in the US has not made it easy to adopt this solution.

This reasoning does not take into account the incumbent airlines' resistance to an expansion which would simply mean that their revenue would be used to allow greater competition. Bluntly, the megacarriers would rather invade the competitors' territory via a new hub than open the door to a new entrant at their own base. While the FAA forecasts tend to predict further traffic at major hubs, and hence justify further expansion there, other forecasters claim that the hubbing system has distorted traffic figures and that airline decisions will determine the future distribution of transfer (or 'soft') traffic (ASRC, 1990). It is argued that the mergers which have created megacarriers will reduce competition and therefore traffic growth at major hubs, but that traffic patterns will shift to the secondary cities, reflecting demographic and information changes and requiring
extra capacity there. The 'soft' traffic should be considered over a range of scenarios applicable to each major hub, considering the incumbent airline's strengths, commitment and potential strategies, together with the characteristics of the city and the hub's competitive position. Such analysis points strongly to the weaknesses of the waypoint concept advanced recently by the FAA (Street, 1989).

However, in a later paper, the same forecasters introduce the concept of a continuous hub (ASRC, 1991). In this, it is argued that the high unit cost of the megacarriers, caused by poor utilisation of aircraft and the hub airport, can be reduced by random scheduling of aircraft rather than allowing the strict 'banking' of connections to determine the schedules. Then the aircraft and airport facilities would be continuously in use, throughput would rise substantially with the same level of investment and the turnaround time would become more important. Connection times would be minimised by increasing frequencies, so that the average aircraft size would fall. Only the largest hubs would be able to operate in this way, so the implications are that there would be less of a requirement for a proliferation of smaller hubs, and an even smaller need for wayports.

**Mergers and competition policy**

In essence, the dominant airlines at the largest European hubs, ie those with the greatest congestion, already operate in this continuous flow fashion. Competition is offered only by the 'spoke' services of reciprocating foreign carriers on a route-by-route basis.

It is likely that this hub dominance will be enhanced by alliances and mergers between airlines, if these are allowed by the regulators. Alliances have offensive benefits in that they increase network coverage and improve frequency competitiveness, and defensive benefits in the ability to consolidate resources. Equity stakes ensure a seat on the Board, but expose the raiding carrier to the financial weakness of the carrier being raided (eg KLM and Northwest).
A full merger emphasises both the strengths and weaknesses of alliances, and requires even more flexibility on the part of the regulators (e.g., BA and US Air). The weaknesses, over and above the regulatory ones, are the difficulties of harmonising the products and the possibility of clashes of interest as multiple alliances are forged.

The extent to which such initiatives, to further consolidate the airline industry, are sought by the carriers and allowed by the regulators will help determine the shape of the air transport network and hence the relative growth in traffic of the airports they choose to serve. The airlines are already shuffling themselves together on a global scale, despite the severe regulatory constraints presently imposed on this activity (O'Toole, 1993).

Air carriers tend to differentiate their products on the basis of quality, which correlates quite well with higher yields and lower load factors (Gialloreto, 1992). It is likely that alliances will be sought between carriers with similar views on their brand image, but other considerations will be the extension of global networks, to protect the market share, and the desire to dominate local regional markets. The first two of these philosophies make it sensible for the major American carriers to align themselves with large, high quality European and Far East carriers - the Americans have huge narrow body fleets but lack wide body long haul fleets and intercontinental operating experience (Mifsud). The domination of local regional markets has been achieved by Air France, with its control of UTA and Sabena.

It is foreseen that today's European high cost scheduled carriers will have to lower costs if they are to survive (Gialloreto, 1991). The chairman of SAS believes that costs must fall by 40-50%, even before taking advantage of further economies of scale from alliances (Noble, 1993). In addition, the generic strategies which are expected to lead to success are development of the home hub, alliance with commuter feeder airlines, formation and expansion of charter subsidiaries and growth outside Europe. Less successful airlines, particularly the smaller and more protected ones,
are predicted gradually to lose market share: becoming non-viable in their own right and unattractive to a potential buyer. In contrast, the more efficient of the smaller scheduled carriers will be very attractive to larger survivors or global carriers. Today's charter carriers have the choice between merger through their tour operator owners (e.g., Airtours/Owners Abroad), global expansion of their core charter business (e.g., Britannia's long haul routes and 767 fleet) or conversion into a scheduled carrier. The latter course is seen to be difficult since Air Europe's attempt which ended in bankruptcy, but the charter carriers have modern fleets and low cost product distribution systems. They might be able to use these to set up low cost second-generation scheduled hubs at second airports in major centres or primary airports in smaller centres, (Gialloreto, 1992), particularly if they align themselves with a smaller, efficient scheduled carrier for the transfer of management skills.

In Europe, the debate will continue about how best the consumer can be served: can local competition be allowed to survive at the risk of diluting a major carrier’s ability to compete globally? It is held by many that the recent mergers within Europe (e.g., BA / British Caledonian / Dan Air) create further strategic obstacles to contestability through the possibilities of geographical price discrimination. The fear is that, together with the existing structural barriers to contestability through hub dominance, ground handling monopolies and computer reservation system bias, these strategic obstacles will deny liberalisation any impact on the present high cost system (Barrett, 1992).

In contrast, a senior commentator on the industry believes that the trend to 'economic disengagement' by governments has four irreversible aspects: liberalisation, privatisation, foreign ownership and multilateral regulation (Wheatcroft, 1992). Foreign ownership is seen as being the fundamental issue, so that the CAA chairman's fear that industry concentration would lead to the major carriers gaining a near monopoly in their home markets is irrelevant, since the creation of an oligopoly of truly multinational companies is,
then, as inevitable as in any other industry, and their operation within a fully-developed multilateral regime would mean that there would no longer be such a thing as a 'home' market. Further, "the best protection of the interests of travellers would be the assurance that all 'home' markets were completely open to airlines of any or no nationality".

The various directorates of the EC have much progress to make before they can align themselves fully to this philosophy, and many individual members of the Community do not hold the view. However there are signs that airlines are starting to take seriously the new route freedoms available since 1 January 1993. Many regional subsidiaries of major carriers are springing up to serve those routes which are too thin for the majors themselves to serve with their high cost structures (Guest, 1993), eg Lufthansa City Line (Hill, 1992). BA has been buying stakes in other countries' regionals, eg TAT or creating a new regional, eg Deutsche BA to secure a presence in competitors' markets, - the TAT deal, by virtue of the majority BA stake, being the first to take advantage of the freedom to operate from another EC country. The success of the thinner regional routes will depend on the major airlines' views as to the value of these services to their hub synergy and also on the financial viability of the newly available 50 seat jets, these allowing the longer distance feed. They may make all the difference to an emerging peripheral hub like Glasgow.

Meanwhile, there are signs from the profitability of Southwest Airlines while all the US majors are posting record losses, that the airline which carefully selects its markets, controls its costs per mile and lowers its fares accordingly can take a very substantial niche without fortress hubs and large CRS systems (Flint, 1993).
CHAPTER 6: SOCIETAL COSTS AND BENEFITS

INTRODUCTION

As aviation moves further into a liberal free market, it needs to sell its products as fiercely as do other industries. Since its growth has substantial national policy implications, it must direct itself not only to the ultimate user but also to policy makers. Society as a whole must see the need for growth if the policy makers are to be persuaded to allocate the resources required to support further growth. Furthermore, society must be persuaded that the need is worth the full social costs which will accrue from the further growth.

It has been noted in Chapter 1 that the industry is well aware of the need to strike a realistic balance between development and environmental impact, but that there seems to be a bias against air transport in the EC. (Koppert 1992) Equally, some in the airport industry believe the balance to be in the opposite direction: “As a consequence, it is vital for German airports - and for the national economy as such - that the unfortunate anti-airport trend can be reversed, that - as reflected by this decision - has reached politics and administrations as well as the public opinion in the country and that the airports can regain the necessary public support - not only of political decision makers but also of the society as a whole - for their efforts, to meet the future demands of an efficient European air transport system without, at the same time, neglecting the important environmental aspects of a further increasing air traffic.” (Nierobisch, 1990) It is the intention of this chapter to analyse the nature and validity of the two sides of the argument.

THE BENEFITS OF AVIATION

User Benefits

Benefits accrue to users and to society as a whole. Theoretically, since any transport is a derived demand and
the user would prefer not to travel in order to undertake a
desired activity, transport is only used when the benefits of
the activity outweigh the costs of travel. Air transport is
used either when it is the only way to derive a net benefit
or when it offers the greatest net benefit, the rationale
holding for both passengers and freight.

Thus, the user benefits are made self-evident by the revealed
demand. However, the benefits should not be overstated.
They extend only to the difference in utility derived from
using air transport rather than the next most convenient
mode, and can be calculated simply (Butler and Kiernan,
1988). Equally, the benefits should not be understated.
Often the whole utility of the activity could not be
experienced if air transport did not offer a sufficiently low
deterrence to travel. An extreme example of this might be
organ transplants.

The evaluation of user benefits might, in principle, be
straight-forward, but the calculation of the traditional
factors (travel time savings, operating cost savings,
accident cost savings, capital and maintenance costs) require
rigorous analysis if they are to give a realistic estimate.
When attempts are made to incorporate additional quality
factors into the evaluation, much more care must be taken to
substantiate the facts. A recent evaluation of these quality
factors (in-travel work capability, access time saving, new
opportunities for day return trips, higher service
frequencies and greater service reliability) are open to
debate (Allport and Brown, 1993). In this case, it seems
that access time savings of rail over air are not properly
justified; further, there is evidence that passengers
reschedule their activities around low frequencies at very
little cost (see Chapter 4); also, the air system delays were
taken from a very bad year, (they could be improved very
substantially by opening out the schedules as the continental
railways do); and there is no justification for the
assumption of no delay to rail.

Over and above the benefits to the users of air transport,
society as a whole benefits from the activities which become
available when the deterrence to travel is sufficiently low. Once again, however, the benefits should not be overstated. These benefits already counted as user benefit cannot be double counted on society's behalf.

The benefits to users and to society may be economic or social. Most attention has been devoted to the economic benefits, but it is by no means certain that these are more valuable than the social benefits. The economic benefits are often overstated by being in gross terms rather than net, are often double counted and are, in any case, much more easily quantified.

**Economic Benefits to society**

Types of economic benefit

Some time ago, IATA suggested that civil aviation could benefit an economy in six ways: employment, income, economic development, international trade, foreign exchange earnings and tourism. Stimulation of innovative research and aviation's role in disaster relief have recently been added to the list (Meredith, 1992; IATA, 1992). These headings offer a good example of the possibilities of double-counting benefits. A preferred grouping of benefits is balance of payments, contribution to the economy and stimulation of the economy.

**Balance of payments**

One measure which is important, particularly to developing countries, is the overall cash balance provided by transport. In the UK, as reported in the annual Pink Book produced by the Central Statistical Office, the Civil Aviation and Travel balance of payments accounts both moved into the red for almost the first time in 1986. By 1990, the Civil Aviation account was losing £0.3 billion, mostly due to a stronger growth in overseas airlines' revenue from UK passengers than vice versa. The Travel balance lost £2.1 billion in 1990 due mostly to a doubling to £8 billion in UK leisure spending abroad since 1985. The balance of payments can fluctuate,
and depends very much on where the boundary is drawn, eg much of the UK leisure spending is in the EEC.

Contribution to the economy

In an attempt to derive a more absolute comprehensive measure of economic benefit it has become fashionable to follow the example of the Federal Aviation Administration's (FAA) methodology (Butler and Kiernan, 1986) to count the contribution made to an economy by aviation, adding up the direct, indirect and induced effects. Direct impacts are the consequences of the economic activity occurring at the industry site. Indirect impacts are those that are directly attributable to, but occur away from, the site. Induced impacts are generated by the direct and indirect expenditures triggering a chain reaction through the local economy. Thus, a study for the International Air Transport Association by SRI (SRI 1990) calculates that aviation's contribution to a 22 country Europe is $200 billion and 6.7 million jobs, 22 per cent of the value and 34 per cent of the jobs being in the UK. In common with the many other studies using this methodology, nearly two-thirds of the contribution comes from the induced effects. The implication drawn by SRI from this evidence of economic activity is that, if the traffic volume becomes 10 per cent less than an unconstrained forecast, there will be $10 billion less activity per year by the year 2000, ie perhaps 3 per cent less than there would have been in the unconstrained situation. A US airport pressure group (USA-BIAS) has used a similar methodology to claim that daily service to a new US gateway from London would add at least $268 million to the local US economy in the first year (Creedy, 1991). These estimates include stimulation of exports and foreign investment of $139 million in addition to the impacts derived using the FAA methodology. Studies have also been carried out at smaller airports in the USA. In North Central Texas it was estimated that each movement at airports without air carrier service was worth $200 per operation or $110,000 per based aircraft per year to the local economy, while for Dallas Love Field the values were $9,000 and $4 million respectively (Dunbar, 1990). Summaries of other studies on Amsterdam, Charles de Gaulle, Copenhagen,
Geneva, Glasgow, Manchester, Munich II and Zurich have been compiled by AACI - Europe (AACI, 1992a), who have issued their own guide to assessing an airport's economic impact (ACI Europe, 1993).

On a much smaller scale, in 1985, East Midlands International Airport (EMA) contributed £20 million and 2,500 jobs directly to the local economy. Using an income multiplier of 1.4, a typical value for local economies in the UK, the total contribution of airport employment to the local economy was estimated at £28 million when the throughput was 925,000 passengers, 15,000 tonnes of flown cargo and more than 8,000 tonnes of trucked cargo (Caves, Gillingwater, Pitfield, 1985). The low value of the multiplier is consistent with 68 per cent of the 11,000 transacting companies trading internationally. Of the five major transactions by the companies on the airport, 29 per cent were on airport, 19 per cent in the immediate locality and 52 per cent were elsewhere. In almost every case, the transactions were linked to international companies. The main purchases were from air carriers elsewhere, aviation fuel on airport, wholesale goods locally and catering supplies elsewhere. The main sales were to air carriers on airport, air carriers elsewhere and freight carriers elsewhere. A similar study of Bristol Airport (Lees, 1990) showed a total of 663 jobs on airport year-round, two-thirds of the 53 establishments being subsidiaries of non-local companies. Transactions were performed with 2,135 companies of whom 60 per cent traded internationally. The throughput of 838,000 passengers and 82 tonnes of flown cargo (1989 data) supported a total remuneration of some £8 million and direct purchases of £15 million. Of the five most important purchase transactions made by each company on the airport, 21 per cent were on airport, 30 per cent in the immediate locality and 49 per cent elsewhere.

There is a clear difference between the total economic impact at small airports, where many of the services cannot be provided locally, and the major gateways and their associated regions. In the latter case, the large multipliers between 1.7 and 2.5 may be justified.
Even though the methodology has been recommended by the FAA, many criticisms have been levelled at the way the impacts of airport activity have been quantified. All other sectors of the economy could claim corresponding indirect effects. The multiplier argument can only be applied to rather self-contained regions, which provide little no alternative consumption. Indirect and multiplier effects can easily be double-counted (Karyd and Brobeck, 1992). The UK Civil Aviation Authority (CAA) has noted several of the more important objections (CAA, 1990). The CAA points out that there are cross effects of increased air transport on other modes, both by diversion from another mode and from increased loading of the airport access systems. More importantly, it is the additional impact of investment in airports over and above the impact which would accrue from alternative investments that matters. Also, trade and tourism operate in both directions. Not only is it the net effect which should be calculated, but the result depends on how the denied passenger would have behaved. Many of these pitfalls have been avoided in the methodology being developed by European airports (ACI Europe, 1993).

The reality of the need to include the outgoing expenditure is shown by the Japanese encouragement of overseas tourism in order to funnel back part of the huge trade surplus (Wijers, 1991). Given the preponderance of UK holidaymakers among UK regional airport passengers, the net effect on the local economy might well be negative, even though most of the holiday spending goes to UK airlines, airports and tour operators, rather than to foreign economies. Since the same discretionary spending would otherwise probably be on a UK holiday, the net effect on the UK economy of this category might be small. Similar comments have been made by the Center for Policy Research of the US National Governor's Association (Cooper, 1990). There is also no doubt that too little account is often taken of the secondary implications of change. The SRI report estimates that some of the potentially lost traffic will be carried by accepting inconvenient timings and higher load factors, but gives no credit for the increased income from the higher fares or the increased average spend per tourist due to the poorest ones
being denied the opportunity to travel. A neutral observer might draw the conclusion that Nelson was still turning his blind eye.

The most fundamental error associated with the use of the multiplier in assessing the aviation contribution to the economy is to embue the resulting linkage as having a causal quality, ie that jobs at the airport cause jobs for taxi drivers. As de Neufville said some time ago: "True enough, activities at the airport are closely tied to the whole web of urban and regional activity. But as everything is connected, the argument is totally circular." (de Neufville, 1976) The remaining direct and indirect impacts are a quite complex accounting exercise which serves simply to indicate the size of the industry relative to the rest of the economy. Thus jobs at Toronto's Pearson airport account for 1.7 per cent of all local jobs (Hickling, 1987) and the total impact of major US airports accounts for approximately 3 per cent of total regional economic activity (Wijers, 1991). The Air Transport Association of America (ATA) estimates that air transport accounts for 5.3 per cent of GNP (though it is not clear whether the 4 per cent of this which is visitor expenditure is not of US overseas tourist expenditure or how much is induced rather than direct) and it is also estimated that, despite high leakage rates, aviation accounts for 8 per cent of Hong Kong's economy (Nyaga, 1989). The numbers are often impressive in absolute terms and certainly indicate to policy makers the extent of the likely short term disruption to the economy which would follow a loss of confidence in the air transport industry. However, given the derived nature of the demand for transport, the large numbers may also prompt the question: "Should an efficient economy not run with a lower proportional spend on intermediate goods?"

Stimulation of the economy

It would be much more helpful to aviation's image to make the case that the presence of air services actually stimulates the local or regional economy associated with an airport, rather than simply being bound up with it. The FAA suggests that this effect be measured by asking firms how vital an
airport was to their location decision or what would happen to the firm if an airport should close. The answers to these questions are obvious in most island and some tourist economies. The Pacific island economies were severely threatened when the intercontinental trunk airlines began to overfly them on the way to Australasia (Britton and Kissling, 1984). Areas with intrinsic tourist potential only blossom into resorts after the provision of facilities for direct air services. This was true, for example, in Greece, Yugoslavia, Tunisia and Spain (United Nations, 1974) and in India at Goa. In remote areas, the maintenance or revival of the economy may depend entirely on the accessibility provided by aviation, whether it be by float plane in Alaska or the conversion of a run-down coalmining economy into a ski resort in Yampa Valley, Colorado (Cooper, 1990). The Norwegian STOL system has encouraged a significant number of people to decide to move into towns with STOL ports thus allowing population development to keep pace with the rest of the country (Strand, 1983).

Even in these clear-cut situations, the economic benefit to the local community may be relatively small, even though the tourist industry is big. In the Pacific microstates (Britton and Kissling, 1984) and in Israel (Haitovsky, Salomon and Silman, 1987), the local economy often receives only 20 per cent to 30 per cent of the total holiday price. This can be improved if the country's own airline brings in foreign exchange, though the aircraft investment can be daunting (Britton and Kissling, 1984).

There are other examples of failed tourist developments where reliance has been placed on the provision of an airport to stimulate the activity, as in North East Brazil and in East Africa at Mount Kilimanjaro. In developing and isolated economies, air transport's net contribution may be more important to release production of specialised products like fresh fruit and flowers from Africa (ICAO, 1977) or to maintain essential administrative links as in the islands of North Orkney (Coull and Willis, 1969).

Many studies demonstrate a close relationship between growth
in exports, growth in total factor productivity and growth in GDP (World Bank, 1992). Some of these studies find a causal relationship in the sense of export growth raising GDP growth (Jung and Marshall, 1985; Rao 1985; Hsiao, 1987). Air transport can certainly assist in the provision of export channels, though, until the profile of exports has moved beyond extraction and agriculture to horticulture and manufactures, it is difficult to justify using aviation on the basis of value per kilogram: over 50% of air freight into and out of the US has a value greater than $16 per kilogram (Boeing, 1992).

It is harder to sustain the same arguments unequivocally in developed economies. Certainly there is no reason to doubt the truth of the classic theory of economic geography that lower transport costs allow firms to gain new markets and then reap economies of scale, the benefits spreading to other sectors of the economy through the multiplier effect, provided that the factors of production are mobile (Evers et al, 1991). The policy makers in Geneva apparently believe their airport to be so important to their economy that they wish to retain control of it and so control its capacity in order to limit their over-population problem (Alcock, 1988).

Studies have been carried out to establish the extent to which a convenient airport was instrumental to a location decision by companies. In a study of general aviation airfields in Massachusetts, 23 per cent of firms surveyed said that an airfield was essential to their site location decision. 19 per cent of firms said they would relocate if their 'base' airfield closed and a further 7 per cent said their businesses would fail, while 66 per cent said they would use the next most convenient airfield. The main effect of closure of a destination airfield would be to use an alternative mode (Weisbrod, 1990). At the air transport level of activity, a survey in Vancouver in 1985 indicated that the sudden loss of transborder services or all international services would reduce economic output by $669 million and $1.2 billion respectively (Cooper, 1990).

A further study (Norris and Golaszewski, 1990) used surveys
to differentiate between the impact of purchase of air transportation and the consumer surplus enjoyed by non-aviation firms through the available air services, arguing that most of the former activity only constitutes a transfer of resources within the economy while the latter reflects the net economic benefits to a region from an airport. The consumer surplus benefits are measured as the consumers' willingness to pay for the non-market benefits of a more accessible region through questions related to whether a firm would relocate, whether its operating costs would increase and what percentage of revenues would be lost if the airport ceased to exist. The surveys were performed on and around Dallas Fort Worth (DFW) airport and also on and around a major international airport in an island economy. Some of the results are given in Table 6.1.

**TABLE 6.1: ECONOMIC IMPACTS OF TWO MAJOR US AIRPORTS**

<table>
<thead>
<tr>
<th></th>
<th>DFW</th>
<th>Island</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase impact:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- total ($ billions)</td>
<td>5.2</td>
<td>3.73</td>
</tr>
<tr>
<td>- $ per resident</td>
<td>1570</td>
<td>612</td>
</tr>
<tr>
<td>Consumer surplus ($ billions)</td>
<td>1.3</td>
<td>11.03</td>
</tr>
<tr>
<td>Per cent of firms relocating</td>
<td>6</td>
<td>19</td>
</tr>
</tbody>
</table>

*Source: Norris and Golaszewski, 1990*

It can be seen that, for the island economy, the net economic impact of the airport was much greater than the transportation impact, whereas the reverse was true for DFW. The difference was due mainly to the proliferation of other transportation modes and competing airports in the case of DFW.

Other surveys have also elicited similar information. Results of some of these surveys in the UK M4 corridor,
Scotland, Ohio, Texas, Boston, Silicon Valley in California, North Carolina, Kansas and Nebraska are given elsewhere (Mahmassani and Toft, 1985; Button, 1988; Hartsfield, 1987). It is clear from the results of these surveys that, in general, there is no consistent relationship between the provision of air services and the location of industry in developed economies. Although 75 per cent of firms in Berkshire were influenced by Heathrow, 63 per cent were influenced by the M4 motorway. Efficient transport facilities were one of nine most important locational factors for more than 50 per cent of Kansas respondents but, in Nebraska, air freight was ranked 33 and air passenger service only 36 out of 46 locational factors. A recent study of the location decisions of foreign multinational corporations (MNC) in the US did not even consider an indicator of personnel travel ability (Friedman, Gerlowski and Silberman, 1992). Other studies make it clear that many other factors than air transport take priority in MNC location decisions. “There is either the absence or erosion in the LFRs (Less favoured regions) of the basic socio-cultural and institutional infrastructure necessary for stimulating the formation of local networks.” (Amin et al, 1992) The arrival of branch plants of MNCs in Ireland, with their beneficial high technology and high ratio of exports to output, have been attracted primarily by tax incentives and grants (Foley and Griffith, 1992): certainly Ireland does not have a high index of international air accessibility. The explanation of the variation appears to be partly bound up with the richness of choice of transport available and partly the nature of the economy.

 Those industries with a particular need for air service, either for shipments of high value-to-weight items or to support Just-in-Time strategies or high-contact personnel, do seem to locate close to aviation facilities, and with good reason. Rapid and reliable shipments are particularly important for Just-in-Time production strategies and for high value per weight items. A survey in Austin, Texas, of high technology industries (Mahmassani and Toft, 1985) showed a value of $333/lb for surveying and drafting instruments, of which 48 per cent were air shipped, compared with a value of
$1.3/lb for all commodities, of which only 2.8 per cent were shipped by air. The employee's propensity to fly per month, from the same survey, are given in Table 6.2. However, the literature also quotes examples of other industrial sectors which show a negative correlation between their location decisions and the availability of air services.

The evidence from these surveys, though apparently having some internal consistency once allowance has been made for richness of air transport supply and for industrial sector, suffers from the lack of any control on the bias in the respondents' answers. Observations of the relationship between air services and the strength of the local economy equally suffer from the criticism that correlation does not show causality.

### TABLE 6.2: MONTHLY TRIPS PER EMPLOYEE IN HIGH TECHNOLOGY INDUSTRIES

<table>
<thead>
<tr>
<th>Type of plant</th>
<th>Propensity to fly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very small R &amp; D</td>
<td>15</td>
</tr>
<tr>
<td>Typical R &amp; D</td>
<td>8 - 12</td>
</tr>
<tr>
<td>Mixed R &amp; D/production</td>
<td>2 - 4</td>
</tr>
<tr>
<td>Large manufacturing branch</td>
<td>0.07</td>
</tr>
<tr>
<td>Average manufacturing branch</td>
<td>0.07 - 0.25</td>
</tr>
</tbody>
</table>

*Source: Mahmassani and Toft, 1985*

As the poet Edwin Muir said:

"Time's handiworks by time are haunted
And nothing now can separate
The corn and tares compactly sown."

Anecdotal evidence is often used by airports to infer causality and to combat the criticisms of stated preference surveys. Atlanta's Hartsfield International Airport indicates that direct foreign services have resulted in
foreign-based firms accounting for 20 per cent of Atlanta's businesses (Hartsfield, 1987). On the other hand, Houston has 125 Japanese companies, four Japanese government entities and the largest Japanese community in the American South, despite having no direct air service to Japan (Lopez and Wilson, 1991). Investment in Shannon appears to have stimulated the regional economy and foreign firms have congregated around Schiphol (IATA, 1992). However, continual investment and subsidy in Liverpool airport has done little for the Merseyside economy, and Toyota has located near East Midlands Airport despite its very limited range of international scheduled services.

More formal attempts have been made to establish causality by measuring the relationship between the economy and the supply of air transport before and after major changes in supply. One study examined the effects of deregulation on three towns and their airports in California (Kanafani and Abbas, 1987). Two airports relatively close to hubs lost much of their service, though in one case the economy grew while in the other it stagnated. A third airport, more remote, retained its local services while its economy continued to grow strongly. If anything, the economies affected the supply of air transport by influencing the judgement of carriers to serve the airport, rather than the air services affecting the economy. Convenient hub service seemed to meet any residual need to support the economic growth.

The impact of the high speed rail service (TGV) between Paris and Lyon was also examined in a before and after survey comparison (Bonnafous, 1991). It was found that the TGV was only exceptionally a determining factor in location decisions, other factors such as government intervention being much more important. An increase in tourist visits was counteracted by a reduction in the number of nights per visit. The most positive influence was the increase in regional service industries establishing branches in Paris. This was not countered by Paris-based expansion of branches, but there was an increase in Paris-based selling of products.

Neither study allows a firm conclusion that the availability
of improved services stimulates the economy, even when there has been a stimulation of trips. They are, in any case, subject to the criticism that there was no study of the counter-factual situation, i.e., what would have happened if there had been no larger changes in the transport characteristics.

This fault can be overcome to some extent by comparing the affected routes with unaffected 'control' routes. The impact of the TGV on air traffic has been determined by this type of analysis, but unfortunately it only extends to ridership rather than the economic impacts. A similar approach, comparing liberal with non-liberal bi-lateral routes in Europe, described in Chapter Three (Caves and Higgins, 1993), showed little long term stimulation of traffic due to liberalisation. Since it might be expected that a stimulation of the economy would be reflected in the traffic levels, even if any rise in traffic might not have been due to an increase in the economy, it can be inferred that liberalisation did not stimulate the economies during the period examined.

Accessibility

The issue of the relationship between transport and the economy is fundamentally that of changes in spatial and temporal accessibility. Spatial inequality is normally defined in terms of income or employment (Slater, 1974), which may be related in some way to accessibility. In terms of transport provision the inequality can occur both in an absolute (or integral) sense in that some regions are geographically remote, and also in a relative sense, in that some towns are coincidentally located on main arteries while others lie between these main routes. The former was the main focus of the analysis in Action 33 (OECD, 1977). A combination of both forms of spatial inequality was revealed in a study of telephone and rail travel costs (Reid and Pritchard, 1970). This compared the integral accessibility for each of the ten largest cities in Great Britain, using both cost and distance as indicators. The results showed very large variations in rail cost. This has more to do with
differences in fare per mile than with distance. The variations between individual cities' accessibility scores were greater if relative accessibilities between non-London pairs were considered.

Not only is it true that spatial inequality exists: perhaps more important is the view that the present uni-modal planning framework reinforces the situation. The consequent 'spiral of disadvantage', which develops as urbanisation concentrates traffic which causes congestion, which triggers the provision of new transport capacity to enhance accessibility of the growing locations, has been noted at the European scale (OECD, 1977). The spiral may well have been developing even before the medieval road system census which rather appositely labelled roads serving London as 'direct' and those making other inter and intra-regional connections as either 'cross' or 'accidental' (Ogilby, 1675). The reinforcement process was evident in rail studies (British Rail, 1976) of improvements in speed on various routes from London. Obviously, an objective of loss minimisation directs investment to the more profitable routes, as happened with the penetration of the High Speed Train, providing average speeds between many city pairs of 100 mph. In comparison, services between major towns on cross-country routes averaged 31 mph - 45 mph, despite improvement in absolute terms (Gadfrey, 1976). Similarly, motivated by the need to develop financially viable airports and air services, experience of the expansion of the medium sized airports has confirmed the trends implied in the earlier policy aims, of concentrating services at a few regional airports (Caves, 1980; Department of Trade, 1978). Scheduled air services therefore become more distant for the already remote areas, unless low density aviation develops by local initiative, as with Brymon Airlines in Plymouth.

It is clear that some towns and regions are spatially disadvantaged and that current uni-modal market-based planning is tending to worsen the situation. One must ask firstly 'does it matter?' and secondly, 'if so, what should be done about it?'. With regard to the first question, the answer clearly depends on local objectives and on whether
spatial disadvantage represents a barrier to them. The choice of objectives may be between isolation coupled to low income or improved access coupled to higher income. If we assume the latter, (ie that it does matter) it is then necessary to examine which elements of the isolation must be reduced to satisfy the objectives at minimum cost. If objectives are formed more from equality of opportunity to take part in activities (as is now common in urban planning), it is only sensible to provide access to relevant opportunities.

There is evidence to support the intuition that economic growth is related to isolation. Firstly there is the theoretical notion of 'impure' public goods, ie centrally located public services which are less useful to some of the community because more of their real income is taken up in accessing them (Breheny, 1974). Other studies also infer strong mutual interaction between communication potential and regional economies. One identifies personnel in high contact employment as the principal determining factor in both sides of the interaction (Tornquist, 1973). Another study notes that more than 50 per cent of jobs in large metropolitan centres of the USA controlled from headquarters are not in the immediate metropolis of its hinterland (Pred, 1976). This study also finds that such linkages are not gravity-based and that they frequently involve smaller towns at a considerable distance. This infers that growth transmission depends on the job-control and decision making activities reflected by these linkages and that only between 3 per cent and 21 per cent of this activity falls within the subject firm's hinterland: ie "No regional planning policy is likely to be either goal consistent or as successful as anticipated unless its formulation is preceded by studies establishing the peculiar underlying structure of growth transmission interdependence within the concerned regional and national system of cities." Both forms of contact require physical travel as well as telecommunications (Nilles et al, 1976).

At a further level of disaggregation, there is much less information as to which job types and which sectors of industry and commerce require to travel, though reasons for
meetings and lengths of meetings are quite well documented (Post Office, 1976).

The link between growth and contacts with their necessary transport provision is not actually established by the above studies. However, there is little doubt that air service as well as the marine links are an essential support to the economic system of isolated communities in Scottish islands (Coull and Willis, 1969; Lea, 1964). Lack of evidence for causal linkages tends to lead to dogmatic statements of correlations between transport provision and economic activity (Black and Morrisey, 1978). Others (ABCC, 1977) suggested an airport system plan for Great Britain, developed out of a frustrated commonsense. It aimed at providing equal transport opportunity as a fundamental objective, reflecting the belief that the differences in regional accessibility to destinations requiring air transport largely explain the regional differences in propensity to fly.

On the other hand, may studies show little relationship between transport and regional growth (Gwilliam and Judge, 1974; Chisholm, 1976). Gwilliam and Judge suggest that the impact of the M62 motorway on regional development has been slight. They support their findings with an extensive literature survey, examining empirical evidence of development roads, general equilibrium (Lowry type) models, theories of location and market areas, behavioural management theory approaches, heuristic statistical estimations and traffic studies. They conclude that in highly developed economies there are unlikely to be many real mutual benefits, either relative or total, and that the interaction between transport provision and the economy of the region is likely to be distributive rather than generative. Chisholm supports this, asserting that, on a regionally aggregate view, it is really only the most remote locations that are at a serious disadvantage in respect of transport costs. He points out that the underlying determinant is whether there are external economies of scale resulting from the spatial concentration of activities and concludes that the evidence is far from clear-cut. A further investigation (Botham, 1980) shows the road programme even to have had a slightly centralising
effect on employment. These neutral views are implicitly supported also by studies of spatial inequality (Slater, 1974), regional dynamic planning modelling (Telford, Burkedin and Yule, 1974) and migration modelling (Weinstein, 1975), in that they take no account of transport provision.

These findings seem to disagree with the approach taken earlier, i.e. that economic growth is related to spatial disadvantage. This thesis, however, concerns itself with situations relevant to air services. Also, the earlier approach is based in human contact potential terms rather than in the access-to-markets effects which tend to be the main interest of those evaluating regional development initiatives.

In lower density settings, it has been shown that small investments in aviation can dramatically increase contact potential (Tornquist, 1973) and the Action 33 study showed how spatial inequalities in Europe can be most cost-effectively minimised by investing in a decentralised air network (OECD, 1977).

In contrast to the British, rather laissez-faire, uni-modal approach to inter urban transport planning, the French believe strongly in the principle of integrated multi-mode planning (Metzinger, 1973) and in the need to support local economies by providing the opportunity to satisfy high value-of-time linkages. This extends to a starting subsidy for third-level operations and participation by national government and the Chambres des Commerce in the funding of local airfields.

The Action 33 study was also aimed at an integrated view of transport in Europe. It lists the following reasons for this:

a) European countries are rather small to be treated as separate planning areas

b) A substantial part of the environment problem comes from international traffic
c) New high speed transport systems (rail and air) are envisaged at the continental level

d) Modes have developed independently, and are therefore not operated in complementary fashion

e) Poorer regions need a preferential share of transport investment

f) Energy consumption policies needs international coordination

g) The retention of a rail system in the face of financial pressures common to most systems, may depend on common policies

h) Common policies towards encouraging public transport may reduce the level of road accident fatalities

i) Opposition (environmental) to airports and motorways is a political problem with international implications

j) The high cost of research and development means that an international budget is desirable.

All of these reasons may be scaled down to form the justifications for integrated planning at the national level, implications of which would include the derivation of policies on spatial inequality and the examination of all available modes to develop the most efficient level of coordination.

Action 33 related the concepts of accessibility to three separate markets: the minimum time and cost to the complete European market; to the nearest market of 25 million people; to the size of population in the subject region's immediate hinterland. The study built its own test objectives of minimising the future differences in accessibility within a given budget. Aviation was the dominant mode in determining these measures of passenger accessibility and a decentralised network was found to give the maximum improvement in differentials. A Scottish Office (1972) study, concerned
with isolated regions in the EEC, also used accessibility concepts. It employed the ratio of frequency to journey time by air (including indirect services) to derive a ranking of actual accessibility to six central EEC cities from a number of EEC cities as remote from the centre as Glasgow. This ranking was compared with an expected ranking of the accessibility of these cities based on the ratio of population to distance: i.e. the study was implicitly accepting the absolute spatial inequality of opportunity due to remoteness and size, merely testing their relative inequality vis-a-vis their spatial contemporaries. In Norway, on the other hand, all remote communities are provided, at a price, with the opportunity to make a day return air trip to Oslo, regardless of the degree of remoteness.

A third study of interest to inter-regional travel in Great Britain also used accessibility measures to determine differences in accessibility among medium-sized towns (Stanley and White, 1973). The study focused on bus services, counting the proportion of all towns of equal or higher central place status within 150 km which were connected to the subject town with a given minimum quality of service. Large discrepancies were displayed, but the practical value of the index was not discussed. The study indicates the need for work in this area of low density trip-making in medium-density settings, pointing out, in particular, that more than half the population live in this type of setting, but confines itself to the opportunity to satisfy social and central place dependent travel needs.

All three studies are pertinent to the consideration of inter-regional aviation and all three attempt to use different accessibility indices to evaluate the quality of transport provision. They offer potentially useful ways of breaking away from assessing transport provision requirements through capacity matching. They also allow consideration of the opportunity to make linkages and to relate transport provision to social and development policies. These uses are already common in urban and rural transport planning.
The literature gives useful taxonomies of accessibility definitions and methods of measurement, from which it is possible to infer something about the relative usefulness of the approaches. Jones (1981) suggests that the definitions of accessibility can be expressed in terms of:

- spatial separation
- travel cost
- opportunity for activity
- consumer surplus

and that they may be measured in terms of

- equivalent networks (Kansky, 1963)
- perceived travel (Department of Environment, 1976)
- time-space geography (Thrift, 1977)
- contours (Black and Conroy, 1977)
- revealed value (Tanner, 1980)
- Hansen measures (Ingram, 1971).

It is also suggested that any valid measure should take account of the location and characteristics of traveller, their relevant activities and the connecting transport system.

Additionally, it is suggested that the indicator should be technically feasible and operationally simple, easy to interpret and preferably be intelligible to the layman. Morris et al, (1979). Finally, only the accessibility to relevant opportunities should be measured, which tends to suggest that some compromise between relative and integral indicators should be adopted, where relative accessibility is the ease of reaching a single destination and integral accessibility is the mean case of reaching all relevant destinations. Jones concludes that network measures are generally insensitive to types of travel and location, and that contours may be the most useful compromise measure, given that each of the alternatives violate some of the criteria at least some of the time. With contours it is possible to disaggregate attraction and deterrence with different aims for different travel types.
This advice helps to determine the value of the accessibility so measured. To some extent, the more measures which can be used, the more information-rich is the picture which can be painted for decision-makers. Breheny (1974) favours this approach, feeling that, although the 'evaluation indicators' are not yet sufficiently developed to do more than support the obvious, they have a strong potential to bridge the gap between the social and quantitative aspects of planning. Ultimately, the quantification will require the structured setting of accessibility objectives derived from political goals.

It has been shown, therefore, that there is a strong background to accessibility measures, but most of the effort has gone into making alternative definitions operational, with little consideration of the value of the measures or their interpretation in terms of objectives to be met in relation to equality of opportunity. This is particularly true in the non-local transport field, where the questions relate to information flow, trade links, access to institutions, governmental supervision, military strategy, cultural and migrational ties, the market for products and the constraints imposed by the economies of urban scale.

There is still no definite feeling for which measures of inter-urban accessibility should be adopted, which activities (destinations) should be considered, what level of accessibility is needed and how much can be afforded. On the one hand, Fullerton (1975) states that a primary route network can be devised for the UK where a total length of 1550 km would pass within 9 km of half the population and a 8800 km network would reach all the population to this degree of accessibility. On the other hand there is the ideal of equality of spatial opportunity for all the population. Tentative efforts have been made to form operational objectives implicitly following Fullerton in the UK motorway programme and explicitly in defining connection to the USA federal highway and air networks, (US Department of Transportation, 1974). The USA National Transportation Report (US DoT, 1976) uses distance to an air service, number of destinations served by direct service, the number of
direct services daily from a given city and connection to a metropolitan area as measures of the quality of accessibility enjoyed by small towns. These measures showed again the advantageous position of those towns on the main transcontinental routes. Action 33 (OECD, 1977) used integral accessibility without any real justifications yet one may ask why, in the light of the diffused need for contact suggested by Pred (1976), the Scottish Office (1972) did not use a more integral measure to derive its relative accessibility status. Stanley and White (1973) used an integral index despite the probability that only a few destinations would hold a real potential attraction. These measures do, however, address the transport requirement at a more fundamental level than those which rely on achieved load factors to indicate disadvantages in air transport accessibility (Jemiolo and Conway, 1991).

Perhaps the most impressive attempt to link the use of accessibility indices to objectives was made by Hall and Breuer (1972), working for New York State to appraise new highway infrastructure, who attempted to maximise the improvement in accessibility over the whole State. They measured each zone’s integral accessibility ($A_i$), summed this for all zones ($A$) and then considered $A_i/A$ as the subject zone’s relative accessibility. The relative impact of each improvement scheme on each zone and on the whole State could then be assessed. The relative changes could also be weighted to reflect their desirability from the point of view of the State’s development plan. The process is however, very lengthy and expensive. No single measure is likely to reflect the different needs identified earlier: the different links for different trip purposes, the distinctions between the improvement of individual utility as opposed to collective economic growth and the further distinction between general demand patterns and specific community of interest.

The market place may be expected to take care of transport provision to support central-place type activities, and low density demand is almost certain to be too small to expect other than a network treatment. But if the important
economic connections are the community of interest ones, no blanket measure of accessibility is adequate and no policies based on it can expect satisfaction. An attempt is made in Chapter 11 to study the relationship over time between local demand and changes in accessibility as measured by the quantity of air transport service at three medium hubs and three spoke cities in the US over the time period 1974 to 1987 (Caves and Ndoh, 1990), even though the specific 'community of interest' factors could not be determined.

Social Benefits to Society

The benefits to society are self-evident when aviation is the only way to respond to disaster relief, medical evacuation, law enforcement or the protection of the environment (FAA, 1978). So are some of the other leisure benefits which are claimed by the FAA, though some would argue that they are socially divisive.

A more all-embracing example of the benefit to society, over and above the benefits to the individual, is the statement by Pope John Paul II that the world is becoming a global village in which people from different countries are made to feel like next door neighbours. Some hold the view that tourism has become a real force for peace in the world (Edgell, 1990). The type of inter-cultural tourism to which the Pope was referring can practically only be accomplished by air.

The social advantages of aviation are more readily apparent in developing countries, in promoting cultural unity within a country and allowing cultural, ethnic and educational links with the developed world. The direct benefits from the support of industrial and social service activities are readily apparent in low density situations and in the pre-industrial phase of an economy. However, it is perhaps the less direct benefits, flowing from the transfer of technology, which have the greater beneficial effect on a developing economy. The transfer process can be formalised as occurring at four levels of sophistication: appropriability, dissemination, knowledge utilisation and that based on communication (Williams and Gibson, 1990). The
latter, requiring international linkages of good quality, has the characteristics of being "ongoing and interactive. It involves feedback at a level so pervasive that participants can be viewed as transceivers. It is often chaotic and disorderly, and contains elements of both technology-pull and technology-push."

It would be very difficult to provide this most effective form of technology transfer without international aviation. The implantation of air services itself brings with it the need for technical back-up, which extends from governmental administration through to qualified fitters, perhaps ending with a country constructing aircraft of its own design. The resulting job opportunities may not be great, since air transport is capital-intensive, but the training and quality control requirements result in a higher total industrial capability. However, if the dependence on foreign expertise is not to be greater than before, the transfer must set its own pace. Aircraft can be bought quickly and building an airfield does not take too long, "but these represent only the foliage of the tree. The trunk and roots of aviation - the aeronautical training, the navigation and meteorological skills, the concepts, rules and procedures - must be nursed along slowly and carefully over many years." (Heymann, 1962) The levels of quality required can only be maintained through a system of specifications and quality controls which educates a broad base of industry into this level of production (Ozires, 1976).

The technological spin-off has a particular part to play around airports in developing regions, where the airport can form a base for local industry in the same way as can a mechanic along a rural road. Indeed, the airport is often the only place where clean water and a consistent supply of electrical power can be found. The effect of an airport can then be beneficial both technically and through increased job opportunities, and real meaning can be attached to the multiplier effect. The principal benefits are, however, unlikely to show up in the short term in calculations of economic contribution, input-output or cost-benefit analyses, since they are embodied in the changes of attitude brought
out in the local people. The effect can be quantified to some degree by ranking projects by the effect they have on attitudes (Wilson, 1967). At one end of a ranked continuum, the projects would only influence attitudes, while at the other end they would only produce directly productive activity. Transport projects appear to be somewhere in the centre of the continuum. Changes in attitude are adjudged to have catalytic long term effects at least as important as the immediate pay-off of the directly productive projects.

In the most advanced economies, society derives its aviation benefits primarily from the economic advantage gained by users who choose aviation in free competition with other available modes of transport. Most societies do, however, have other goals than economic growth to which aviation can make a positive contribution. Japan has a relatively explicit statement of its goals and the role of transportation in meeting them. "The Fourth (Comprehensive National Development) Plan, approved in June 1987, aims for a dispersed multi-polar pattern of development as Japan enters the 21st Century, emphasising the development of the nationwide high-speed transportation and information/communication networks through Integrated Interaction Policy. Although each (earlier) plan reflected the major issues discussed at the time, the basic theme underlying these plans has been the spatially equitable growth of a better and more stable living environment. Transport investment has always been emphasised as the major policy instrument to achieve the basic goals". (Ohta, 1989) "The theme ... was building a country to act as the place for interactions: interactions between people, regions, and nations; interactions between people and nature; and exchanges of information. .... In such a (high-mobility) society, speed, reliability and comfort will be demanded of transportation. ... The (transport) network will enable a choice among several different routes and transport modes. ... In addition to the conventional vertical links between major metropolises, regional hub cities, and regional core cities, it will be necessary to prepare a network that places importance on the horizontal connections among regional cities. ... A major task facing Japan is to promote social overhead capital, including the
transport infrastructure, during this century while the economy still has vitality and before the average age of the population rises. ... The major objective of the plan is the construction of a nationwide transportation network that connects the major cities from anywhere in the nation within three hours (or nationwide day-return). To achieve this objective, the plan proposes the construction of the expressway-type road network of 14,000km, several Shinkansen lines, and about 50-70 commuter airports." Norway has adopted similar goals of social interaction which has resulted in a string of Short Take-off And Landing (STOL) ports (Strand, 1983). The social benefits of these STOL ports have been carefully documented (Wilson and Neff, 1983).

Goals of mobility, and of social and spatial equity, call for much the same transport solutions as does the economic goal of regional development, since they both imply improvements in relative, and well as absolute accessibility. The EEC is clearly keen to promote inter-regional accessibility and to encourage aviation in that role, and the SRI report (SRI, 1990) points up the value of this, though it has still to be determined whether a large number of direct linkages is to be preferred to hubbing.

Intuitively, it seems that aviation offers the best prospects of meeting both the social and the economic accessibility objectives of peripheral regions without allowing the economic advantage to drain towards the centre, ie it might be the most effective way to reverse the spiral of spatial disadvantage caused by the mutual reinforcement of economic success and the resulting transport investment.
DISBENEFITS OF AVIATION

Types of Disbenefit

A major problem to be faced in any assessment of an impact is that people do not necessarily welcome the direct consequences of economic development, even if they are in favour of the economic growth. It may not comfort many English nationals to know that aviation is partly responsible for 31 Japanese banks controlling 36 per cent of London's international banking (Crandall, 1988). Equally, the urbanisation which must inevitably accompany major airport expansion (Breheny, 1987) may be more unacceptable than the direct impacts of the airport, ie the 'benefits' of the multiplier may be unwelcome. Estimates of the number of new dwellings required to support 50 million passengers per annum (mppa) at Stansted ranged from 20,000 to 72,000. The range for 15 mppa was 4,350 to 21,000 dwellings. Since 1985, when permission for expansion was granted, initially to 8 mppa and later to 15 mppa, local opinion swung from 3:1 in favour of the second phase expansion to 5:1 in favour in 1988. The swing presumably reflects both a new concern for the local economy and a realisation that the reduced scale of development will be acceptable. Another instance of concern about the consequences of too much economic activity, in this case tourism, is the Hawaiian island of Maui. While two other islands are to extend their runways, Maui has rejected the idea on the grounds that it would result in higher property prices, congestion, crime and a reduced sense of social responsibility (Fujii, Im and Mak, 1992).

It is, however, the direct social costs which cause the majority of complaints against the growth in aviation, and these will now be examined. Social costs of aviation may accrue from considerations of safety, severance of communities, visual intrusion, disruption of the ecology, resource depletion, air and water quality, and noise, as well as the indirect effects brought on by development. All of these factors may be important in specific cases, but attention is mostly focused on noise, air pollution and energy depletion.
Noise

The aviation community can only be pleased that golfers in Wellington, New Zealand, jump in surprise when the BAe 146 flies into the airport because they have not heard it approach (Aerospace, 1990). Presumably, though, the surprise is due to the obvious noise of the rest of the fleet, because the City Council has introduced a byelaw banning non-Chapter 3 aircraft from 1994 (Flight, 1989). Some 400 airports in the USA have some noise restrictions on the type of aircraft and the time of day (Marsh, 1990). This imposition of an environmental capacity is also common in Europe, for example, there are night quotas at Heathrow. At London City Airport there is continuous monitoring of noise energy contours and maximum levels, curfews, movement limits per aircraft noise category and a system of incentives and penalties, all embedded in local planning law (Turner and Freeborn, 1992). The ICAO has certified more noisy aircraft as 'Chapter 2' and other less noisy aircraft as 'Chapter 3', and set deadlines for the withdrawal of those in Chapter 2 (ICAO, 1988). It was feared that Munich II would open with a night curfew and with an environmental capacity of the equivalent of 710 Chapter 3 aircraft per day which would be fully used up if even 40 per cent of the movements were to be by Chapter 2 aircraft (Hogan, 1990). The Bavarian State Court counts a single Chapter 2 movement as two Chapter 3 movements in controlling Munich II's capacity. Depending on the range and payload, most Chapter 3 aircraft are less noisy than is implied by this weighting. Measurements at Frankfurt show that while the measured reduction between a Stage 2 737-200 and a Stage 3 737-300 of 6dB(A) approximately agrees with that weighting, replacing a 727-200 with an A320 provides a reduction of 12 dB(A) (Huxhorn, 1990). The proliferation of individual airport noise limits leaves aircraft operators with a tangled web of constraints; to base the restrictions on unreal comparisons is an unnecessary added burden.

These restrictions are being applied despite the remarkable reductions in noise at source. The take-off, Effective Perceived Noise in Decibels (EPNdB) reduced from 112 to 87 between 1960 and 1985 for aircraft of comparable capability.
(Wesler, 1988). Even at airports with strong growth of passengers, this had the effect of reducing the overall noise nuisance. The areas within the 35, 45 and 55 NNI contours at Heathrow reduced by 61, 53 and 39 per cent respectively between 1972 and 1987. This was due in part to the arrival of high bypass engines, but also to the 1978 rule banning further expansion of the fleet of non-noise-certificated aircraft. The government view now is that even large aircraft need not be subject to a night noise quota if their certificated EPNdB is less than 90 (DTp, 1993a).

The early withdrawal of the Stage 1 aircraft cost the operators considerable sums of money in earlier replacement and low resale value. The policy now agreed in ICAO, ECAC and the EEC to require the Stage 2 fleet to be phased out between 1995 and 2002, with some exemptions for age, size and engine type (Pilling, 1991), will also impose costs on operators. ECAC claims that this policy will only add 0.5 per cent to airline costs, while the Nordic Council suggests only 0.4 per cent (Bennett, 1989). Extrapolation of ICAO's estimates, however, suggest that the additional costs of accelerated replacement for the world fleet would be $23.2 billion, for 1995, $8.3 billion for 2000 and $4.8 billion in 2005 (Avmark, 1989a). This would be equivalent to 1 per cent of expected purchases for a cut-off in the year 2002. A particular problem would occur with Third World airlines, whose costs would, according to ICAO, increase by $2.2 billion for a 1995 cut-off. The Third World airlines' attitude is that built-in obsolescence is not appropriate in resource-constrained countries, that only 3 per cent of developed world traffic is by Third World airlines and that the balance of advantage is entirely in favour of the developed world's aircraft industry (Gilson, 1990). The FAA's Notice of Proposed Rule Making is similar to ICAO's rules, including the exemption for aircraft under 34,000 kg. but with earlier phase-out and none of the other exemptions (Daly, 1991). The cost to US airlines is estimated to be $5.58 billion.

The UK airports are being encouraged by the government to take full responsibility for the effects of noise and incur
the costs, on the basis of 'the polluter pays' (DTp, 1993b). Most airports are already pressing for Stage 2 bans because they are suffering from environmental capacity constraints and because they are having to pay large sums for noise control. Dallas Fort Worth has proposed a noise mitigation programme with a net cost of some $150 million in conjunction with its plans for a $3.5 billion development of two new runways. The main expense would be in buying out all 500 homes within a 70 Ldn contour, together with an avigation easement of 25 per cent of the house value to 2,600 houses in the 65 Ldn contour (Street, 1991).

There are three basic approaches to reaching a working agreement between airports and their neighbours over increasing noise levels. The airport can buy out the property, offer compensation in return for an easement or offer some grant towards insulation. This follows from the general legal position that developers should meet the full costs of restoring local inhabitants' position to its previous state, ie the cost of 'internalising the externality' (Ruddock, 1992). A similar ruling exists in the US under the Code of Federal Regulations, 49 CFR Part 24.

A prime difficulty is in establishing the deterioration in property value relative to a fair market price. It has been found that values fall initially after an increase in noise, but the process is dynamic: noise avoiders sell, some shift in land use occurs and prices eventually regain the long term trend (Crowley, 1973). Other historical evidence suggests that a noise discount of some 0.5 per cent to 0.6 per cent per decibel exists: a 1968 study at Heathrow gave a 0.25 per cent to 0.30 per cent reduction of value per unit of Noise and Number Index (NNI), while a 1969-1973 study at Toronto gave a reduction of 0.5 per cent to 1.3 per cent per unit of Noise Exposure Forecast (Nelson, 1980). The Roskill Commission (Button and Barker, 1975) found something less than 1.0 per cent unit of NNI, depending on the value of the property: the higher the price, the more the occupiers were sensitive to noise. This result is confirmed by a later Canadian study (Uyens et al, 1993), which also found a much higher percentage impact of noise on vacant land than on
houses. However, a recent study at Manchester, matching noise contours to mortgage valuations, gave only a weak and non-robust relationship. It was shown to be difficult to assign any changes of value definitively to the effects of aircraft noise (Pennington, Topham and Ward, 1990).

A clean method of approaching the problem, if a fair market price can be established, is for the airport to buy out the property in the same way as would happen if a Compulsory Purchase Order were to be obtained, with compensation for moving in compliance with the Land Compensation Act, 1973. British Rail (BR) has offered to do this for properties within a 240 metres wide corridor around the channel tunnel rail link in negotiation with Kent County Council. Since 1974, the Port of Seattle has spent $100m acquiring 1,360 homes and relocating 3,900 residents. Similar practices are being adopted by the airport authorities at many other locations, including Dallas/Fort Worth (DFW) and Zurich, based on the comparable value of houses not affected by airport expansion.

In the case of DFW, residents are offered a choice between buyout or the purchase of easements or the assurance of guaranteed sales: $125m has been allocated to mitigating the effects on the city of Irving, relative to a likely project budget of $3.5 billion. In Seattle, as a result of a mediation exercise (Johnson, 1989), properties within the most severely impacted area (the Neighborhood Reinforcement Area) have a guarantee of 90 per cent of the free market value and have the choice of easements or insulation. The easement ensures that the owners will not sue for noise, vibration, fumes or other damage resulting from reasonable increases in airport activity.

In both the US and the UK, there are planning guidelines for the acceptable level of noise inside dwellings. The FAA will apply its Trust Fund money to contribute 80 per cent of the cost of ensuring that houses inside the 65 Ldn contour have interior noise less than 45 dB (Shade, 1990). The cost of compliance averages $21,000. In Seattle this is budgeted at $13m per year to the year 2000. It is often possible in
negotiation for residents to push the airport into settling for considerably more than the legal minimum. The State of California estimate for mitigation of effects of expanding San Francisco International was $28m, but the residents appear to have obtained $120m. Again, the benefits of a mediation approach, incorporating an agreed noise budget, are seen in the Seattle arrangement (Port of Seattle, 1990).

In the UK, the Department of the Environment has issued a draft guidance to replace Circular 10/73 (DoE, 1991). As well as confirming that any scheme involving a runway greater than 2,100 metres in length falls within Schedule One of the Town and Country Planning (Assessment of Environmental Effects) Regulations 1988, and therefore requires a full Environmental Assessment, it also gives guidance on the compatible use of land under given levels of 16 hour Leq, in four categories:

- less than 57 Leq (category A), noise is not a determining factor in planning
- 57-66 Leq (category B), noise should be taken into account for dwellings
- 66-72 Leq (category C), there should be a presumption against planning permission for dwellings
- above 72 Leq (category D), even industrial use is debatable.

The UK transport industry's reaction to this and previous guidelines has been very variable. BR has offered to finance 50 per cent of the cost of noise barriers for houses inside a 65 Leq contour. Manchester Airport meets 80 per cent of the cost of double glazing up to a maximum of £1,920 plus venetian blinds for houses inside 62 Leq. Birmingham Airport allows £1,880 within 66 Leq. Stansted Airport allows £2,190 within approximately 57 Leq. In comparison, the 1970 Heathrow agreement was for 100 per cent of the cost of double glazing within the 69 Leq contour.
Even with legislation to phase out Stage 2 by the year 2000, at the average large airport the size of the 67 Leq contour will remain constant if the movements grow at 5 per cent per year to 2000, while a 50 per cent reduction in area (ie approximately a 3 dB reduction in each noise event) would require all Stage 2 aircraft to be banned by 2000 (Nitsche, 1990). Any environmental restrictions based on maximum noise event levels rather than the energy-based metrics could give lower capacity, though there is no serious scientific background for them.

At John Wayne airport, it appears that local residents have been complaining at movements they could see even though they could not hear them (Airport Forum, 1989) - reminiscent of New Zealand golfers. This may reflect less articulated concerns, such as the safety implications of overflights. It is also a classic example of how the irritation threshold follows the noise capability down. The EEC's Environment Commission tends to support the syndrome, in that it suggests a further round of legislation beyond Chapter 3, so that all the benefits of noise control per movement are not offset by traffic growth, noting that some aircraft can already outperform Chapter 3 by 12 dB(A) (Paylor, 1991). Whatever the improvement in noise measurements may be, it is most unlikely that complaints will decrease. An objector at Toronto airport said recently: "Stage 3 jets have a different sound; it penetrates through your body" (Rowan, 1991). It is also preferred that aircraft Day/Night Levels (DNL) should not exceed ambient DNL as a threshold for noise intrusion in quiet areas remote from an airport (Wesler, 1990). The tensions between the regulators, the airports and the airlines are thus likely to continue into the indefinite future, with ICAO's Committee on Aviation Environmental Protection (CAEP) already receiving evidence that there is no cost-effective technical breakthrough which would allow the manufacturers to respond to a more stringent Chapter 3 (Smith, 1989).

Emissions

Aviation has already put a great deal of effort into
minimising its impact on air and water quality in the airport environment. These initiatives are taken individually by airlines, but there is concerted activity by AEA, IATA and by ICAO through CAEP (Somerville, 1992). Electric or methanol power is used for ground support vehicles. Many of the services to aircraft are piped. New procedures are being used for runway deicing, so avoiding the harmful effects of urea in the storm water (Karrman, 1991; Gould, 1992). Impressive advances have been made in the control of aircraft exhaust emissions, despite the facts that the majority of the pollution around airports comes from ground vehicles, that aircraft contribute less than one per cent of air pollution in the cities they serve (Longhurst and Raper, 1990) and that the concentration of pollutants near airports is lower than the averages for the cities they serve (Williams, 1988). In two decades, the weight of emissions per passenger during a standard landing - take-off cycle has been reduced by 90 per cent for hydrocarbons and by 65 per cent for Carbon Monoxide as engine technology has improved. Nitrous oxide emissions have only been held constant due to the increase in engine pressure ratios (Snape, 1990). Smoke has been almost eliminated. The recent measurements of air pollution do not yet reflect these reductions, because the average age of fleets at most airports is at least 10 years.

Impressive though these advances are, they will not be sufficient to satisfy the environmentally concerned policy makers. Sweden has already instituted an emissions tax based, in the case of aviation, on a 370 km flight. Linjeflyg's response was to cut emissions by 72 per cent with new combustors (Beech, 1991). The EC is also considering a carbon tax among other policy measures in its search for 'Sustainable Mobility' (EC, 1992a and 1992b). Amendments to the Clean Air Act in the USA are likely to result in pollution capping of airports, and restricting chemicals in the production and maintenance of aircraft (Rheingold, 1991). The United Nations (UN) discussed the climate in June 1992, making some progress towards ratifying a convention on reducing emissions by perhaps 40 per cent through a carbon tax.
The main concerns of the UN 1992 Rio Conference were the ozone layer and the 'greenhouse effect'. This concern is also expressed by the EC's Environment Directorate, who note the NASA study showing that, while the main problem for the ozone (O\textsubscript{3}) layer is CFC production, a fleet of SSTs might reduce the O\textsubscript{3} layer by 15 per cent (Paylor, 1991). There is still considerable uncertainty surrounding the nature and extent of both these concerns. Certainly a reduction in the ozone in the stratosphere leads to an increase in harmful ultra violet radiation at ground level, and nitrous oxides (NO\textsubscript{x}) do break down ozone. However, NO\textsubscript{x} can also be a source for O\textsubscript{3} (Williams, 1988).

Subsonic jets, flying in the troposphere below the O\textsubscript{3} layer, could be an important source of NO\textsubscript{x}. They generate O\textsubscript{3} which unfortunately cannot escape upwards to restore the O\textsubscript{3} layer. Instead, O\textsubscript{3} and Carbon Dioxide (CO\textsubscript{2}) contribute to the greenhouse effect. The original ICAO environmental regulations did not consider the full flight cycle, but CAEP is working to develop high altitude emission limits.

The impending environmental legislation can only increase costs for the industry. KLM is already spending $50 million per year in this area (Pilling, 1991). United Airlines has a team working to apply a "cradle to the grave" philosophy to the control of pollutants (Rheingold, 1991). Many other operators are similarly aware. However, even more changes, of direction rather than emphasis, will have to be made. Less hydrocarbon fuel will have to be burnt, as well as burning it more efficiently. In the long term, alternative fuels may be needed in the air as well as for ground vehicles. This will give massive problems in the design of aircraft and infrastructure, and should be approached with care. Hydrogen as a fuel avoids many pollutants but still results in high emissions of NO\textsubscript{x} (Snape, 1990).

Ironically, at least in Canada, the more severe the effects of the 'greenhouse', the greater the potential market for air and marine transport as the settlements disperse to the progressively less inhospitable tundra (Irwin and Johnson, 1990). The same argument may apply worldwide as populations
concentrated along coastlines may similarly be forced to disperse.

**Resources**

A seminal paper was published some time ago which reviewed energy and other resources used in air transport and assessed the possibilities for alternative fuels (Allen, 1977). The main conclusions were that the best short term option was to apply the results of NASA's energy-efficient vehicle study, that in the medium term kerosene derived from coal or shale would be available, and that in the long term, though advanced forms of hydrogen might become available, the best hope lay in the suggestion that "there ought to be some encouragement for some quite radically new ways of flying and fuelling aviation so that overall costs are substantially reduced below present values. ... If we leave a complacent atmosphere, so that all that is required is expediting present programmes, we may never spark off the so-far undefined advance that will once again lift civil aviation into a glorious future."

Of the NASA suggestions for improving fuel efficiency, most have already been adopted. These are advanced aerofoil design, increased aspect ratio, lowered structure weight by less swept thicker wings and the use of composite materials, fuel conservative engines, and active controls. A further suggestion to reintroduce turboprops on short routes has surfaced in the slightly different guise of the ducted and unducted fans. The fans, together with the final suggestion of laminar flow by boundary layer control, are in obedience, waiting for the financial impetus to justify the required investment. Where the available solutions have been adopted, they have allowed the fuel burn per seat on a 500 nm sector to be reduced by 50 per cent compared with the first generation of short haul jets (Snape, 1990). The overall fleet efficiency has improved by much less, because even these more modest improvements have not been justified financially. The remaining solutions could reduce consumption by a further 50 per cent.
These actual and potential improvements in aviation fuel efficiency are in line with overall energy savings in the economy at large. The UK's energy intensity (ie consumption per unit of GDP) fell by 10 per cent to 0.98 tons of coal equivalent (tce) per $1,000 between 1982 and 1987 (House of Lords, 1991). It is estimated that the OECD has the technical potential to save 30-40 per cent energy by 2000, but that it will only be possible economically to save 15 per cent. Unfortunately, while aviation is more sensitive to fuel price and quantity, much of the available fuel saving has been squandered by congestion in the air and on the ground, by long taxi times, by inefficient routings and by modern operating practices. Also, the increased passenger kilometres associated with hubbing and the excessive frequencies resulting in small aircraft use on short high density sectors produce a poor product from the resource point of view. As for the medium and long term, disappointingly little has been done about the validation of alternative fuels or in researching radically new ways of flying and fuelling aviation, with the remarkable exception of HOTOL for the extreme range market.

The debate on benefits and disbenefits is carried forward to a notional evaluation of air transport in Chapter 11, in order to indicate the further changes that aviation managers should require of the technology in order to ensure a continued sustainable growth.
CHAPTER 7: AIRCRAFT/AIRPORT COMPATIBILITY

INTRODUCTION

The design of airports is viewed predominantly from the perspective of the infrastructure requirements which flow from an aircraft's design specification (ICAO, 1990). Figure 7.1 indicates an alternative aircraft/airport compatibility perspective, itemising the interactions which need to be considered during the planning of each element of an airport. Each element should be considered with respect to:

- safety
- capacity
- environmental impact
- economics

The issues range through the way in which the fleet mix affects the use of terminal airspace; the protection of the neighbouring public from noise and accidents; the safe and efficient operation of aircraft on runways, taxiways and aprons; the efficient transfer of the passengers and cargo to and through the terminals. Three important interactions are taken to illustrate the analyses which need to be undertaken if the aircraft/airport compatibility issues are to be managed efficiently in the future competitive, cost-sensitive and litigious setting. These are safe runway length, spatial implications of new large aircraft and apron space requirements. A fourth example is third party safety (see Chapter 9). The examples are considered after historic aircraft/airport interactions and trends in aircraft technology have been reviewed.

The chapter first considers the historic and future trends in technology. It then focuses on the size/frequency choices available to operators, in order to assess the extent of the requirement for larger aircraft.
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HISTORIC PERSPECTIVE

From the earliest days of powered flight, there has been a mutual relationship between aircraft and the supporting infrastructure. The relationship began with slow and light aircraft using the omnidirectional runway of a field, except for limitations on the approach and departure paths caused by obstacles to navigation. As time went on, the infrastructure had to respond to the changes in aircraft technology which were allowing aviation to fulfil its military and civilian potential.

Some innovations, like the airship, required only the addition of a mooring mast to the airfield, though, had they been successful, they would have caused the most enormous parking problem. Others, like the flying boat, required the construction of artificial lakes (as in Milan) at those cities with no natural anchorage. Lack of the flying boat's ability to meet the traveller's demand for long distance flights over water cheaply and quickly led to proposals for floating runways where there were no convenient islands.

At the times when these technological initiatives were being suggested, it was very difficult to predict which might be successful, and therefore, how the infrastructure should be developed to support them. It was even more difficult to predict the success of the 'conventional' combination of the fixed-wing landplane powered by the turbo-jet engine. Faced with the apparently proven technologies of the fixed-gear landplane, flying boat and airship - all powered by piston engines, and faced also with the emergent technology of autogiros and helicopters, the British Under-Secretary of State for Air announced in 1934: "Scientific investigation into the possibilities (of jet propulsion) has given no indication that this method can be a serious competitor to the airscrew-engine combination". The Second World War committed the resources to develop the speed, range, size and ultimately the power-plants which were to disprove that forecast. The piston engine gave way to the turbo-prop, the turbo-jet and now the turbo-fan engine. The power-plant developments and retractible landing gear allowed increased
cruise speed, so reducing cost by improving the productivity in terms of seat km per hour. Range was increased at the expense of greater take-off weight. The improved range capability made many staging-post airports, like Shannon and Gander on the North Atlantic almost redundant. The increased take-off weight, together with the poor low speed performance of turbo-jet engines, required much longer and stronger runways, generally in locations closer to cities than the wartime runways. This gave rise to extreme noise nuisance, which was only partially alleviated by the ability of the jets, with their high approach speeds and nose-wheels, to accept strong cross-winds and hence operate mostly in a single runway orientation.

The second and third generations of turbo-fan aircraft have gone some way to reducing the runway length requirements and noise impact, while increasing range still further. With the continued need to improve productivity while being limited to subsonic speeds and by problems of infrastructure capacity, there has been a progressive growth in the size of the largest aircraft. While the use of multiple-axle landing gear has been largely successful in limiting the need for stronger runways, the effect on the infrastructure of the larger aircraft, particularly the increases in span, has been felt in terms of airside separation and apron space (McKelvey, 1983). Turnround problems have also worsened, due to a combination of factors: the need for increased flow rates of passengers, cargo and baggage; the increased density of the use of apron space; and the increased floor height of the wide-bodied aircraft. The latter effect alone has required massive investment in airbridges, mobile apron equipment and safety equipment, while the increases of span have caused many alterations to taxiways and aprons as well as many operational restrictions. The airside separation problems were made worse by the increases of span in the search for increased fuel efficiency, though this is being alleviated by the development of wingtip 'horns' or 'sails', as on the Boeing 747-400. The world is coming to terms with this largest current civil aircraft with its 64.3m span, 70.7m length, 19.5m height, 385,000kg maximum take-off weight and load of 509 passengers in a two-class layout (though
British Airways tends to use a 400 seat configuration). A particular problem of the tail height, combined with fuselage length, has been the maintenance of legal clearance under the transitional protection surfaces during nose-in parking. It should not be forgotten that the problems of increasing aircraft size can be just as acute for a small airport accepting a 767 replacement of a 737 as for a large airport coping with a 747-400. The evolution of aircraft technology is described in more detail elsewhere (Caves, 1984).

POSSIBLE FUTURES

The historical survey uncovers a series of interactions between aircraft technology and airport provision, operating at strategic, tactical and operational levels of planning. The interactions have been almost entirely one-way, with the aircraft technology driving the provision of the infrastructure. There have been noticeable exceptions to this trend, eg aircraft have to meet the special runway conditions at La Guardia, New York, and the altitude and temperature conditions at Denver; also the VC10 was designed for take-off at full payload from Johannesburg.

More recently, environmental concern has had an influence on the development of the turbo-fans, and handling costs have caused replacement aircraft to match to some degree the equipment and space requirements of their predecessors, eg 727 and 757. However, it is still predominantly true that the greater operating cost of the aircraft has ensured that airports have had to respond to, rather than drive, the technological and operational changes in the fleet. This has been possible partly because, in many countries, airports are provided as a service and the aircraft operators are not faced with the real costs of the infrastructure. More often, and particularly in the USA, it has been a conscious decision of the airlines to meet the costs of aircraft size impacts, even though they tend to pay directly the full costs of aircraft and passenger handling. They do pay for a large share of airside capacity and flight safety through a ticket tax, but have little control over the size of the tax or the governmental budget restrictions on its use.
The increasing size of the largest aircraft stems mainly from the desire to minimize seat km costs in a growing market, consistent with adequate frequency on long haul routes. The same considerations apply to the smaller categories of aircraft operating on shorter routes, but in this case it can be argued that the trend to larger aircraft should be augmented in response to a lack of capacity in the infrastructure. The lack of system capacity is now extremely serious (Dunham, 1989). In strategic planning terms, if air travel is to continue to increase in the developed world, there are only two fundamental alternatives:

a. the infrastructure must allow a greater capacity in terms of Air Transport Movements (ATMs);

b. each ATM must carry ever larger payloads.

In either case, a massive spend and huge effort in infrastructure planning is required. Figure 7.2 illustrates the changing balance of the pressures at the interface between aircraft and their infrastructure. Even if traffic continues to increase at a historically low rate of 5 per cent per annum, it will increase by a factor of six by the year 2040, while there appears to be no scope for increasing the capacity of either the airspace or airports by more than a factor of two at today's levels of flight safety, assuming that the basic existing aircraft technology remains the same. Then the only solution, other than a capping of capacity, must be for the average payload per ATM to increase by a factor of three (Hitch, 1988).

Tactically, the picture may not be quite so black. At many of the busiest European airports, the average payload is approximately 150 passengers per aircraft, compared with 300 passengers at a reasonable load factor in a 747. The average load is lower still in North America. There is, therefore, considerable scope for increasing average load without increasing the largest aircraft beyond a 747-400, at least until the next century. At least one manufacturer (Boeing, 1985) predicted that while traffic would double, the fleet would increase by 43 per cent, only 28 per cent of the
FIGURE 7.2: PRESSURES ON AIRPORT/AIRCRAFT INTERACTION

Aircraft

Safety → 1920 ← Safety
Technology
Cost
Size

Stabilised Technology?

Airport

Land use

Environment

1990

Environment

Cost

DEMAND
(6 times 1990)

2040

Capacity

CAPACITY
(twice present level)

Cost

Environment
increased capacity being provided by growth in average aircraft size, because increased utilisation will provide 24 per cent of the growth in traffic and load factor 5 per cent. It is, however, doubtful if the utilisation of the fleet can increase significantly even with the introduction of quieter aircraft to counter curfews: the tendency is for block times and turnaround times to increase due to delays in the system. The above forecast has recently been revised (Boeing, 1993); it is now expected that utilisation will only improve by some 7 per cent even with the continued trend to longer haul services.

Any change in the average fleet mix which skewed the distribution towards larger aircraft could, of course, only occur in step with substantial changes in the operational character of air transport. In the limit, a fleet consisting entirely of 747-400s could only occur if either the rate of traffic growth was inversely proportional to traffic density, with no growth on present 747-400 routes, or if denser and longer routes had very high frequencies while thinner and shorter routes lost frequency. Although there may be some truth in the former hypothesis, and while some longer routes could benefit from higher frequencies, relative loss of service on thin and short routes would cause the demise of hub-and-spoke networks as they are operated today. It could well be argued that in the USA this type of network causes many of the capacity problems, but the airlines appear to believe the benefits still outweigh the costs. Indeed, solutions to the capacity problem in the USA have even been proposed in the form of wayports or superhubs which emphasize the continuing and enhanced role of hub-and-spoke networks (Ginn, 1989). Although the FAA continues to forecast an increase in aircraft size of two seats per year in the US domestic market, others argue that the structural changes in the industry since 1980 make the four seat per year growth in the 1970s irrelevant (ASRC, 1992). The last ten years have seen a stabilisation at about 152 seats, and the trend is for major US carriers to reequip with small short haul jets (eg F100, 737-500, A320) and to replace their long haul trijets with smaller Extended Range Operations (EROPS) twin engined aircraft. This strategy is driven by the need to be even
more competitive on frequency while attempting to improve load factors in a market which is beginning to show signs of saturation. Even in the highly congested and relatively uncompetitive case of Heathrow, the average seats per summer ATM only increased from 160 to 175 between 1985 and 1992 (CAA, 1993a). The short haul international services in Terminals One and Two remained constant at 140 and 158 seats per ATM respectively, as did those in Terminal Four at 245 seats per ATM, these being predominantly long haul services by British Airways. Significant changes in aircraft size occurred only in the long haul Terminal Three and domestic Terminal One operations. The former decreased from 270 to 230 seats due to the transfer of British Airways services to Terminal Four and the introduction of EROPS. The latter increased from 105 to 148 seats due to the withdrawal of low density turboprop regional services made unprofitable partly because of the airport’s runway congestion pricing policy, and due also to the introduction of larger capacity aircraft on British Airways’s very high frequency “shuttle” routes. Any slots gained by reducing frequency on the high frequency routes can be used more profitably on other routes where frequency competition is expected to increase, but there are few such routes where an individual carrier might consider its frequency to be too high. Also, with full liberalisation of access, these routes will be seen as very attractive by new entrants. Their entry will increase the total route frequency again, and the incumbents may well feel the need to revert to their previous frequency in order to retain market share. The densest routes are so important to the airlines that it will probably take intervention by the UK government or the EC to limit frequencies on these routes, in order to preserve some access for new entrants in the face of increasingly severe capacity problems at the most attractive airports.

In Europe, the implantation of half a dozen superhubs would be a politically unacceptable use of land; also, a larger proportion of ATMs is intercontinental than in the US. For legislative, as well as capacity, reasons it may be more difficult to institute a genuine hub-and-spoke system. It is therefore probable that growth in seating capacity will tend
to be more uniform across the whole fleet mix, with the consequence that the size of the largest aircraft would have to treble in the lifetime of airports currently being constructed. The present tendency is to perform a greater proportion of intercontinental ATMs with small twin-engined aircraft, but, as the capacity crisis bites further and new generation large aircraft become available, this must alter. Similarly, there is a need for a short haul aircraft of 747 size. The 747 is already used in that way in Japan, but it is rather uneconomic, even at small seat pitch. The implications noted in the Annex, of throughputs at Heathrow of 80 million passengers per annum (mppa) in 2005 or 120 mppa in 2015 with three runways, certainly are that all ATMs will have to increase in size by at least 50 per cent compared with 1992 sizes. This view of a capacity driven increase in aircraft size is supported by other authors (Beyer, 1990).

The implications for airport design of these larger aircraft are examined later. The major manufacturers are beginning to discuss near-term responses to the NLA design challenge including larger conventional designs, double deck aircraft and wide fuselage aircraft (Donoghue, 1992; Elliott, 1992, Oelkers, 1992). Other new technologies with some potential are joined-wings, multi-bodies, integrated planforms, all-wing, slew-wings, tilt-rotors and other forms of vertical and short take-off and landing (V/STOL) aircraft (Blythe, 1989; Lange, 1980, 1984 and 1986; Morris, 1989). All except the V/STOL aircraft are potential solutions to the search for further reductions of operating cost and may therefore attempt to continue the tradition of causing airports to adapt to their needs. Joined (or diamond) wings (Aviation Week, 27 Feb 1984, page 25) would give efficient aerodynamics and structure, but would pose difficult problems of handling during turnrounds. Integrated planforms (Flight International, 4 March 1989) have additional advantages of mutual enhancement of propulsion and aerodynamics but with similar turnround difficulties. Both these projects would tend to reduce the spatial requirements per passenger at airports. The slew-wing (Cooksley, 1980), which has already been flight-tested in the USA at reduced scale, has a primary aim to improve the design compromise between low speed and
supersonic flight, but could take the other designs spatial efficiency further by using the supersonic highly swept configuration during taxi and turnaround. The multi-body aircraft is again aerodynamically and structurally efficient, but its main purpose would be to increase payload with minimum development cost: unfortunately it would need wider runways as well as wider taxiway separations and larger aprons. It is as difficult now to predict which, if any, of these potential solutions will be adopted as it was in 1934 to predict the role of the jet engine. Only recently, the apparently certain introduction of the unducted fan aircraft (eg Boeing 7J7) has been indefinitely postponed. The future of these and other aircraft projects will depend much more than in the past on their impact on the infrastructure and the extent that the real costs of this are recovered.

SHORT / VERTICAL TAKEOFF AND LANDING AIRCRAFT

V/STOL has had potential for effective transport ever since the first piston-engined helicopters were used in a civilian role. Since then, a large amount of research on fan lift has been done in the UK and on tilt-wings and tilt-rotors in the USA; also there has been steady development of conventional helicopters which has recently managed to produce for the first time in the EH/101 a vehicle which can continue in flight following an engine failure at any part of the flight profile. At the moment, all available V/STOL aircraft suffer the disadvantage of being slow in cruise flight, being more expensive to buy and operate per seat km and having a maximum capacity of some 50 seats. Also, in the case of VTOL, they have a high energy content and high noise at source. They have been seen historically as aimed at solving the transport problem between city centres and to be out of their element in a conventional airport, principally due to their high operating costs. However, Figure 7.2 indicates that, while the primary pressure on the future air transport system will be capacity, the other pressures from the environment, cost and safety will continue to be very important. These pressures may be examined in turn, with respect to the ability of V/STOL to alleviate the difficulties.
Capacity is a function of the safe density of the system and the flow rate. As the approach speed falls, so the safe separation distance can be allowed to reduce, and this helps to maintain the capacity of a given traffic stream as the flow rate reduces towards zero. The safe separation varies directly with speed due to the reaction time of the pilot and the controller. In a single traffic stream, the maximum safe capacity may well be obtained at a lower approach speed than is currently used, subject to constraints imposed by vortex separations, decision height and descent rate. Low approach speed provides further, and more significant potential to increase capacity by reducing the horizontal separation between multiple approach paths. Some indication of this gain has been obtained from the Separate Access Landing System (SALS) developed by de Havilland Canada and Ransome Airlines at Washington National (Shaw et al, 1988), but these benefits could increase substantially with the introduction of Microwave Landing Systems (MLS) or other systems for guiding curved approach paths.

Two of the main environmental problems are noise and third-party safety in the vicinity of airports. Already there is pressure for a further stage of aircraft noise certification beyond the ICAO Stage 3 rules. This will bring the requirements close to the ultimate limits defined by the aerodynamic noise (or self-noise) of the hull. The most potent method of reducing noise, other than reducing noise at source, is to remove the source further from the listener: the sound intensity falls with the square of the distance. V/STOL with its steeper approach and descent paths provides the only feasible way of increasing the distance. It should be possible to more than double the average distances, and so shrink the noise footprints to the extent that all significant noise occurs within the airfield boundary, eg to perhaps a 2 sq.km footprint, compared with 50 sq.km for a Stage 3 wide body at 90 PNdB (Quick, 1971), or even lower if true VTOL operations with 300 foot vertical descents and ascents can be performed.

The probability of third-party accidents would fall at the same time because the designated approach tracks could always
be on or below the power-off glideslope and also because the impact velocities would tend to be low. The occupants' survivability would likewise be improved (MacPhail, Jackson and Moore, 1993).

The direct operating cost of V/STOL is currently higher than that of conventional take-off and landing (CTOL) aircraft due to the lower productivity per hour and the extra weight required to achieve the short field performance. The speed deficiency can be eliminated by using turbo fans with augmented lift as in the American Quiet Stol Research Aircraft (QSRA) further developed with a pneumatically deflected circulation control system (Englar et al., 1984) or reduced significantly by using the tilt-rotor concept at little additional cost. The cost of the improved field performance can only be alleviated by taking account of the savings in infrastructure cost. These would accrue from the increased density of operation in terms of passengers per hour per hectare through an airport dedicated to a V/STOL operation; also from reductions in noise penalties as airports increasingly take noise nuisance into account in their charges. Similar cost trade-offs between field performance and access cost failed to convince the market when V/STOL was being proposed for city centre operations in the US Europe in the early 1970s (Chichester-Miles, 1974; Higgins et al, 1973; Stamper, 1975; Stepniewski, 1974). The trade-off, in its role of increasing environmental and flow capacity, will depend on the value placed on noise and congestion.

All available safety statistics point to the fact that both active and passive safety vary inversely with approach speed, where active safety is the ability to avoid an accident and passive safety is the ability to survive after an accident. The safety margins may, of course, be taken up by reducing cost and/or increasing capacity, but the potential is available if it should be judged necessary to increase safety.

A notional comparative analysis of CTOL, low speed V/STOL and RTOL is made in Figure 7.3, where RTOL is an acronym for
Reduced Take-off and Landing. This is a compromise between CTOL and V/STOL offering field lengths of approximately 1500 metres with very little cost penalty over CTOL. Clearly, an enormous amount of research would be necessary before an accurate version of this chart could be drawn up, but the indications are that a progressive move from CTOL towards V/STOL could well provide the best overall aircraft in the future as the airport problems bite harder. The cost and airspace capacity drawbacks of V/STOL could largely be overcome by using the high speed QSRA version. In the very long term, it may well be possible to develop this concept to the limit, with supersonic VTOL.

**FIGURE 7.3: COMPARATIVE ASSESSMENT OF AIRCRAFT TECHNOLOGY OPTIONS**

<table>
<thead>
<tr>
<th>Type of aircraft</th>
<th>CTOL</th>
<th>V/STOL</th>
<th>RTOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating cost</td>
<td>+</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Safety</td>
<td>-</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Environment</td>
<td>-</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Airspace capacity</td>
<td>-</td>
<td>?</td>
<td>+</td>
</tr>
<tr>
<td>Airport capacity</td>
<td>-</td>
<td>+</td>
<td>0</td>
</tr>
</tbody>
</table>

where + ≡ best, - ≡ worst, 0 ≡ base case.
RUNWAY LENGTH AND SAFETY

An unsafe operation results from: a) failed take-off, b) overrun from rejected take-off, c) overrun after landing, d) undershoot and/or off-track landing. An analysis of 53 accidents since 1962 where aircraft have overrun the end of a runway after rejecting a take-off, concluded that the single largest cause of rejection was engine malfunctions but that vibration and tyre failure are becoming major causes (Ashford, 1984). Rejections resulting in overruns occurred frequently when the decision to reject was taken earlier, as well as when it was later, than the Scheduled Engine Failure Recognition Speed, V1. The study concluded that the overrun rate was too high when only cold jet reverse was available. The US Federal Aviation Authority states that 87 per cent of all rejections are caused by tyre, wheel or brake failure, yet the regulations assume full effectiveness. Further analysis of the overruns suffered by jet aircraft worldwide between 1962 and 1983 inclusive, shown in Figure 7.4, indicates that these accidents are much more likely to happen on wet or contaminated runways, bearing in mind that the large majority of all take-offs are performed on dry runways. It is normally illegal to operate on a contaminated runway, yet four of the six accidents which happened were directly attributed to these conditions. Fortunately, only some 30 per cent of these take-off overrun accidents proved fatal. The average regional airport, with perhaps 10,000 ATM take-offs per year, will probably only see this sort of accident once in 15-100 years, depending on the weather, the state of the runway and the percentage of take-offs for which the runway length is critical. Yet they occur with sufficient frequency to increase the overall accident rate considerably.

Figure 7.5 presents a similar analysis for landing overruns to that performed for take-offs in Figure 7.4. It shows an even greater effect of wet runways, and also that almost all overruns result from abnormally high and/or fast approaches. Only 12 per cent of the accidents occurred on runways which were nominally too short for the operation. These landing overruns also occur more frequently than is intended by the regulations.
A. Decision speed relative to $V_I$

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Above</td>
<td>37</td>
</tr>
<tr>
<td>Below</td>
<td>9</td>
</tr>
<tr>
<td>At</td>
<td>2</td>
</tr>
</tbody>
</table>

B. Condition of the runway

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry</td>
<td>14</td>
</tr>
<tr>
<td>Wet</td>
<td>15 (3)</td>
</tr>
<tr>
<td>Con</td>
<td>6 (4)</td>
</tr>
</tbody>
</table>

( ) due to condition

C. Proportion of accidents resulting in fatalities

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal</td>
<td>17</td>
</tr>
<tr>
<td>Not fatal</td>
<td>36</td>
</tr>
</tbody>
</table>

Con - contamination

N.B. : 53 accidents in total : some had insufficient data to complete
FIGURE 7.5: WORLDWIDE JET LANDING OVERRUN ACCIDENTS, 1962-1983

A. Condition of the runway

<table>
<thead>
<tr>
<th>Condition</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry</td>
<td>7</td>
</tr>
<tr>
<td>Wet</td>
<td>46</td>
</tr>
<tr>
<td>Con</td>
<td>7</td>
</tr>
</tbody>
</table>

B. Type of approach

<table>
<thead>
<tr>
<th>Type of approach</th>
<th>Dry</th>
<th>Wet</th>
<th>Con</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>High</td>
<td>1</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Fast &amp; High</td>
<td>1</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>Normal</td>
<td>4</td>
<td>10</td>
<td>3</td>
</tr>
</tbody>
</table>

C. Accidents with tailwind

<table>
<thead>
<tr>
<th>Tailwind</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>3</td>
</tr>
<tr>
<td>No</td>
<td>57</td>
</tr>
</tbody>
</table>

D. Accidents on runway nominally too short

<table>
<thead>
<tr>
<th>Short</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>8</td>
</tr>
<tr>
<td>No</td>
<td>52</td>
</tr>
</tbody>
</table>
The primary responsibility for operational safety must always rest with the pilot and the airline which operate the flight. Their correct interpretation of the regulations and the conditions at an airport are essential to the safe operation. However, there are many areas where safety-conscious design could minimize the rate at which the overrun accidents occur, or alleviate the severity of the incident. Certainly the pilot can have a difficult task, eg the rejected take-off demonstrated distance has no built in margin of error, yet a Boeing study shows that a 'reject' decision at 6 kts above V1 can result in the aircraft leaving the end of the runway at 80 kts (Flight International, 5 December 1987). Figure 7.6 shows the results of an analysis of impacts which occurred in 77 survivable overruns in the USA. Obviously there have to be approach aids for the complementary runway threshold, but they should, of course, be frangible. It is less easy to excuse the presence of most of the other items on the list. One of the worst offenders is an embankment, which may often be there due to some other earthworks associated with the airport's construction, eg for site drainage or ironically in order to obey safety regulations with respect to the levelling of the runway strip or the lowering of a road to leave it below the approach surfaces. A balanced view of the relative safety on and off the airfield is necessary in the light of the relative probability of impact and the resultant severity of the accident, and the proximity of the fire service.

One solution, already in use at Manchester, England, is an arrestor bed designed to stop the aircraft safely before it reaches an embankment. That particular example uses waste granules from a steel-making process, but another possibility is foam (Hewes, 1983) which has been considered for Kennedy Airport, New York (Aviation Week, 31 October 1988). A totally invalid solution would be to lengthen the runway, unless the extra length were not declared. An island in the Caribbean had two fatal accidents while operating 727s from a 4000 feet runway. Since the runway was extended to 7000 feet, still with no Runway End Safety Area (RESA), it has been accepting DC 10s.
It is also essential to pay full attention to individual airfield characteristics of weather, terrain, local runway slopes and runway surface condition. This is not the place to elaborate on runway friction, but both the frequent measuring and real-time reporting of friction are essential to safe operation in inclement weather. A recent accident at Leeds/Bradford, England (AIB, 1987) showed not only that local runway slope, both at touchdown and during braking, can be an important factor, but also that any discrepancy between the friction used in wet-runway performance certification and the actual operating conditions can be crucial.

Neither RESAs nor arrestor beds can have any benefit for those undershoot landings or failed (ie unrejected) take-offs which contact the ground well outside the airfield boundary. Statistics vary, but the evidence shows that a significant proportion of all accidents and a major share of fatal accidents contact the ground between 0.5 km and 20 km from the threshold. The UK declares a Public Safety Zone (PSZ), which stretches 4500 feet in a fan either side of the extended centreline of busy runways in order to protect third
parties from the majority of likely accidents. Improved approach aids, particularly simple aids where none exist or alternatively Cat III equipment for fully coupled approaches, should offer significant help in avoiding both the fast and high approaches which lead to overruns and the more fatal undershoots. Again, it is important that the benefits are not taken in improved performance if the aim of installing better approach aids had been to improve safety. It is all too easy to declare lower decision heights and allow the pilot to take up the same risk factor with a more regular operation: an equally important safety initiative is to set and enforce appropriate operating rules for whichever facilities exist.

**FUTURE LARGE AIRCRAFT**

Most new airports are being planned to accept some variant of a New Large Aircraft (NLA). The likely dimensions of such an aircraft are shown in Figure 7.7, together with the physical separation distances which would be required on the airport if the existing ICAO methods of calculating separations were to be used. Many existing airports will find it even more difficult to provide these clearances than it was to accommodate the first 747's.

In fact, some 15 per cent of the world's international airports do not conform fully to ICAO's Annex 14 recommendations in this respect, and over 50 per cent do not meet the 180 metre separations required between runway and parallel taxiway centrelines for instrument runways (Wilde, 1981). In the USA, many of the airports only just meet the regulation for the existing 747s. The FAA proposes a 600 ft separation for stretched 747s, which would be very difficult to provide at Kennedy Airport, among others (McKelvey, 1983). However, the British Airports Authority (BAA) has conducted trials of the track-keeping capability of aircraft on taxiways. It has developed probability curves which suggest that the ICAO separation recommendations are too generous when applied at airports with good guidance aids (Wilson, 1988). It has been agreed between the BAA and the UK's CAA that the 747-400 will be allowed to operate to
FIGURE 7.7: NEW LARGE AIRCRAFT DIMENSIONS

FUTURE AIRCRAFT may be:

- 84m span
- 20m gear span
- 84m length
- 23m height
- 567,000kg mass.

AIRSIDE GEOMETRY

PLANNING TARGETS:

Separations:

- Parallel runway/taxiway 192m
- Parallel taxiways 105m
- Taxiway/fixed object 64m
- Stand taxilane/object 56.6m

Widths:

- Runway 60m
- Taxiway 30m

existing separation recommendations. It is less likely that the NLA will be able to operate in the same way without restrictions.

There are many other areas where the NLA will give problems. These include vortex wake separations, fire and rescue cover, runway strength, noise and apron handling. The apron problems associated with capacity are considered below, but additional difficulties will arise with respect to the compatibility of the fin height with the transitional surfaces and the arrangements for the flow of passengers, cargo and services between the aircraft and the terminals.

Further in the future, new larger aircraft will have to be developed, rather than derivatives of the 747. A future large aircraft, dedicated to short haul, would be relatively
lighter and smaller, particularly since its wing would not be optimised for low cruise drag (Corning and Sampath, 1976). So also would a future long haul aircraft since its fuel efficiency would be improved, perhaps by the use of boundary layer control and by ultra high by-pass engines, to the extent that their application can be made compatible with noise regulations (Morris, 1989). The short term improvements in aerodynamics structures, propulsion, avionics and systems are well documented (Blythe, 1986; Davies, 1986; Driver and Maglieri; Miller and Bennett, 1986; Schmitt, 1990 and Swihart, 1986). Even so, it is unlikely that the technology of CTOL aircraft will advance sufficiently to cancel out the size implications of the required increase in payload.

APRON SPACE REQUIREMENTS

If progressively larger capacity aircraft are to be used, the constraints on separations discussed above will call for either a complete redesign of the airside, making use of closer parallel runways (when and if this proves possible) or a large reduction in the ratio of span to payload of the aircraft. Meanwhile, many airports are becoming so short of gates and apron space that they are having to tow aircraft to remote parking, via routes which are often in conflict with active taxiways and runways. As payloads become larger, apron space will probably cause even more problems than airside separations for two reasons. Firstly, there is often no possibility of expansion because they are sandwiched between terminal and runways. Secondly, the overall plan area of the aircraft contributes to the space problem, rather than just the span. Los Angeles International has already thought it necessary to construct two remote aprons for the NLA, with aircraft-to-bus transfer buildings, each apron having one building and serving two aircraft.

In order to investigate the amount of spare potential capacity there is in the system now, a sample week's turnrounds were examined at each of two busy European airports and also at some busy US hub airports. The results are presented fully (Caves, 1987) and in summary (Caves, 1988a) elsewhere. Some of the conclusions were that:
- Less than 10% of turnrounds are achieved within the times determined by the capability of the aircraft ground handling technology.

- The actual average times achieved range from twice the minimum manufacturers' times for some narrow body jets to five times the manufacturers' times for the larger wide body jets.

- The narrow body turnround time results are more a function of the stage length the type of operation than of their size, with based and foreign operations tending to have a much longer tail to the frequency distributions than domestic operations, but there is a strong correlation between size and average observed turnround time.

- For a given aircraft type, the observed turnround time is not materially affected by the number of passengers exchanged or the seating capacity of the particular model of the aircraft. Short scheduled times do not result in a larger number of delayed turnrounds.

- The aircraft’s ground handling technology therefore has a minimal impact on apron capacity needs.

- Future aircraft technology inputs to apron productivity will come more from increases in spatial efficiency than shorter turnrounds.

- Improved spatial efficiency is largely a question of reducing wingspan. Small decreases in span will always be available from general design advances, but these are unlikely to keep pace with traffic growth. Winglets just about compensate for the recent trend to greater aspect ratios and smaller sweep.

- To maintain aprons at a constant size as traffic grows will require more radical solutions such as folding wings, skewed wings or power-assisted (V/STOL) aircraft.
- V/STOL solutions would be useful on the apron if they were adopted to improve runway efficiency - runway systems currently require twice the area per boarded passenger compared with the apron for a given aircraft.

Figure 7.8 shows the comparison in narrow-body turnrounds between the European airports L and M on the one hand and the USA hubs D, H and F with airlines A and C on the other hand, 90 per cent of all turnrounds being completed within 50 minutes in the US sample. These results show the potential for reducing European turnrounds, within the limitations of present technology. In fact, neither in the USA nor Europe were more than 10 per cent of the turnrounds completed within the minimum times claimed by the manufacturers in their Airport Planning Manuals. It appears that operating methods, and particularly the need to open up schedules to dilute the effect of unscheduled delays, is dictating the actual turnround times.

It would be helpful if apron productivity could be improved by reducing the time on stand, because this would help both the airport and the aircraft's utilisation, and would go some way to justifying Boeing's predictions of improved utilisation referred to above. Figure 7.9 shows that theoretically it would be possible to achieve a productivity of 12.5 pax per hour per 100 sq. metres of apron compared with the present European value of 5 pax per hour per 100 sq. metres. Alternatively, where the problem is one of apron width (or terminal frontage) rather than area, theoretically with wide-bodied aircraft it would be possible to achieve to work to 10 pax per hour per 100 sq metres. However, with delays worsening rather than improving in Europe, it is most unlikely that these improvements will occur.

With the increasing tendency towards hubbing, the problem is likely to be simply one of space rather than flow rate, because there is a gap between complexes when the stands are unoccupied, ie the fact that hub turnrounds appear to be completed more quickly does not automatically imply improved apron productivity. In this case, larger aircraft will always use the apron more efficiently, because the shorter
FIGURE 7.8: NARROW-BODY TURNOVER TIMES

![Graph showing Narrow-Body Turnaround Times]

- **Per cent**
- **Operations**

**Legend:**
- Euro at M
- Euro at L
- US Line C at D
- US Line A at H
- US Line A at F

**Time (mins):**
- 0
- 50
- 100
- 150
turnaround times of the smaller aircraft are of little benefit.

A wide-body aircraft will allow 5 pax per metre or 6 pax per 100 sq. metres, while a narrow-body will allow only 2 pax per metre or 4.5 pax per 100 sq. metres. It is therefore important to apron efficiency that the fleet mix should skew towards the larger aircraft and also that the airside separations should be adequate to allow the larger aircraft to operate. In the long term, the only viable solution will be a larger reduction in the ratio of aircraft plan area to payload than can occur simply by using larger aircraft and increasing load factor.

**CONCLUSION**

The conclusion of this strategic assessment of aircraft/airport compatibility is that planning of airport systems and individual airports must take account of the fact that the interaction between the infrastructure and aircraft technology will be stronger than in the past. Much more effort will have to be made to carry traffic forecasts through to the implications for fleet mix on a route-by-route basis, perhaps by improving the CAA's LARAME model (see the Annex) to include the effects of hubbing, fragmentation, mergers; also route competition and its regulatory control. Alternative aircraft designs will have to be evaluated increasingly against their compatibility with the infrastructure. If V/STOL were to be the most appropriate solution, the system would have to develop the ability to function in a mixed CTOL/ V/STOL environment for at least a generation before it moves over fully to V/STOL. Meanwhile, virtually the only concession being made to changing aircraft technology in the current planning of major airports (eg Kansai, Denver, Munich II, Stansted) is a small increase in size over the 747-400.

The three examples given above illustrate the many interesting and important areas of interaction between the aircraft technology and the airport which must service it. It is vitally important for adequate infrastructure planning
that longer term predictions of technology be made accurately, and that the technology be appropriate to the infrastructure that could be made available. Open-ended explorations of feasible technology abound both for the medium term (Albers and Zuk, 1988), and for the longer term, the latter ranging from conservative technology (Schmitt, 1988) to smart skins, noise cancelling and vortex dissipation (Graves, 1988). Formal technological forecasting methodologies must be developed of a much improved calibre. The industry's own trend forecasting (IWG, 1990) is no more helpful than analysis with changes in watchmaking since 1790 (Makridakis, 1989) in setting potential technologies into a useful 21st century context. Yet it is correct to ask the question "In what areas of current research is there the possibility eventually to provide capacity increases up to four times the passenger traffic of today for the year 2040? It is possible that the facilities to be developed at a cost of hundreds of billions of dollars over the next 10 years will not be needed 25 years from now if an entirely new aviation network and system is adopted which can handle the traffic levels expected for the 2015 to 2040 time period." (Schoen, 1991). Some formal efforts have been made to develop methodologies to assess the risk of advanced technology (Batson and Love, 1988) and to predict technological changes by a Delphi technique (English and Kernan, 1976). The latter study predicted quite correctly the limited success of Concorde but expected 200 US SSTs and some 400 aircraft of 600-800 seats in 1993. These answers to the technology questionnaire implied twice the traffic predicted by a parallel traffic questionnaire. Clearly, improved methods of technological forecasting are required, probably with some normative element based in system needs. Both overall strategic system studies and a series of tactical sub-system studies are necessary if these aims are to be met. Piecemeal development is most unlikely to lead to an adequate system (Eggers, 1989).
CHAPTER 8: AIRPORTS

INTRODUCTION

Having reviewed the other important actors in the airport planning process, airports themselves must now be examined. It is necessary to establish their status and their potential to compete, in terms of their cost and revenue structure, their internal efficiency and their regulatory control. Attention is also given to strategic management and the strategic options available, both in this and later chapters. Since ownership may have some influence on an airport's capability to respond to pressures induced by liberalisation and the imposition of market rules, the discussion starts with a brief review of privatisation issues.

PRIVATISATION

Privatisation is a trend which is proceeding in parallel with liberalisation, both in airlines and in airports: indeed, there are possibilities for privatising ATC as well. It is seen as a way of improving internal efficiency and of making funding for expansion and renewal more available than when under government borrowing limits.

Apart from the creation of plcs for the UK regional airports (see the Annex) and a similar scheme for Kastrup and Roskilde airports in Copenhagen to be 100% government-owned plcs, five different forms of airport privatisation have taken place: the sale of existing airports, long term leases of airports to private firms, contract operations, creation of new terminal facilities by build-operate-transfer consortia, and the creation of new airports as private business ventures (Poole, 1992). Prime examples of these are BAA, Atlantic City, Lockheed Air Terminal's contract at Burbank, Toronto terminal 3 (and Birmingham Euro-Hub) and London City respectively.

There is no doubt that truly private ownership is able to unlock more development capital, but at higher interest rates than government funding, and Danish law allows this for even
a 100% government-owned plc (Thorning, 1990). On the other hand, the plc status of UK regional airports does not alter the restrictions of local government borrowing until a majority of the shares pass into non-government hands. Most local authorities are loath to take this step, but Liverpool has sold a majority stake to British Aerospace. There were no buyers when the CAA put its eight small Scottish airports up for sale. Apart from funding, which particularly helped Birmingham's Euro-Hub, it is hard to find evidence that the change to plc status itself has produced the expected benefits: BAA's own performance indicators show no real discontinuity before and after privatisation, and the heavy post-privatisation spending was already on stream (Poole, 1992). Equally, it could not be shown that the changes produced any adverse direct effects.

At the smaller scale, management contracts for British Airports International (BAI) to run previously local government-run airports have not managed to rescue their fortunes. BAI sacked all 93 employees at Southend at the beginning of its £100,000 per year contract in 1984, in an attempt to recoup a £500,000 loss. After a spell of increased services the airport is once again virtually without service (Airline World, Dec.6, 1984). At Liverpool, British Aerospace's plans for a major inter-continental hub appear doubtful, and, in the short term, it has not been able to retain British Midland's Heathrow service. Privatisation is clearly not a panacea. It may increase an airport's options, but can also increase risk and uncertainty.

COST INFLUENCES

It has been noted in Chapter 5 that there is considerable variation among airline costs, most of which can be explained without resorting to an examination of efficiency. With airports, the differences can again be explained, but usually only on a one-off basis. Each airport will tend to have specific opportunity costs of land, civil engineering problems and objectives with regard to cost-effectiveness, which make it rather pointless to generalise. It is, however, useful to mention the factors which influence the
costs, in order to set the discussion which follows in context.

Most of the fixed capital (ie that not dependent on throughput) is associated with airside development. It may only be £10,000 for a rural STOL strip or £200 million for a Dallas-Fort Worth: in both cases a large part of it must be spent before the airport can operate at all. It is also subject to very large indivisibilities; expenditure may have to increase by 80 per cent in order to double airside throughput. The groundside (ie from the access road to the aircraft gate) may eventually cost considerably more than the airside, but the initial investment can be much less and expenditure can keep much more in step with throughput. There may, however, be diseconomies associated with keeping the indivisibilities too small, in that congestion costs may arise from capacity effects and inefficiency due to construction.

Operating costs increase with the size of an airport, particularly if the expansion is groundside. The groundside unit costs per terminal passenger or tonne throughput depend on:

- traffic mix: facilities for charter and domestic passengers are cheaper than scheduled long haul

- sharing of facilities: leads to a greater utilisation of space

- policy on space standards (level of service)

- peakiness of traffic, affecting airport utilisation.

The airside unit costs depend on:

- scale of aircraft used: the effect on cost is hard to predict because large aircraft generally require a higher standard of provision of facilities, a higher regulatory classification, a much larger area to be maintained and amortised and a lower maximum movement
rate, but these factors must be balanced against the greater throughput per aircraft movement.

- apron layout: eg remote stands and shuttle buses versus nose-in parking and air bridges.

The economies of scale which should be associated with larger buildings and their servicing are hard to realise because other factors are almost always increasing as airports' throughput increase, namely:

- aircraft size
- number of operators
- international operations
- capital borrowing
- opening hours
- unionisation
- construction on the airport
- ancillary services.

An idea of how these factors combine to affect unit costs at different UK airports is given in Table 8.1 and Figure 8.1, where a Work Load Unit (WLU) is one passenger or 100 kg of cargo. The WLU is commonly used to attempt to account for the cargo contribution to expenses and revenue. There is no intention to infer that 200lb of cargo is equivalent to one passenger plus bags except in weight and therefore the certificated weight of the aircraft which carries them.

The BAA data are taken from their Report and Accounts. The airports owned by the CAA in the Highlands & Islands have their own Report and Accounts, published by the CAA: the results given here do not include a grant of over £3m from the Scottish Development Agency to allow them to make the return on assets required of the CAA by HM Government. The accounts of those airports owned by the Local Authorities are gathered together annually by the Chartered Institute of Public Finance and Accountancy (CIPFA 1987), and their report is the source of data for the other airports. Only Southampton and Plymouth are not represented, although data on Southend could not be used because of the method of
TABLE 8.1: UK REGIONAL AIRPORT DATA 1989/90

<table>
<thead>
<tr>
<th>Local Authority</th>
<th>Hours/day</th>
<th>Total pax x 10^3</th>
<th>WLU x 10^3</th>
<th>Total operating cost (£x10^6)</th>
<th>Total Exp. per WLU (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manchester</td>
<td>24</td>
<td>10164</td>
<td>10913</td>
<td>81.26</td>
<td>8.00</td>
</tr>
<tr>
<td>Luton</td>
<td>24</td>
<td>2803</td>
<td>3107</td>
<td>26.81</td>
<td>9.58</td>
</tr>
<tr>
<td>Birmingham</td>
<td>24</td>
<td>3394</td>
<td>3454</td>
<td>28.45</td>
<td>8.39</td>
</tr>
<tr>
<td>East Midlands</td>
<td>24</td>
<td>1511</td>
<td>1716</td>
<td>11.82</td>
<td>7.83</td>
</tr>
<tr>
<td>Newcastle</td>
<td>24</td>
<td>1545</td>
<td>1577</td>
<td>12.88</td>
<td>8.31</td>
</tr>
<tr>
<td>Bristol</td>
<td>15</td>
<td>879</td>
<td>901</td>
<td>14.04</td>
<td>15.95</td>
</tr>
<tr>
<td>Cardiff</td>
<td>24^1</td>
<td>708</td>
<td>728</td>
<td>5.73</td>
<td>8.07</td>
</tr>
<tr>
<td>Leeds</td>
<td>15</td>
<td>899</td>
<td>947</td>
<td>5.98</td>
<td>6.65</td>
</tr>
<tr>
<td>Liverpool</td>
<td>24</td>
<td>385</td>
<td>632</td>
<td>7.35</td>
<td>19.09</td>
</tr>
<tr>
<td>Teesside</td>
<td>14.5</td>
<td>344</td>
<td>344</td>
<td>4.21</td>
<td>12.24</td>
</tr>
<tr>
<td>Norwich</td>
<td>12.5</td>
<td>230</td>
<td>243</td>
<td>4.31</td>
<td>17.74</td>
</tr>
<tr>
<td>Exeter</td>
<td>11</td>
<td>228</td>
<td>246</td>
<td>3.93</td>
<td>15.98</td>
</tr>
<tr>
<td>Blackpool</td>
<td>14</td>
<td>134</td>
<td>148</td>
<td>2.49</td>
<td>16.82</td>
</tr>
<tr>
<td>Bournemouth</td>
<td>14</td>
<td>194</td>
<td>295</td>
<td>4.07</td>
<td>13.80</td>
</tr>
<tr>
<td>Humberside</td>
<td>15</td>
<td>116</td>
<td>116</td>
<td>2.23</td>
<td>19.22</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BAA^2</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gatwick</td>
<td>21207</td>
<td>23409</td>
<td>128.28</td>
<td>5.47</td>
<td></td>
</tr>
<tr>
<td>Heathrow</td>
<td>40321</td>
<td>48075</td>
<td>248.65</td>
<td>5.16</td>
<td></td>
</tr>
<tr>
<td>Glasgow</td>
<td>3934</td>
<td>4169</td>
<td>25.43</td>
<td>6.10</td>
<td></td>
</tr>
<tr>
<td>Aberdeen</td>
<td>1791</td>
<td>1872</td>
<td>12.18</td>
<td>6.57</td>
<td></td>
</tr>
<tr>
<td>Edinburgh</td>
<td>2432</td>
<td>2571</td>
<td>14.02</td>
<td>5.46</td>
<td></td>
</tr>
<tr>
<td>Prestwick</td>
<td>322</td>
<td>514</td>
<td>9.10</td>
<td>17.70</td>
<td></td>
</tr>
<tr>
<td>Stansted</td>
<td>1386</td>
<td>1712</td>
<td>18.54</td>
<td>10.84</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. Not 24 hours in winter.
2. Traffic data corrected to fiscal year by interpolation from CAA Airport Statistics.
3. Oil-related movements not included.
presentation of its accounts now that it is run by Airports UK. Indeed, CIPFA admit that comparisons within the Local Authority grouping are made difficult not just by the differing nature of the airport but also by differing accounting principles and reporting practices, particularly with regard to depreciation. These differences widen in the comparison between this group and the BAA and CAA airports, so that it is more relevant to consider the trends within each group than to compare absolute measures of financial performance.

Figure 8.1 plots the total operating cost (excluding debt charges) against Work Load Units (WLU). The only airports showing a more than 10% difference between passengers and WLUs are Exeter, Blackpool, Bournemouth, Humberside, Prestwick and Stansted. There is generally a quite linear relationship between cost and WLU, particularly if the different cost basis of the CAA airports is acknowledged and it is recognized that Prestwick, Stansted, Liverpool and Coventry are all very over-provided airports relative to their traffic levels.

The strong economies of scale which underly the linearity of Figure 8.1a are shown more clearly in Figure 8.1b, as it examines expenditure per WLU. It indicates that, even before debt charges are considered, no airport was achieving less than £4 per WLU in 1986/87. Airports in the 100,000 to 300,000 passenger per annum bracket were costing of the order of £8-£10 per WLU, while those with 10,000 to 30,000 passengers were costing about £26 per WLU. Those airports with conventional facilities and staffing but with traffic below 5,000 passengers per annum were costing £120 per WLU, though Tiree, with a small runway and few staff manages a cost per WLU equal to airports with an order to magnitude more traffic.

The major item of operating cost is always staff, which never accounts for less than 36% (with the exception of the special cases of Humberside and the CAA airports). The average staff cost for the Local Authority airports is 55% of the total operating cost before the addition of debt charges. The 2711
FIGURE 8.1: OPERATING COSTS OF UK AIRPORTS, 1986/87

a) TOTAL OPERATING COST
b) TOTAL EXPENDITURE PER WLU

![Graph showing total expenditure per WLU with key: LA airports, BAA, CAA. The graph plots Cost per WLU (£) against Work load units. There are data points for Prestwick and Sumburgh.](image-url)
staff were employed to handle £224m of net assets, ie £82,626 per employee, which is much higher than the average for airlines, ie airports are capital-intensive in this sense, as well as being labour-intensive. The variation in the employee cost per airport largely depends on the functions performed in-house rather than put out to tender, eg Luton does virtually everything in-house whereas Birmingham lets car parking etc out to concessions. Other airports with high costs for supplies and services are Manchester, Cardiff and Bournemouth. These airports employ the CAA to provide air traffic services. Humberside, Liverpool and Birmingham also have high costs of Agency Services where services (and the associated staff) such as security and the fire service were being provided by the local authority on behalf of the airport. The staff cost also depends on the cost per employee. The variation here is considerable: although some of the variation is due to the range of functions performed and the opening hours, there are also locational and other factors at work. The BAA costs per employee would be less if corporate and central service staff had been allocated to each airport to reflect the way the central costs have been allocated.

The second largest item is almost always the depreciation and interest on loans (ie debt charges). There is a general trend to relatively low debt charges in airports with a low throughput. Leeds was still paying heavily for its recent development, while Bristol has been very frugal with its spending. Dundee recently nearly doubled the length of its runway with some help from the EEC Regional Development Fund.

The variation about the mean cost per WLU after taking account of economies of scale are due to the differing levels of utilisation of the built facilities, to policies which emphasise regional advantage rather than airport finances and to the differing mix of traffic. The latter effect can often be reflected also in the income levels eg an international airport has to provide customs and immigration facilities but can usually benefit from the income of a duty-free shop.

These costs are not normalised to account for the lack of
homogeneity in the airports: some provide their own security, baggage handling, ATC, etc. Attempts were made to carry out a normalised analysis in the 1970s (Doganis and Thompson, 1973; Doganis et al, 1978). These concluded that there were substantial economies of scale, particularly below a throughput of three million WLU per annum, and that the costs were strongly dependent on the ratio of international to domestic passengers, on the way in which ATC was provided (CAA or in-house) and on the degree to which an airport had undertaken a recent development programme. These studies were later extended to include those European airports whose accounts were sufficiently self-standing to be analysed (Doganis and Nuntinen, 1983). The larger average size of these airports may have obscured any economy of scale; certainly none was found, and neither development programmes nor the proportion of international passengers appeared to affect unit costs. The most recent update of the European study confirms these earlier results and also the labour-intensive nature of airport costs: the average result across 16 airports was that staff accounted for 42 per cent of the total annual costs, while capital amortisation was responsible for only 24 per cent (Graham, 1992). Only the European studies made an attempt to allow for differing degrees of capacity utilisation between the airports, and they were not very successful. It is therefore difficult to use these results to guide investment decisions, though they provide a useful basis for the generation of performance indicators to monitor the management of productivity.

An analysis, with similar methodology to that used for UK airlines, was performed on BAA airports (Tolofari, Ashford and Caves, 1990). Due to the lumpy investment which is characteristic of the airport industry and the large contribution of that capital spend to the total costs, a capacity utilisation variable was used and the emphasis was placed on a variable cost model: the long run cost curve was derived from the short term curves. The resulting RTD of the airports are given in Table 8.2, averaged over the 1975 - 1987 period of the data set. The values for the London airports did not change substantially over the period. The results show that, whereas there is every reason to increase
Stansted's output without further expansion, this cannot be said of Heathrow. On the other hand, Heathrow does have a long run economy of size of 1.84, which is not much less than the RTS of 2.01 for the 'average' airport in the sample.

**TABLE 8.2: RETURNS TO DENSITY OF BAA AIRPORTS**

<table>
<thead>
<tr>
<th>Airport</th>
<th>Return to Density</th>
<th>Output WLU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heathrow</td>
<td>0.99</td>
<td>32.84</td>
</tr>
<tr>
<td>Gatwick</td>
<td>1.21</td>
<td>11.86</td>
</tr>
<tr>
<td>Stansted</td>
<td>2.69</td>
<td>0.54</td>
</tr>
<tr>
<td>Glasgow</td>
<td>1.13</td>
<td>2.55</td>
</tr>
<tr>
<td>Edinburgh</td>
<td>1.04</td>
<td>1.31</td>
</tr>
<tr>
<td>Prestwick</td>
<td>3.06</td>
<td>0.49</td>
</tr>
<tr>
<td>Aberdeen</td>
<td>1.03</td>
<td>1.46</td>
</tr>
</tbody>
</table>

*Source: Tolofari, Ashford and Caves, 1990*

**TABLE 8.3: LONDON AIRPORTS' COSTS (£ PER WORK LOAD UNIT)**

<table>
<thead>
<tr>
<th></th>
<th>Heathrow</th>
<th>Gatwick</th>
<th>Stansted</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a. Average for 1975-1987</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short run</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>3.64</td>
<td>3.27</td>
<td>9.29</td>
</tr>
<tr>
<td>Marginal</td>
<td>1.76</td>
<td>1.50</td>
<td>1.72</td>
</tr>
<tr>
<td>Long run</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>3.65</td>
<td>3.13</td>
<td>24.60</td>
</tr>
<tr>
<td>Marginal</td>
<td>3.84</td>
<td>2.76</td>
<td>4.95</td>
</tr>
<tr>
<td><strong>b. Average for 1986-1987</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short run</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>3.92</td>
<td>3.09</td>
<td>9.18</td>
</tr>
<tr>
<td>Marginal</td>
<td>1.83</td>
<td>1.57</td>
<td>2.46</td>
</tr>
<tr>
<td>Long run</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>3.95</td>
<td>3.43</td>
<td>22.70</td>
</tr>
<tr>
<td>Marginal</td>
<td>4.40</td>
<td>3.29</td>
<td>3.86</td>
</tr>
</tbody>
</table>

*Source: Tolofari, Ashford and Caves, 1990*
If unit costs of the airports are to be minimised, the results of the analysis suggest that Stansted should be strongly encouraged to increase its throughput with minimal further investment, while other airports, including Heathrow, display greater RTS than RT, and hence should be encouraged to further expand their facilities. This is particularly so since the long run marginal costs of both Heathrow and Gatwick are on average lower than those of Stansted, and similar for the latest year in the sampled period, as shown by Table 8.3.

This is not to say that airlines will be directly influenced by the marginal or average costs of airports. While the airports may be trying to minimise those costs and though average charges may be based on them, the use of peak pricing policies will mean that the more congested airports will appear to the airlines to be more expensive than shown by the analysis. This is not a subject which can be considered further here: it is fully covered in the literature (Brander and Cook, 1986) where it is argued that, if capacity is not constrained, the overall market will settle at zero economic rent and that social surplus will be maximised when peak prices are based on estimates of the social costs of congestion. The implications for the construction of methods for effecting transfer payments under such a system are numerous and difficult. The implication for airline costs is that the marginal airline would be indifferent to the choice of airport.

In summary, the cost evidence suggests that there are returns to scale available at Heathrow and Gatwick of the same order as the returns to density available at Stansted. If cost minimisation were the main consideration in airport planning, these results would support the Eyre Enquiry decision for short term growth at Stansted and long term further expansion at Heathrow.

**REVENUES**

In fact, in a liberalised and competitive setting, particularly where there is an element of airport
privatisation, the profit motive is likely to be a primary determinant of policy. Although this depends on the difference between revenue and cost, maximum profit may well not be made at minimum unit cost, even in a competitive situation. BAA quite deliberately provide more space for passengers than is strictly necessary for processing, in order to improve concessions revenue: this not only produces a high marginal profit contribution but also helps to keep airline fees down. On average, 16 European airports obtained 45 per cent of their revenue from non-aeronautical sources (Graham, 1992). Also, the more competitive the situation, the more it may be necessary to maintain a high and costly level of service, in order to persuade the airlines that their passengers are satisfied. Little research has been done into the ability to influence passengers' choice of airport by level of service, other than the price of duty free, particularly for transfers (eg Dubai, Manchester). However, airlines' decisions certainly appear to be based partly on level of service - eg American Airline's decision to use Stansted (since terminated).

At the margin, ie for those operations which are financially fragile, airlines are also swayed by the landing fees, passenger charges and other infrastructure costs which have to be incorporated in the ticket price. A considerable amount of attention therefore needs to be given to these charges.

The charges can be used as a competitive tool in an underutilised situation, but also as a method of controlling demand and maximising cost recovery in a congested situation, hence funding of additional capacity. In fact, "under the assumption of perfect divisibility of capacity expansion, the well-known cost recovery theorem states that congestion toll revenues just cover (fall short of, exceed) the amortised costs of capacity expansion if there are constant (increasing, decreasing) returns to scale in capacity construction and the congestion delay time is homogenous of degree zero in traffic volumes and capacity. However, perfect divisibility of capacity expansion is not a realistic assumption for ...... airport runways and terminals."
We have shown that when capacity investment is lumpy, the cost recovery ratio depends on the time path of traffic growth, and thus the conventional cost recovery theorem no longer holds". (Oum and Zhang, 1990). The same authors point out that social marginal cost pricing, which gives the most efficient allocation of resources, implies increases in user charges prior to expansion and a rapid reduction immediately after expansion, which is difficult to manage: a constant optimal price is, however, seen to result in too high a welfare loss. The IATA favours a minimum of forward funding from a development fund raised through congestion fees, preferring that the capital be raised in other ways and amortised over the life of the project.

In the matter of maximising revenue from scarce runway capacity, by charging a flat fee rather than one varying in the traditional fashion with aircraft weight, IATA tends to favour the flat fee whereas ICAO prefers this method only when the capacity problem is severe (Vandyk, 1993). Since congestion tends to occur only at peak periods, some airports, notably BAA at Heathrow and Gatwick, have for many years differentiated their landing and passenger handling charges between carefully defined peak hours and those in off-peak periods. They found little ability to control the schedules of the major operators with this pricing mechanism, though marginal operations are sensitive both to this and to the flat fee; the latter being particularly onerous for short haul operations by small aircraft. Operators who do retain their peak slots do not pass these extra costs specifically to their peak passengers. It has been suggested that passengers themselves ought to be charged directly through a peak surcharge, thus creating additional indirect pressure on airlines to shift to off-peak slots (Hardaway, 1986).

CONTROL OVER PRICING

In the UK, most regional airports have always been in a competitive and uncongested environment, (see the Annex), despite the regulated nature of the airline industry. The temptation was always to keep fees low in order to retain airline service, despite the nominal uniform pricing policy
of the Aerodrome Owners Association (AOA) and the Joint Airports Committee of Local Authorities Airports (JACOLA). The poor joint profitability of these airports (Doganis et al, 1978) led to a five year plan of phased and coordinated increases in fees, particularly the passenger load supplement. These were agreed between AOA, JACOLA and the airlines (Bowers, 1979). This would, of course, have been against the principle of cost-related pricing, given the apparent economies of scale, though perhaps not to the same extent as the principle of 'what the market would bear' which had been firmly ingrained in the industry. The Director of Fair Trading ruled that, under the Restrictive Practices Act which had been made applicable to the service industries in 1976, the agreement would have to go to a Court ruling, but the essence of the agreement was carried through.

At the other extreme, in a profitable but potentially monopolistic situation, as is the case with the BAA South East airports, and has also been deemed to be the case with Manchester, the CAA is required under the 1986 Act to rule on the allowable fees after consultation with the Monopolies and Mergers Commission (MMC). In its latest review of the BAA, the CAA ruled for a very marked reduction in fees, which was modified after support came from the airlines for BAA's argument that their investment plans would be put in jeopardy. The situation was resolved by the CAA tapering off the fee reductions (in real terms) to Retail Price Index (RPI) -8, -8, -4, -1, -1 over the five years from 1992, and the BAA agreeing not to cut back on necessary investment (Nuutinen, 1991). It is not certain that the CAA has been equally vigilant in ensuring that Stansted is not subsidised by revenues from Heathrow and Gatwick, indeed, Luton Airport has accused BAA of predatory pricing (Betts, 1993) - though it is a matter of balancing competition policy against expansion funding.

These two cases of regulatory intervention are examples of the difficulties that airport companies have in behaving like a profit-maximising private enterprise. They also exemplify the importance of a clear analysis of the power relationships in the industry if workable strategies are to be developed.
and implemented successfully. This is further elaborated in Chapter 12. Profitability will certainly be affected by the UK and EC regulators’ view of monopoly pricing, predatory pricing and cartels in a privatised airport industry, just as they are in the airline industry.

It will also be necessary to predict likely initiatives by legislators with respect to charges and their harmonisation. There is already a tendency in Germany, Australia, Canada and the US to ring-fence some peak hour slots for General Aviation and Third Level scheduled services, with the implication of reduced fees for these slots, as indicated in Chapter 3. It is also likely that fees will have to increase in real terms to cover the costs of expansion, even if after the event, and also for levies to be raised for the control of noise, emissions and energy use, as indicated in Chapter 6 (Toms, 1993). There is a general feeling in the industry that these taxes should be harmonised worldwide through ICAO, but the basis for harmonisation is far from being agreed. Also, some legislators feel that it is wrong to insist on the airports being able to earmark the taxes for the alleviation of the nuisance, on the basis that pollution knows no boundaries (Vaagen, 1993).

The EC legislators appear to be against the recognition of the monetary value of a scarce runway slot (see Chapter 3), despite the fact that trading in these slots occurs legitimately under FAA regulation in the US, and the US airlines valuation of their predecessors’ routes to London were clearly influenced by the high value of slots at Heathrow. It has been argued that the real owners of the slots are the airports, and that sales or leases to the highest bidder would give the most appropriate method of funding capacity expansion (Cameron, 1991). This would require coordination, which might be helped by slot leasing with slot pricing. It would also require more rigorous ‘ring fencing’ and would do little to alleviate the problem that slots are useless without traffic rights. It seems that the transition from State-owned to plc-owned slots would certainly present many difficulties, but might take some of the strain off capacity funding in an era of rigorous control.
of monopoly pricing.

**PROFITABILITY**

While the large established airports may be viewed as a limitless source of profits, even allowing for regulatory intervention, this will only be true to the extent that they manage their resources effectively. If they opt for a 'fat cow' policy, there is every danger that the consequent stagnation of profits would displease investors, and the competing airports and the airlines which use them will increase their market share. If they do invest, the absolute level of investment to gain a reasonable percentage increase in capacity and hence a reasonable uncongested time horizon may be so great that the economies of scale no longer apply: non-linear costs of large scale environmental disturbance may occur. The Annex indicates how non-linear these may be with respect to an extra runway at Heathrow, though it also shows that even the high costs of a full third runway could be acceptably amortised over the large number of extra passengers that could be accommodated.

The greater danger lies with those small airports who feel the need to expand or die. Figure 8.2 shows the reported operating surplus for the UK airports, ie before covering debt charges in the 1986/87 financial year. Leeds/Bradford appears to perform very well, but, after allowing for debt charges, it performs no better than average. The overprovision of Stansted and Prestwick becomes apparent, though again it is not possible to make a strict comparison between the BAA and other results. The effects of scale appear to be strong, with a breakeven on operations at approximately 0.2m passengers per year and an operating surplus of £1m at 0.5m passengers per year. The addition of debt charges requires perhaps a further 0.2m or 0.3m passengers to ensure similar results for profits. It is clear from Figure 8.2 that it is very easy to lose money if traffic does not materialise to cover an investment, and also that below 50,000 passengers it is very difficult to avoid losses - though Gloucester/Cheltenham succeeds in staying in the black by not investing, by maintaining almost exclusively
FIGURE 8.2: OPERATING SURPLUS PER WLU
a domestic operation (i.e., charter to the Channel Isles) and by only opening 10 hours per day.

The concept of escapable costs can be applied to airports, as indicated in figure 8.3 (Doganis and Thompson, 1978). Thus, while salaries are inescapable, maintenance and repair cost could be postponed for a year, and depreciation and renewal costs might be postponed for five years, subject to CAA licensing requirements, interest and development charges could theoretically be postponed indefinitely. The implication of this policy is that the airport's traffic would at best stagnate and the airport would lose market share. Southend, Stansted and Bristol survived for a long time using this approach, as have Coventry and Staverton. The really difficult choice is whether to accept declining share of the overall market, with perhaps a niche function whose market is close to saturation (ferry routes at Blackpool, Bournemouth; general aviation at Coventry; oil at Humberside and Norwich), or to attempt supply-led expansion in the hope of reclaiming natural market share. This is a real dilemma for East Midlands, Teeside and Liverpool. It is addressed from the viewpoint of the potential market in Chapter 4, from the viewpoint of airline strategy in Chapter 5 and implicitly from the viewpoint of the planning potential in Chapter 6.

MANAGEMENT STRATEGY

The discussion of airports' trends and possibilities clearly illustrates the challenge facing airport management teams in an era of airline liberalisation and an ethos of free competition. The US experience of deregulation produced a great deal of turbulence and instability in airport market shares (de Neufville and Barber, 1991), inevitably resulting in greater risk for any given investment. It has been suggested that airport owners should therefore cease to conform to conventional master planning, which generates a single solution for a long term future. Instead, planning should consciously put the owners in favourable positions relative to new needs and opportunities as they arise, minimising risks by continually adjusting the plan to the
real situation. This is clearly desirable, but needs to be supported by

- a knowledge of the real potential in the marketplace, and the probability of realising it (Chapters 4, 5 and 10)

- a realistic view of the potential role of the airport within the overall air transport system (Chapter 2)

- the likelihood of successful planning approval (Chapter 6)

- continuous scanning for risks and opportunities (Chapter 3)


Even so, for the smaller airport, the scope for taking up favourable positions is particularly limited: low traffic levels and thin profits create a greater risk than protecting or expanding from a strong market base, as evidenced by the experience of Cardiff and Liverpool, whose supply-led initiatives have not been successful. When on the edge of viability at, say, half a million passengers, the experience of Bristol and East Midlands suggests that a better approach might be to wait for clear demand pressure for expansion.

This view is strengthened by the knowledge that the turbulence and uncertainty can only increase as liberalisation develops. The risks will come from the enhanced role of market leaders, doubts about the long term demand trends, EC policy for intervention and their implications for costs, the reshaping of the airline industry, and from the unpredictability of the planning process. A real difficulty is that smaller airports do not have the expertise (or the funds) to perform the sort of risk analysis which the market leaders perform (Volgers, 1992). When this can be done, the potential risks can be ranked and
controlled, both those external risks mentioned above and internal risks eg human resources and accidents. The small airports can also do little proactively to influence the level of risk, eg by forging an active role in bilateral route negotiations, though it would be wise to press for an enhanced role in these proceedings (Katz, 1991).

Since one of the reasons for privatisation is the ability to obtain funds for development, it is quite likely that the preferred policy for smaller airports would be to refuse to rise to the bait, and rely on local or regional support to avoid closure. Alternatively, the management could be privatised to boost efficiency by means of a franchise, with the existing owners retaining firm control of investment decisions.
CHAPTER 9: PLANNING METHODS

"A rational problem solver wants what he can get and does not try to get what he wants."

- Hirschman and Lindblom, 1962

INTRODUCTION

The five main elements of the air transport system have now been examined, together with the liberalised setting within which the industry must ensure the development of the infrastructure necessary for growth. The remaining important influence is the planning process through which development initiatives must pass. There are actually two aspects involved in the planning process. This chapter first reviews the processes by which the evidence for and against a scheme, as drawn up in Chapter 6, might be gathered and analysed. This is the evaluation stage of the overall planning and decision process. The relationship between the setting for development and the appropriate evaluation method is explored. The chapter then reviews the parallel shifts required in the overall planning style and decision framework, again according to the setting. The discussion is focused on the need for processes which might lead to the implementation of projects which are efficient for all of the principal actors.

EVALUATING THE BALANCE

Difficulties

It is often inferred that the evaluation problem is one of balancing air transport benefits against environmental costs at an airport. Then it should be possible to develop an index of, say:

\[ \frac{\sum \text{total environmental disutility per person affected}}{\sum \text{utility per person boarded}} \]
and set a maximum value which could not be exceeded legally and below which a sliding scale of compensatory tax would be paid per departing passenger. Of course, difficulties arise because of differences in perception of values, ignorance of the full societal costs, the existence of societal benefits as well as costs, and the important interests of power groupings other than simply local passengers and local residents. Figure 1.1 indicates some of the more powerful interests and their interrelationships.

Economics and Politics

A speaker from the FAA at the 7th World Airports Conference in 1983 said that airport operation becomes increasingly one of balancing the benefits to the community, gained from an airport's operation, against the costs to the community arising from that operation (Wesler, 1983). He went on to say that, in the US, it is estimated that less than 3 per cent of the citizens are adversely affected by airport noise, while the vast majority of its citizens benefit from the operation of those airports. While accurately putting his finger on the pulse of the dilemma, the speaker appeared to take a rather naive view of the complexity of the task of striking the balance. His approach was towards pacification of the minority, rather than taking a broad-based neutral evaluation position.

In an ideal market economy, the price of transport would determine not only how each mode would be used but also how much travel was beneficial for society at large. In other words, the full social costs imposed by each unit of travel would be reflected in the cost of travel. However, market forces operate with a decision rule that one dollar equates to one vote, while democracy operates on the basis that one person equates to one vote (Flyvbjerg, 1984). So, even if the price of transport accurately reflected the true long term value of resources used, the ethics of an egalitarian society would still require additional judgements to be made. This must be especially so if there is an underlying culture of justice, where each person is to have an equal right to the most extensive system of equal basic liberties compatible
with a similar system of liberty for all, and justice should prevail over efficiency and welfare objectives (Rawls, 1971). Ultimately, these judgements are made through the political process, but the judgements should be informed ones. The Environmental Impact Statement (EIS) is important in this respect, as well as proving publicly that environmental concerns are being properly addressed (Anderson and Rideout, 1992).

Adequate Mobility Concept

In the political arena, aviation often loses through being seen as benefiting the rich, while offering little to the poor. It is also seen as being resource-thirsty in comparison with other modes. It has been suggested that the most important goal of freedom of choice relates to access to opportunities (Wilson, 1969), but there is a growing opinion that all modes of transport are consuming more resources than could be justified if the long term resource costs were truly reflected in the price. Thus, some take the view that, if the main EEC objectives are prosperity, accessibility, cohesion, safety and fair competition, then transport policy must reflect a proper balance between freedom and excessive consumption (Group Transport 2000 Plus, 1990). Planners are coming to the conclusion that ever greater mobility is no longer an acceptable social goal (Nijkamp and Reichman, 1987). Similarly, freight transport stands accused of 'carrying too many coals to Newcastle' because pricing does not reflect true costs (Hägerstrand, 1987). The rearrangement of total logistic chains around the Just-in-Time concept is criticised on the same grounds (Hillsman and Southworth, 1990).

It is not necessary to hold the ultimate introspective view that 'the final delusion is movement, change, and variety for their own sakes alone' (Merton, 1987), to see that there is a self-fuelling process at work in the availability of mobility which is of no more benefit to society than to the individual. The so-called 'tip-toe' effect or the 'paradox of universality' (Nijkamp and Reichman, 1987) refers to the phenomenon that those who managed to improve their well-being
following a transportation improvement are bound to lose it sooner or later to others who follow their example. A new attempt to maintain their advantage by buying further mobility sustains the process. Ultimately, chaos would reign if everyone had a magic carpet (Hagerstrand, 1987), not least because time bottlenecks would replace the space constraints. A good example of this situation would be the future success of the Bede supersonic single seater aircraft. In other words, the existence of an unsatisfied demand is not a sufficient condition to justify further transport investment.

The Scope of Evaluation Methods

The discipline of Technology Assessment (TA) was, for some time, an accepted way of investigating the overall value of advanced transport concepts. It has been used formally, by the Office of Technology Assessment in the US, in a reactive way to give early warning of undesirable side effects. An example of its use was the cancellation of the US SST programme by President Nixon (Fox, 1974). In contrast, in the UK, assessment has been much more narrowly based around benefits to users. The assessment of high speed rail (APT and Maglev) and vertical take-off aircraft (VTOL) on the London-Glasgow trunk routes, for example, rested on the sum of the money and time cost (IWPICT, 1970). Partial quantification of the issues, whether simplistic like the previous example or complex like the Roskill Commission, has then been subsumed in broader, unquantified and less open decision-making by the political party in power. This has been so, even when a change of land use requires the proposed transport investment to pass through the filter of a public inquiry. The intended role of the public inquiry process is undoubtedly fulfilled, i.e. that the interests of the citizen closely affected should be protected by the grant of a right to be heard and also to ensure that the Minister should be better informed of the facts of the case (Heijne, 1983). However, such isolated testings of local feeling fall well short of a national public debate of the absolute merits of mobility and the relative merits of the modes in providing that mobility.
Environmental Impact Statements

The adoption in the US and now in Europe of the legal requirement for an Environmental Impact Statement (EIS) to accompany any major project goes some way to allowing the public to become involved in a more constructive way than through litigation or through the adversarial forum of a public inquiry (Gillingwater, 1988). When conducted on federally initiated projects, an EIS also allows national level debate. The EIS then becomes part of an active form of assessing the mode's impact, facilitating the evaluation of the alternative projects which are a mandatory part of the EIS (Smits and Leyton, 1988). The process is still imperfect. Not only is there no legal requirement to adopt the results of an EIS, but the generation of alternatives can be as mistakenly narrow as the guidelines given to the Roskill Commission or to the CAA in their considerations of the location of new runway capacity in the South East of England (see the Annex). The EIS for the DFW extension contained 14 alternative runway layouts but no alternative which considered the use of satellite airports (Street, 1991). There are fears that both the FAA and the Courts endorse the use of EIS for internal decisions on options rather than for the ends of ensuring full disclosure (Orlick, 1978). Since the FAA delegates the production of the EIS to the applicant, there is an almost inevitable bias towards those schemes which will be financially favourable to the applicant. The Courts tend to stress procedures over substance, since the National Environmental Policy Act of 1969 only requires 'consideration' of the environment rather than 'protection and enhancement of the human environment'. The EIS preparation and review process has therefore taken on the role of resolving conflict by avoidance, following the "Theory of Desirable Omission". In this, "the sponsor prepares as incomplete a draft as it feels it can get away with, thorough enough to avoid total embarrassment.... Once comments are received within the prescribed time limits, the agency (FAA) can conduct studies (if necessary) only on the issues raised.... Should the 'watchdogs' be asleep, disorganized, or lacking enough political influence to have their objections acted upon,.... the Draft EIS may become ...
Informed Public Debate

A rigorous and extensive use of EIS could assist proactively in developing long term policy and in broadening the decision process (Smits and Leyton, 1988). To do this successfully, the evaluator must be independent of the established bureaucracy while maintaining political realism (Pollitt, 1980). Ultimately, the evaluation will have to be made at the political level, both because of the well known difficulties of quantification, of unequal distribution of costs and benefits and of the comparison of apples-with-pears-with-oranges experienced in cost-benefit analyses, but also because of the theoretical impossibility of deriving a social welfare function to aggregate individual utilities.

Though the debate on future aviation activity has to be resolved politically, it needs to be informed, and to inform the public, through formal evaluation techniques. In turn, the evaluation practitioners need to be informed by the political machinery of the prerequisites for success. The aims and objectives in a democratic society are often only implicit in the behaviour of politicians, and the practitioners are left to best-guess how their efforts will be judged. The objectives given to the CAA for their recent search for runway capacity were explicit but far too narrow to produce alternatives which had a realistic chance of completing the passage through the planning process. Although it is possible to hazard a guess, based on previous government statements, of the broader objectives which would have to be satisfied by any entrepreneurial solution to the runway problem, and this has been attempted in the Annex, there is a high risk that the goalposts will move before implementation.

Evaluation Factors

In meeting likely criteria in the UK and the EEC, any societal evaluation of air transport will have to concern itself with the following factors:
• resources: energy, materials, land, capital, labour, time
• safety: passengers and third parties
• social: cohesion, accessibility, equity, opportunity, severance
• political: carbon tax, competition
• future technology: aircraft, ATC, other modes
• future system efficiencies:
• planning: land use, spatial distribution of population

as well as the more traditional concentration on

• environment: noise, air, water, ecology
• demand: cost, other modes, propensity to travel
• economics: contribution, stimulation

if the wider debate is to be initiated which alone can result in synergistic policy development, ie those with the capability to improve the majority of the evaluation factors, thus opening the possibility of a WIN/WIN solution.

Many of these factors can be, and have been, evaluated in relation to air transport by the industry or by independent studies. For example, a 1977 OECD study showed how well aviation could improve intra-EEC accessibility. On the other hand, studies suggest that the lagged endogenous long run gasoline elasticities for all uses are -0.8 for price and 1.2 for income. Thus consumption will grow unless taxes rise to ensure that prices rise faster than income growth (Sterner et al, 1992). Other factors need much more attention. Those which may favour aviation include third party safety, value of time, land take, severance, ecology, accessibility, competition, future technology. Those which may favour a limitation on aviation include other modes, equity, carbon tax, ATC.

Perhaps the least explored evaluation area is that of future cross-relationships, eg the impact of the technology of other modes and of changes in propensity to travel on air transport demand, and therefore on the future appropriate air
transport network.

The other evaluation area commonly missed is that of the secondary effects of transport. In the area of CO₂ emissions, for example, the emissions come not only from the transport energy but also from the energy used in refining petroleum, in making and maintaining the vehicles, in building the infrastructure and in making the materials from which the vehicles and infrastructure are made (DeLuchi, 1993; Hillsman and Southworth, 1990). The BART San Francisco Bay area rapid transit system used 44 per cent of its 50 year energy budget during construction (Wilson and Neff, 1983). The German government purports to adopt a common evaluation procedure for investment across all modes according to criteria relating to the federal economy, regional policy, ecology, etc. The economic items are assessed using cost-benefit analysis, where environmental benefits from eg accident, emissions and energy reductions are included (Gand, 1991), but it is unlikely that if all these important secondary effects are properly accounted.

The Usefulness of Full Societal Evaluations

The ultimate value of realistic evaluations of air transport would be that the mode's development would become effectively self-regulating, proceeding in a way which the political and planning processes would rubber stamp. Striking the balance would, as it were, be settled out of court. Any such development would require a broad appreciation of society's economic and social needs and of the necessary trade-offs to be made. The emphasis would have to be on joint progress and mediation rather than conflict and confrontation. The theory of negotiating a 'win-win' situation is well known (Fisher and Ury, 1986). The principles are to separate the people from the problem, to focus on interests rather than positions, to generate a variety of possibilities and to insist on some objective standard on which to base the results. Prototypes for this type of framework exist in mediation exercises at airports in the US (Johnson, 1989) and in the initiative between IATA and the Airfields Environment Federation (Logan, 1990). A suggestion as to how the process
could be implemented to deal with UK aviation infrastructure planning will be made in Chapter 12.

Other modes are already being scrutinised in this way, either on their own initiative or by policy makers, as cultural and ethical concerns are beginning critically to affect the development and use of technology (Nikolajew, 1991). The Swiss Board of Education commissioned the MANTO study of the implications of advanced telecommunications on society (Rotach, 1988) costing Fr 2.3 million over 3.5 years with 40 experts, concentrating on those indicators appropriate to Swiss interests - jobs, fuel, office space, disposal of equipment. The Community of European Railways (CER) has estimated that the social rate of return from the European High Speed Rail Network, due to safety, congestion, pollution and energy savings as traffic switches from road and air, will add a further 10 per cent to the 9.4 per cent economic rate of return on between 50 and 90 billion Ecus (Avmark, 1989b).

Air Transport Evaluations

An impressive attempt at a multi-dimensional evaluation was made in 1975 when Boeing performed a comparative analysis of inter-city transport modes which included fuel efficiency, circuity, load factor, safety, emissions and modal split as a function of cost and value of time, as well as drawing attention to a large number of other planning facets which should be taken into account (Schott and Leisher, 1975). Similar studies were performed in the UK at the time when STOL and VTOL aircraft were being designed (Chichester-Miles, 1974; Quick, 1971). Times have changed. Air would not compare so well on circuity now that hubbing is more prevalent, but would be better placed on energy. A less detailed but more broadly based study was completed in 1990 in the US (TRB, 1990), following an earlier panel recommendation (TRB, 1988) when the FAA and Department of Transportation requested the Transportation Research Board (TRB) to convene a committee to study the strategic choices for US air transport to the year 2040.
The TRB panel evaluated eight strategic options against each of ten factors, rating each option on a scale between -3 and +3. The factors were capacity benefits, capital cost, operating cost, safety, passenger effects, industry effects, environment, local and regional effects, funding and financing, and implementation. Clearly many criticisms could be raised against the methodology, not least on the matter of subjective judgements but the results led the panel to recommend that three options were worth more detailed investigation. These strategies were:

- Further construction of airports combined with the centralised management of demand allocation
- Let the market decide about building new airports and introducing new technology, relying on local management to allocate traffic by economic measures
- Revolutionize intercity transport technology, with new aircraft, air traffic control and high speed rail.

One of their general conclusions was that, like friction, congestion and delay are inherent to any efficient transport system. They also concluded that the 'best' solution must conform to social values, be based on sound economics and find political support locally and nationally. They rejected the strategies of retaining the present system of management, of simplistically planning to build new airports and of reconfiguring the system around transfer-only airports. Their recommendations with respect to new aircraft were the development of 150 seat RTOL and VTOL to replace conventional jets, so using airport space more efficiently, and the development of large aircraft.

The form of panel analysis, adopted by TRB, goes some way towards recognizing that decisions are more complex and that the future is less certain than they appeared to be 20 years ago, that the understanding of relationships and preferences is also admitted to be uncertain, and that decisions need therefore to be taken on a less rigid basis than computation. It has been suggested, as depicted in Figure 9.1, that it may
be necessary even to move beyond compromise and judgement (as used by the TRB panel) to inspiration (Thompson, 1967). If a paradigm shift like this is to occur, similar changes will be necessary in the whole framework of planning in which the evaluation process is set. The framework is therefore examined next.

PLANNING FRAMEWORKS

Changes in planning methodology

There has been a decline in the use of formal planning in the development of infrastructure in general, particularly in the field of air transport. In the mid-1960s to late-1970s, strategic planning commanded esteem both in Britain and
abroad, even though central government did not make any specific commitment to it. The process had evolved to the point where it could be described as essentially fair and humane, though with a slow and cumbersome machinery (Buchanan, 1972). However, by the mid-1980s, the Regional Economic Planning Councils, the Centre for Environmental Studies, the Greater London Council and the Metropolitan Councils had all been dismantled, while the Strategic Plan for the South East had all but disappeared. Structure planning had lost status in favour of more pragmatic local planning, which in turn had become more influenced by "piecemeal industrial promotion" (Breheeny and Hall, 1984). Thus in the space of some twenty years, planning in its allocative as opposed to its innovative mode (Friedmann, 1973) had gone through all four identifiable phases of methodological development ie definition, formalisation, maturity, decline (Teitz, 1974). In the process, it had passed through three eras: the blueprint-type Master Planning, the systems view and finally continuous participation. This is similar to more general trends noted in the literature (Muller, 1992). Despite these attempts to remain relevant to the changes in society, the practice of planning had declined dramatically, with practitioners becoming "at best indifferent, at worst hostile to theory" (Breheeny, 1983, p 102).

This must have been due in part to planning's lack of success in meeting its objectives, though the failures might have been more because of the timorous nature of the policies, the shortage of investment and the inertia inherent in the situations requiring change (Buchanan, 1972). Other possible causes might have been lack of economic and demographic growth, local authorities' liabilities in relation to compensation, or a long period of Conservative government: the government clearly feel that planning constrains freedom and interferes with the market economy. It has been observed that the most serious result of the decline of planning has been the stifling of debate and allowing the development of a style of government by 'cabal', with small cliques debating and resolving public affairs (Breheeny and Hall, 1984). The strong economic growth of the late 1980s and substantial
inter-regional migration did nothing to reinstate planning, so the causes of its decline are likely to have been those associated with a right-wing government, together with the continued perceived failure of allocative planning to achieve its goals. Other commentators have already drawn the latter conclusion: "where allocative planning is most feasible, it is superfluous, and, where it is most needed it is infeasible" (Friedmann, 1973). The rational/experimental model has been seen, in a complex environment, to suffer from information overload ie actors generate different and incompatible perspectives of the situation; further, any conclusions reached are not stable over time. In these circumstances decision makers are even more likely to appeal to ideology and to substitute power play for inquiry, thus making the political dimension of inquiry the exclusive one, and treating the inquiry itself as a cover or rationale for the resolutions achieved through dominance (Schon, 1973). Nevertheless, goal-oriented planning has enjoyed a recent resurgence in the UK metropolitan areas (May, 1991), even if with incomplete participation. These Integrated Transport Strategies stress a vision for a city, financial constraints, multicriteria evaluation, and, most importantly, the use of 'cartoon' strategies to test a wide range of policy instruments.

In the development phase of planning, systemic approaches were adopted as the primary tool. Taking a system as "a grouping of parts that operate together for a common purpose" (Forrester, 1972), an analysis structure was developed which recognised the essential features of all systems and their control by feedback. The principal features are the goals, the actual output, the system's interacting components and a boundary containing them. The feedback information is obtained by measuring the difference between the goals and the output. The interacting behaviour must be assumed to be independent of inputs from outside the boundary. Decisions are made within the feedback loops, the more complex systems being assemblies of interacting feedback loops. Systems are intrinsically dynamic, with time lags between a control action and a response to it. An element of 'feedforward' is therefore required for this and other reasons, to sense
disturbances and their consequences before they actually affect the system (Jackson, 1985).

The methodology for analysing social, and in particular transport systems was developed from that used in the design of physical systems. Thus alternative solutions to meeting objectives were designed and evaluated against each other (McLoughlin, 1969). The methodology rapidly became oversophisticated as practitioners grappled with the problems of 'soft' data, inadequate understanding of relationships within the system and conflicting goal statements (Roskill, 1971; Pardee et al, 1969). The excessive complication of the methodology, combined with the doubts as to the possibility of quantifying some variables and the resulting difficulties in understanding the output of the studies, rather discredited the systemic approach to planning transport systems except perhaps for short term control of the system as in Transportation Systems Management (TSM) (Lockwood, 1979).

The inability of 'rational decision making' to cope with complicated social situations was being predicted even during the first applications of systemic analysis to transport planning (Hirschman and Lindblom, 1962). It was pointed out that social conflict often does not allow clarification of objectives; that information is often lacking; that the future can be too uncertain and the problem too complex for human intellect to grasp. In such circumstances, it was deemed preferable to adopt a strategy of 'disjointed incrementalism' towards the improvement of a system. This would mean discarding the wider analysis of the system in its environment in favour of incremental, and therefore more easily understood, changes. It would mean pragmatically choosing ends and means simultaneously and in the light of their mutual interactions; it would also mean indefinite iteration of the analysis - policy loop rather than expecting to achieve a convergent solution in a single pass. The iteration would tend to move away from ills rather than moving towards objectives. The analysis of consequences in any one sector could be allowed to be incomplete, since it would become central for some other sector during an
essential but natural process of 'partisan mutual adjustment'. It was maintained that this strategy is not a flight from rationalism or a second-best approach; rather, it avoids inevitable errors which otherwise arise from over-ambitious attempts at comprehensive understanding; it accepts that systems are never complete or in equilibrium, thus not wasting effort on achieving early integration or balance; it makes use of the fact that individuals can often agree on policies when they cannot agree on ends; it relies on the truism that, in the long run, policy choices have as great an influence on objectives as the objectives have on policy choices. In fact, the strategy of 'disjointed incrementalism' is seen as more rational than the systemic approach to decision making, "since a rational problem solver wants what he can get and does not try to get what he wants except after identifying what he wants by examining what he can get" (Hirschman and Lindblom, 1962).

The pragmatic incremental approach has been combined with a systems methodology in Multi-Year Programme Planning (MYPP) in the US. In MYPP, the difficulties of obtaining any agreement about goals and values in a participatory framework are partially overcome by the discipline of having to spend each year's budget before moving on to later, and progressively less well defined, elements of the longer term plans (Manheim, 1979).

The rational (systems) and incremental models have also been incorporated in a 'third approach' by Etzioni in an attempt to give long term direction to the cumulative small changes (Starkie, 1987). The incremental decisions would be nested inside a broader framework provided by high-order, fundamental policy-making processes, which, while exploring the main alternatives seen by each actor, would omit the details and specification that the rational model would require if it were to be used on its own. The MYPP and 'third approach' models were early pragmatic attempts to overcome the weaknesses of the programmed paradigm in accounting for the decision-making concerns which caused the poor record of implementation (Flyvberg, 1984). In particular, the programmed evaluations based in monetary
terms failed to reflect the one-person-one-vote nature of the democratic decision process.

A second main paradigm for evaluation and implementation grew out of the need to overcome these difficulties by emphasizing the importance of social interaction. It is based in the scientific tradition of 'verstehen'. It views goals formulation as part of the social and political dynamics, and subject to change during the social interaction process. Theories are inductive, based on the cases under study and striving for valid subjective knowledge. The criteria for a successful conclusion are learning and consensus. The identification of target groups and the implementation of policies are dealt with adaptively during the decentralised and incremental process. Quantitative analysis is not abandoned, but integrated into a holistic framework through qualitative methods: often these rely on ranking of factors and weights (eg Paelinck, 1977).

The need to respond to increasingly turbulent environments was one of the factors which encouraged the adaptive planning paradigm. To the extent that it is successful, it is clearly more necessary to adopt this methodology as air transport liberalisation and industry privatisation increase the turbulence inherent in the politics of late twentieth century Europe. Also, since the evolution of the system will essentially be driven by them, any attempt to plan for an adequate air transport system in Europe will have to incorporate an understanding of the way in which large corporations themselves do their long term planning. Large organisations are, in fact, integrating programmed Strategic Planning Systems (SPS) methods with Strategic Issues Management Systems (SIMS). The latter is more adaptive to the issues raised by the strong or weak signals obtained from continuous and comprehensive monitoring of the environment in which their activities are set (Camillus and Datta, 1991).

It has also become evident that, whether within corporations or governments, planning will only be successful if it recognizes the power relationships which shape the broader ongoing debates which are inherent in the adaptive planning
paradigm. Further, it also needs to recognize that the more open the debate, the more likely it is that political antagonisms will be awakened and enabling coalitions will be endangered (Patten and Pollitt, 1983). It is therefore necessary for any useful planning paradigm to be responsive to the implications of democratic theory including the ways in which individuals and groups take decisions (bias, satisficing, cohesiveness, bolstering decisions, Groupthink), and in which power is exerted (coercion, expertise, authority, inducements, constraints). In particular, this is important in the public domain and with a free market setting, as the actors will seek to control the changing environment (rather than adapting to it) by dominating the debate and developing direct links to the decision-makers: the possible consequence being the coalescing of administrators with powerful interest groups against weaker groups, thus maintaining stability despite democratic pressure. Thus human-relation techniques embodied in the adaptive paradigm would be thwarted by the "Hydra-headed nature of bureaucratic power factors" (Patten and Pollitt, 1983). This is seen clearly in the use of law firms by airlines in Washington DC to communicate with the government officials and politicians, following a formula of IA²: Influence and Access, on political issues, and Information and Advice on substantive issues" (Donoghue and Nelms, 1993). A powerful marketing advantage of the large carriers is their ability to engage all the major law firms thus precluding them on ethical grounds from being able to represent their competitors. This is particularly important in view of the poor knowledge of the industry among the political representatives. In the UK, the lobbying ability of British Airways is envied by at least one of its competitors who relies on the equally important power relationship with public opinion (Branson, 1993).

On the other hand, there is clearly some requirement for at least initial evaluations to be essentially private, while retaining public legitimacy: initially the experts themselves will be in a learning process, and public debate only serves to confuse. It has been suggested that, in the early stages,
there is a need for a unit that has the technical capability and the political independence to evaluate (the expert discussion) and to criticize it (Stevenson, 1972). However, others, reviewing 14 different forms of citizen participation, concluded that the best approach is some form of partnership between planners and citizens, the decision being left to politicians (Larrabee 1970). The delegated power technique, which allows the citizens to control the decision making, was considered to be inappropriate for highway planning (and, by implication, airports), because of the need to consider links to other highways and regions. However, this is essentially the approach taken recently by the city of Austin in planning its airport expansion (Austin, 1991). A decade later, it was suggested that early interaction to generate social information was necessary (Wilson and Neff, 1983).

Having completed this brief survey of the development of planning paradigms, the actual practice of airport planning is now examined so that comparisons can be drawn between theory and practice.

**US airport planning methodology**

It is instructive to examine the US experience of airport planning in rather more detail than in Chapter 2 since its system has been more subject to the pressures of deregulation than any other. It should, however, be noted that the responsibility for the provision of infrastructure is, as yet, firmly in the hands of the FAA.

The identification of the need for alternative approaches to formulating policy for large projects with significant social consequences did not diminish the enthusiasm with which systems analysis was applied to transportation in the US. Indeed, by the mid 1970s it was being claimed as a profession (Manheim, 1976), whose analyses "must clarify the issues in ways which contribute to the constructive resolution of potential conflicts and to the reaching of implementable decisions by responsible decision-makers". This methodology, as well as the long range planning studies
within which it has been used, has been embraced warmly by the public sector transport planners and politicians in the U.S. Congress used that approach to study the transportation system to the year 2000, though with a major adaptation for resolving conflicts: they first derived policies independently to resolve key issues, then resolved conflicts in a second phase evaluation, so generating consistent policies (Shuster, 1975). Although intermodal planning has now lost favour at the Department of Transportation, this has been largely due to the fact that all the modal administrations within it have adopted at least medium range planning of their statutory programmes (Hazard, 1988).

The Federal Aviation Administration (FAA), as the agency concerned with air transport, has been a strong supporter of the classic systems analysis approach to planning (McLoughlin, 1969). They have long advocated that the process be adopted by States in their airport system planning (FAA, 1972), complete with derivation of goals; with citizen participation from the beginning of the process; with integration with other modes and planning agencies; with continual monitoring and adjustment of goals. Strangely, in their own first response to the Administration's recent National Transportation Policy initiative (FAA, 1990), the FAA admit that they have not yet formalised the strategic planning process. Indeed, it could be said that their first strategic plan is not a plan at all but rather a series of strategy statements - a wish list in response to a decision to move from a reactive to a proactive regulatory body in order to ensure the future health of the industry. Their immediate future intention is to support these strategies by formalising and institutionalising the process. The process will entail continually surveying the transportation environment; identifying issues; developing and choosing strategies to address them: all in coordination with other transportation agencies.

The General Accounting Office (GAO, 1992) feels that improvement is needed in the following areas: specific planning goals are necessary to give direction and meaning to a national airport plan and form a basis for later feedback;
a national plan must be based on credible proposals for individual airport improvements which can be compared consistently with planning goals established for the national system: to be effective, a national airport plan requires a feedback mechanism to measure the airport system's performance against goals or expected benefits.

It is interesting to note that the strategic planning process which the FAA expect to adopt is to function only within the confines of the aviation community, and only the aviation community were consulted on the planning. They do anticipate the need to coordinate the development of the system between Federal, State and local governments, to mitigate adverse environmental impact and to ensure early involvement of, and communication with interested communities. There is, however, no mention of the evaluation of alternative strategies and the resolution of conflicts at that stage. Presumably, as in the past, evaluation will be by cost-benefit analysis. Any conflicts still evident despite early citizen involvement and despite coordination between modal agencies will have to be resolved by the political process.

It appears that the FAA, and the State and local governments who conform to its preferred methodologies in order to prequalify for finance from the FAA-administered Trust Fund, have managed to continue to adopt a systems analysis approach to planning by bypassing the most difficult parts of the process. Federal level plans are mostly constructed by subjecting State and Metropolitan plans to entry filters. The plans from these other administrative tiers will have incorporated the constraints imposed by non-aviation interests at the earlier consultation stages, making it legitimate to rely on cost-benefit calculations internal to the aviation sector for the final evaluation. This is an illustration of how the evaluation methodology may have to change at each clearance point in a hierarchy of decisions, though it might have been expected in reverse, i.e. a cost-benefit analysis within each sector, with a later comprehensive multi-objective evaluation (Hill, 1986). Thus any application of multi-objective evaluation methods which
have been developed to deal with the need for the resolution of conflict between the various affected parties, e.g., planning balance sheet (Litchfield et al., 1975), goals achievement matrix (Hill, 1968), the minimum requirements approach (Hill and Lomovasky, 1980), will have been needed only at the local level of the FAA planning process. This is where the majority of the non-aviation interest is likely to be, particularly if the national level debate on 'green' issues also has local representation. In fact, joint development of scenarios and forecasts by the industry, the local business interests and community leaders, led to a common decision for expansion at Minneapolis - St Paul (Hardison et al., 1990), and assiduous consultation between FAA Air Traffic Controllers at Denver reversed the initial mistrust of minority users (Roberts, 1991).

There must be some remaining doubts, since the application of these techniques in this context is seldom reported, as to whether the early citizen participation in the planning process adequately reflects these non-aviation interests, and also whether national-level issues such as multi-modal competition and the overall value of aviation are sufficiently addressed. It is also said that there have been no formal goal-setting processes employing citizen input, that community views about aviation and the environment have been either ignored or intuitively estimated or responded to only after litigation, that only a small number of alternative aviation solutions have received initial attention, that evaluations have been on the basis of subjective listing of benefits and costs by those persons conducting the analysis, and that little or no monitoring of the impacts of completed projects has been incorporated into the continuous planning practices of operating agencies.

At least, by retaining the other elements of systems analysis, the FAA has a relatively rich knowledge of the system it is trying to manage, thus avoiding the criticism that the decline in formal planning results in decisions based on ignorance, when complexity would appear to require more knowledge and understanding (Breheny and Hall, 1984). The FAA appears to believe that it has developed a workable
method of allocative planning where the comprehensiveness and the balance between sectors is achieved by bottom-up planning and consensus at the local level. Systemic analysis is imposed on both the local and also the State 'clearance' levels. The balance within the aviation system is achieved at the federal level of 'clearance' by the application of entry and distribution rules which again, have been adopted by industry consensus.

The record of completion of those major new projects which have been incorporated into successive National System Plans is, however, quite poor. This lack of success is due more to the process resulting in proposals which have tended to be economically feasible but politically unacceptable than to the budgetary constraints on the Aviation Trust Fund. It was suggested some time ago that a new approach to the EIS process was needed: a 'community context of influence' which put the community rather than the airport as the focus of influence, viewed from the perspective of the people living in the region (Orlick, 1978). The assessment of the cumulative impact of an airport, and the formulation of public policies, requires systematic understanding of the multiple actions and their relevance to community priorities, aspirations and values. This synergistic policy-oriented approach is in many ways similar to that adopted in the UK Metropolitan Area Integrated Transport Strategy studies (May, 1991), as well as reflecting the Edwards Committee's ideal of decision by the affected community and the EC's principle of subsidiarity.

More recently, there has been a call in a similar vein from the National Governors' Association's Center for Policy Research for comprehensive analyses of airport development to be integrated into state economic development planning (Cooper, 1990), requiring understanding of the implications for the state rather than just the local community.

The UK airport planning situation

In the UK, systems analysis for long term planning, and indeed, long term planning itself, have both become
unfashionable. The last major studies of this type were done by the Post Office (1976) and British Airways (1976b) prior to privatisation. Improvements in the methodology of systems analysis, (eg Chadwick, 1978; Wilson 1987) have not been taken up. Use of the techniques which claim to deal with the unquantifiable and multi-sector problems are rarely used, at least not explicitly and not in public. In the air transport field, this is certainly so. The UK's aviation policy and planning are discussed in the Annex and elsewhere (Caves 1992a), and are only summarised here in the context of their consequences.

The CAA's economic analysis division is explicit about its methodology and its planning responsibilities. The CAA sees its primary concern to be the interests of the user (CAA, 1990a), to which end it conducts passenger surveys at airports which allow the construction of models to predict both levels and distribution of future demand through the UK's airports. This analysis is available to the public (eg CAA, 1986a). The CAA also has the responsibility of responding to specific requests from the Secretary of State for Transport (SoS) for advice on airport and airline policy. This advice is given after consultation with the industry and its users, and its boundaries are constrained largely to the interests of these two groups. The CAA's advice, again open to public scrutiny, does not contain references to any quantitative modelling of the supply side of the industry eg of the type performed by external observers (Doganis et al, 1978; Tolofari et al, 1990; Ndoh, 1990). The CAA's terms of reference give it little or no responsibility for wider issues eg multi-modal effects, environmental or other planning matters, nor, indeed for the planning of preferred networks or the airports to support them.

These issues, when and if they are considered, have three effective modes of expression. Firstly, they may be discussed in private by the SoS and his civil servants. Policy statements will then be made in parliament and the grounds for them will be subject to questioning from members. Secondly, the state of any part of the industry may be examined by a governmental standing committee (usually the
Transport Committee), a standing Commission (e.g., Monopolies and Mergers (MMC)) or a Special Commission (e.g., Roskill). The Committees are convened in a spasmodic way and are often subject to the criticism that they were given the wrong job (Rhodes, 1975). While these bodies can accept evidence from a very wide net, and the results of their deliberations are open to public scrutiny, the deliberations themselves are not necessarily in public. Despite holding public hearings at each short-listed site, and later general hearings, at least one of the Roskill Commissioners felt that the process by no means ensured public acceptance, probably due to the public’s lack of trust in quantification by cost/benefit analysis (Keith-Lucas, 1974).

Thirdly, the public inquiry process which is almost invariably necessary, since any major infrastructure will require a change of land use, allows wider issues to be raised publicly. The ensuing debate is always long and comprehensive, though the boundary is usually drawn around purely local issues. To the extent that the combined Stansted/Heathrow Terminal Five inquiry was concerned with two locales and debated wider implications for the London aviation system, it was an exception to the rule. Ultimately the Inspector issues publicly-available advice to the relevant SoS, whose eventual decision is taken in the same way and subject to the same sanctions as the first mode of expression. Some in the industry feel that the Public Inquiry system is the main obstacle to the addition of airport capacity because it is adversarial and the loser loses all. It is felt that a proper system of compensation for disbenefits would ease and speed the process (Egan, 1992). The large airport issue does not fit comfortably in a process which was devised for smaller-scale development issues, where there is a limited number of actors and they do not each have multiple roles. The government, for example, was the initiator of the Stansted proposal, the individual government departments had their own responsibilities and the government had its own economic and political policies which could be expressed through its decision, whereas its nominal role in the inquiry process is merely to act as an adjudicator (Toms, 1984). This can easily lead to "a wide-
spread cynical resignation to the notion that airport decisions are political, that politics is the power of organised interests" (Sharman, 1984).

There is a fourth mode of expression, namely the Planning Inquiry Commission (PIC), which was initiated in the Town and Country Planning Act 1968 (Harrison and Williams, 1991). However, despite its retention in the 1990 Act and it being expressly designed to tackle large non-local issues, it has not been invoked. Essentially, the PIC allows a pre-inquiry assessment process, taking into account technical and national issues.

None of the sectoral bodies who have in the past given evidence to the committees or the inquiries have embodied a long term plan for civil aviation within that evidence, though there have been many calls for one. Nor have the committees or Commissions called for the production of such a plan as an aid to their deliberations. The only remaining opportunity for any such plan to influence the decision-making process is in discussion between the civil servants and the SoS, where the civil servants would have had to be the sole authors of the plan. There is no evidence of such a plan. Hence it must be concluded that the long term future of aviation infrastructure is being decided by an unstructured interplay of information from four main sources: a) the CAA offers advice which has been preconditioned to detail the user's interests, expressed as relatively unconstrained long term demand forecasts; b) the SoS for Transport and the Environment balance the issues on the evidence from their civil servants; c) locally-oriented long term plans are submitted in evidence to public inquiries; d) all the actors lobby the responsible officials.

Perhaps the most surprising example of the lack of public scrutiny is over the long term provision made for airspace by the National Air Traffic Services (NATS), whose civil functions are a part of the CAA. From time to time, CAA reports are issued of actual and expected loadings on sectors of the network, the expectations being derived in some way from aircraft movement forecasts prepared by its own Economic Analysis Division. However, since the latter's forecasts
make no attempt to allow for the possible future types of airline and airport structure (CAA, 1990a), it is difficult to believe that adequate provision is being made to prevent likely demand from being constrained. Yet government policy is that there are no good reasons for inhibiting traffic growth (HMSO, 1985) and the latest MMC evaluation did not raise the issue of future provision at all.

The individual airport operators certainly do their own planning, but this is usually based on relatively short term forecasts of the airport's organic growth, and on the art of what is possible in terms of facility provision; evaluation is by expected rate of return, tempered by judgements as to the preferred scheme passing the public inquiry hurdle. Any longer term and formalised master planning along the lines of international recommendations (ICAO, 1987), which themselves derive from the FAA's systemic approach, is often performed confidentially to avoid creating undue alarm about long term expansion. The BAA's laudable attempt to develop and implement a long term master plan for Stansted suffered a near fatal setback when the government directed it to sell the land which it had bought to safeguard the possibility of constructing a second runway. As yet it is rare for an independent airport to go through the full system planning process from the setting of goals through to continuous monitoring of out-turn in relation to the goals, though some do embody elements of the process in their five year corporate planning. It is even rarer for these exercises to identify and quantify a role for the airport relative to other airports or to use the analysis to create a new role, as Manchester has recently done (Bowen, 1991). Indeed, many airport authorities have previously joined with other pressure groups in asking the government for a national airport plan to guide them in the role they should adopt, and there is now the desire in some quarters to see a similar European-wide plan. When a national plan was presented in 1978, it was seen to be little more than a categorisation of airports: it had few teeth and it had not been derived from a full systems analysis, the CAA believing that a compilation of regional plans was adequate (Caves, 1980). It was no surprise when at the next major review of airport
policy, the national plan was abandoned in favour of market forces, but with strong governmental control of the international role of airports through the route rights negotiation process. Thus airports must now hunt for their own roles, both in the airline market place and in government circles.

The quality of UK airport planning

It is impossible to say how satisfactory the relaxed style of planning has been. There are basically three ways in which the planning might be judged:-

a. how well the system meets its own internal goals
b. how well the interests of the UK and its citizens are served by the system
c. comparison of the planning methodology with best planning theory and its application in other situations.

Since there are no clearly stated system-wide goals internal to the air transport system, there can be no strict answer to (a). The FAA judges the need for new investment by measuring the delays incurred by aircraft. The CAA has only recently started measuring delay, in response to the extreme delays encountered by passengers in 1988 throughout Europe. The subsequent recession has in any case eased the pressure, but the statistics will only give temporary indications of underlying problem because the airlines will allow greater scheduled times, preferring to suffer known delays rather than random ones. Either way, the longer term result of delay is that more aircraft are required to operate the same network, resulting in lower productivity per block kilometre and higher cost per passenger kilometre. The effect is best detected by industry models of total factor productivity: unfortunately the only model presently available for the UK airline industry did not capture data for the years when congestion was most apparent (see Chapter 5).

It would, in a free market, be natural to use financial appraisal to judge the internal health of an industry. On this basis BA and the major airports certainly make rates of
return which satisfy their shareholders. Most smaller airports have managed to operate without subsidy, though some are in danger of being sold for non-aviation use. Small, and even medium-sized airlines are shaken out of the market in every recession. It can be argued that this is exactly the advantage of a free market, but in fact, the market is not free due to capacity and bilateral constraints ie it may be, as discussed in Chapters 3 and 8, that inadequate infrastructure provision is denying smaller airlines the opportunity to be financially efficient.

It might also be possible to judge an industry's health by its rate of growth. This is slowing down as the industry matures, but it is difficult to judge whether it is a more rapid slowdown than is warranted in the interests of the potential users. In any case, neither this nor the other measures of the industry's internal health can more than hint at the adequacy of today's planning.

Given the extreme lead times of 10 years for new runways and more than 20 years for major changes in air traffic control hardware, what the airlines and their customers would like is some assurance that today's planning will be more effective in providing infrastructure in a more difficult future environment than that which has influenced the industry's ability to develop over the last decade.

In retrospect, the development of UK air transport has been a rather classic example of disjointed incrementalism. The piecemeal development of London's runways described in the Annex was made to seem reasonable by the presumptions that airlines would continue to be regulated and that airlines and their passengers would not have strong preferences between airports. Development of single runway airports was similarly condoned by taking traffic forecasts only 15 years ahead and neglecting the possible development of 'fortress hubs'. The role of the regional airports was dictated not by the most concerned community as recommended by the Edwards Committee (Edwards, 1969), but by airlines' policies which in turn were shaped by bilateral agreements favouring BA and London. BA's international position has been protected (not
very successfully in the latest agreements allowing United and American to gain access to Heathrow) without supporting its position with adequate capacity at its main base.

The apparent ignorance of the dynamics of the industry, together with attempts by each element of the system to sub-optimise to its own short term advantage, has led to cutbacks in infrastructure investment at just the times when it was most needed.

Market liberalisation has been encouraged, despite the distortions produced by lack of capacity in the infrastructure. Although Edwards' (1969) advice to consolidate route licensing, airport development and the management of air traffic services under a single authority, was taken precisely to allow coordinated development of services and their infrastructure, air traffic capacity is now well below that required for 'free flow' because the recent strong demand was not predicted. Too often, predictions have been based on assumptions of little change in the capability of aircraft technology, in airline management or in the regulatory environment; while all these factors actually have had a strong influence on the volume of air transport movements and the pattern of service.

These are all instances of advancing one element of a system without apparent consideration of the implications for other elements of the system. The arguments in favour of adopting this form of incremental planning have been given above (Hirschman and Lindblom, 1962): undoubtedly, those involved would say they had been practising 'the art of the possible', which might be tantamount to epistemological nihilism (Schon, 1973). They might also ask why the methodology should be faulted if it has provided a system which 'satisfices'. The difficulty here is that it is not possible to decide whether or not the system is self-satisficing. The decline of formal strategic planning has brought with it the failure to learn. Monitoring of policies has not occurred (Breheny and Hall, 1984) and authorities consciously avoid any attempt to question the effectiveness of policy (Young and Mason, 1983). Thus the single runway at Stansted can be seen to be
repeating the mistake at Gatwick. Also, Chapter 3 shows that the dogma of competition may be presuming results which the market does not confirm (Caves and Higgins, 1993). The presumption that the system satisfies its users cannot be sustained with any certainty.

The same may certainly be said in answer to question (b). The interests of the UK and its citizens are an amalgam of those of the system's users, the benefits derived from 'invisibles' and other less evident contributions to the country's and regions' trade and well-being and the disbenefits imposed by users on non-users. It would be necessary to carry out a full societal assessment of the industry if this question were to be answered properly, both in absolute terms and also relative to other countries' performance. This has never been done for any other technology in the UK and is usually outside the remit of planning inquiries. Yet the industry is beginning to realise that it needs to conduct studies of this nature in order to 'accentuate the positive' (Sharman, 1984) and so counter the arguments in favour of limiting growth in air transport which are being put forward by some economists and environmentalists. If a lead is not taken by some impartial body, there is a danger that the public will be presented with the rigorous results of a much biased analysis on both sides. In a court of law, this method of obtaining a decision would be acceptable, because the facts would be exposed to learned cross-examination. However, the method of disjointed incrementalism does not provide a similar convenient forum for reaching a single clean decision. Instead, the 'clearance points' (Hill, 1986), together with the evaluation methodology used at each point, are indistinct and variable over time and place.

If it is not possible to decide how adequately the system has developed to serve the UK and its citizens, it is still possible usefully to question how well the methodology for planning the system compares with best planning practice. Best practice varies with its context (Breheny, 1986). In Western democracies, planning theory has evolved from rigid master planning, through advisory planning based on a systems
view, to continuous participation by all interested parties (Teitz, 1974). In that latter process, compromises can be made rather than having decisions dominated by technocratic positivism or politics (Torgerson, 1986); and the 'ordinary knowledge' of decision-makers can be taken into account (Breheny, 1986). The participatory style of planning is appropriate where the power in a system is dispersed rather than centralised (Friedmann, 1973).

In the corporate arena, the strategic planning emphasis has moved from predictive models to an holistic scanning of the total environment - economically, socially, culturally, technologically and politically - to identify the obstacles to a safe passage into the future (Trowbridge, 1988). "It is impossible for managers to plan or envision the long term future of an innovative organisation. Instead, they must create and discover an unfolding future, using their ability to learn together in groups and to interact politically in a spontaneous, self-organising manner" (Stacey, 1993). In an environment where changes are rapid and where there is tight interconnectedness between the elements of a system, (ie the environment is turbulent, organisations cannot understand cause-effect chains and cannot predict either the consequences of their own actions or local effects of distant events), the only way to regain control is through a collective and cooperative search for new values and rationales for behaviour (Emery and Trist, 1965).

This, however, is an unpalatable conclusion for elements of a system attempting to adjust to a new environment of untrammelled competition coupled with freedom from public intervention, both of which actually contribute to turbulence (Stubbart, 1985). Further, anti-trust legislation usually creates obstacles to intra-industry collaboration. If systems analysis is incapable, at its present stage of development, of handling the complexity of turbulent environments, and if dominance, ideology and epistemological nihilism are all to be avoided, then the remaining approach to conducting the collective and cooperative search is through existentialism (Schon, 1973). In this case, only the here-and-now can contain valid knowledge, but "theories drawn
drawn from other situations may provide perspectives or 'projective models' for a situation. This process of existential theory-building must grow out of the experience of the here-and-now of this situation, must be nourished by and tested against it." Thus it is possible to examine other experience to gain useful perspectives, but the value of those perspectives must be tested in the system under examination, by noting processes internal to the system.

Some western countries with relatively regulated environments have applied traditional systems analysis to the planning of the air transport system, notably France and Norway. (Gennari, 1989). In each case the state has decided goals for the system, roles have been identified for the airports and the airports' individual plans have been developed to fulfil those roles. The plans and their consequences are reviewed and the cycle is repeated. There seems to be general satisfaction, both at local and national level, with the resulting system, though there is much vacillation over the location of a new airport for Oslo (Langeland, 1990), and it has been speculated that the development of Paris Charles de Gaulle airport was, in part, at the expense of democracy (Breheny, 1984).

In the much less regulated US, it has already been noted that planning is based primarily at the local and detailed level, with a filtering and enabling clearance point at national level. At the national level, goals in terms of accessibility to the system, of the furtherance of interstate commerce and of the harmonisation of planning methodology are managed. Not only is a full systems analysis required for eligibility for federal funds, but so is full and early citizen participation in the local and State planning. Yet the methodology and the resulting system have their critics. Some larger airports question the value of being a part of the process, due to the resulting lack of flexibility in managing their own affairs. The Trust Fund, nominally managed by the FAA, is actually subject to Congressional capping of the annual outflow of funds. Despite the early citizen participation, only a very few of the new airports contained in the National Plan of Integrated Airports System
have survived local planning decisions. The fear that unilateral action by airports on charges and on noise control will result in 'de facto' national planning has led to calls for clear federal airport policies to pre-empt these actions. The system is subject to substantial delay in bad weather despite flow control and slot rationing at the major airports. There is also a widespread consumer feeling that levels of service and punctuality have fallen since deregulation, and that delays and cancellations have greatly increased. The traffic forecasting methodology developed during the regulatory period has proved incapable of handling the rapid creation of new hubbing points. The FAA has responded to the situation with proactive and longer term planning studies, but these rely very much on the existing planning methodologies. There is no sign that the links within the Department of Transportation, or between it and Congress, will change markedly. Certainly the system analysis approach to planning, combined with freedom of information, allows informed public debate. However, given the relative freedom from international influences and the airmindedness of the US public, the present system appears to have a full quota of drawbacks, despite calling on at least some of the latest planning techniques to supplement the systems analysis. This has been realised and has recently resulted in the adoption of an adapted form of holistic scanning in the latest US government strategic studies (TRB, 1990).

Given the ambiguous conclusions from these brief case studies of other countries on the value of the rigorous application of formal planning methodologies, and of systems analysis in particular, the primary plank of existential analysis must be used i.e. internalised criticism of the UK airport system and its planning. The system can be seen to be suffering the same ills as the US system, the most pressing being lack of capacity at the hubs and often a low utilisation of capacity at the smaller airports - the small airports' capacity being necessary only for peak demand. It is not clear how the present laissez faire approach to planning can solve the problem of capacity. Substantial commitment is required simply to make a planning application of sufficient
magnitude, followed by a far greater commitment to construct facilities sufficiently in advance of the traffic being generated to be able to convince the airlines that they should make full use of the facility when it is available. Meanwhile, the airlines object to financing from profit ie to contributing now to investments which will benefit others 10 years later, and are often prepared to accept some congestion costs rather than make access easier for competitors. It would appear that the investment could only be made entrepreneurially when congestion costs become so great that the airlines would benefit from spending on new capacity. This would require a different approach to the price control mechanism imposed on BAA so that prices could rise to the market-clearing level, and some way would also have to be found of feeding the excess rent back into the industry (Bass, 1989).

Solutions of this sort would not benefit competition by opening up access to attractive destinations. Nor would they resolve the implementation difficulties prevalent in both the UK and US (the NIMBY 'not in my back yard' syndrome) caused by the frequent incompatibility of local and national, and user and non-user, interests, unless the market-clearing price is allowed to be high enough to provide generous compensation. In the UK, the debating forum for these issues is the public inquiry, where the national need is subsumed into the local traffic predictions and the non-user interests are limited to local environmental fall-out, adverse economic impact and alternative land use. Whilst these are all important and necessary issues, they do not, and cannot represent more than a localised indication of the national consequences of these issues. The national interest requires wider consideration, so quite properly the relevant Secretary of State (SoS) then deliberates on the decision. At this point the UK planning system diverges from the 'best planning theories' appropriate to its context. The national level decision process is subject to uncontrolled lobbying and is ultimately secret unless and until a Select Committee investigates the decision, while theory suggests a maximum degree of participation on a wide front and has developed specific evaluation tools for the situation. Methods such as
the Minimum Requirements Approach (Hill and Lomovasky, 1980) have not been given an opportunity to function. Instead, the resulting decisions have perpetuated the disjointed incrementalism in airport development. There is no evidence that the decisions have been informed by other than the local information and central dogma, plus some sort of political judgment of what the consensus would have been if it had been possible to achieve one, coloured by lobbying and the private advice of civil servants. The consequence is that the government's objectives for the system, where they have been stated, have only partially been met. Further, many objectives which it would be normal to include in transport planning studies have not even been stated. Also, the decisions being taken now will only influence the system in the next century, yet little, other than the CAA's demand modelling, has been done to explore what either air transport or the world could be like then. Lack of full quantification of those factors which can be quantified results in undue weight being put on those which are quantified eg demand estimates for regional airports which were meant primarily to educate the London airport debate but which may erroneously influence regional planning, as discussed in Chapter 4.

Entrepreneurs in airport development, who wish to capture a large quantity of traffic in the future, must look to the European and world stages and compete for long haul and feeder traffic. Initiatives like those by British Aerospace at Liverpool or Marinair in the Thames Estuary will have to compete with similar foreign initiatives which are being developed under different philosophies of planning and implementation, as well as competing in the UK on a non-level playing field with the BAA London and Scottish airport groupings. These various initiatives will each tend, in the absence of firm knowledge of the other proposals, to predict that a majority share of the same future traffic base will use their facility. The eventual winner of the unfair competition will then be dictating national and EEC air transport policy by default, unless that policy does exist and is, in some covert way, dictating the progress of the various proposals.
In fact, even if the national policy does not exist explicitly, the power of the SoSs for Transport and the Environment, and the necessity for all plans for major projects to pass through their hands, means that projects based on British soil can only proceed with their consent. However, this filter makes it difficult to retain the 'market force' ethos unless the issues and the methods of judging them are sufficiently transparent: otherwise the entrepreneur is buying a ticket for a very expensive lottery. It is no wonder that the team leader for the planning of the new Denver airport, almost the only new airport in the US to be built in 10 years, was a lawyer with experience in lobbying Congress. In the relatively simple situation of a supermarket chain with one hundred branches applying for planning permission for one more branch, the issues are usually clear and only of local import; the relative commitment is low; the inspector's advice to the SoS is rarely overturned. Where a major airport development is concerned, not only is the relative scale much greater but also the Inspector, the SoS for Transport and the SoS for the Environment become effectively three separate filters; further, the arguments balancing national and local interests are much less well rehearsed. Yet, if private initiatives for airport development could be encouraged, in sufficient quantity and quality, it would ensure that useful solutions were not overlooked by early and crude filters of a strategic planning process conducted internally by government as described in the Annex. They would not, however, avoid the need for compromise which the planning system seems to generate: thus Gatwick's second runway was traded for Terminal 4 at Heathrow, Stansted's second runway was forfeited in order to gain permission for its single runway development and an early opportunity to secure a second runway at Manchester was lost due to fears of the political consequences of developing into another county. BAA's attitude after various public inquiry experiences is that it is essential to wait until the need for the facility is quite indisputable before attempting to pass the public inquiry clearance point.

The issues involved in planning airport systems have now been
raised and difficulties identified. Part 3 of the thesis now examines how an understanding of the roles of the actors and the planning process can allow better judgements to be made and better procedures to be established without resorting to the regeneration of the heavy hands of regulation and central planning.
PART III

Improving methods for synergistic policies
CHAPTER TEN: THE PREFERENCES OF AIRPORT USERS

PREDICTING PASSENGER PREFERENCES

It appears from the discussion of the CAA modelling in the Annex that a full national model of traffic generation and distribution, incorporating the smaller airports, would be difficult to calibrate with sufficient accuracy; also, it would be difficult to retain sufficient flexibility to cope with individual regional characteristics. However, the CAA model has been developed on a rich data base obtained from surveys (CAA, 1986) which sample approximately 2% of departing passengers at most UK airports, on a three to four year cycle. Information is collected on socio-economic characteristics, journey origins, access modes, trip purpose and airports used, among other data. So much data of individual travel are available from these CAA surveys that a more limited use of an airport choice model within each region, or between each region and national hub airports, could contribute considerable accuracy to regional airport traffic estimates. While it may be possible to develop a satisfactory behavioural model to share regional traffic between the local airports and large national airports, in practice this has proved difficult (Caves, Ndoh and Pitfield, 1991). Problems are likely to arise with any particular continuous form of frequency function. The very high frequencies at large airports are likely to mean that passengers will be less responsive to a given percentage, or absolute, change of frequency at these airports than at smaller airports with only one or two services per day. Also, there are both attractive and unattractive features of large airports, apart from the services to specific destinations, which are difficult to model convincingly, particularly as they vary over time. Added attractions include the synergy of large networks, choice of airlines, shopping opportunities, availability of official and unofficial discounts; conversely congestion both inside and outside the airport is unattractive.
A HYBRID MODEL APPROACH

The alternative approach is to take advantage of any stability in the national and regional situation to establish regional shares, reserving the rich information derived from discrete airport choice models for local airport competition. Stable relationships between national and regional traffic can form the basis of a 'step-down' approach to modelling regional traffic, given the existence of uncontroversial national forecasts. These are available in the UK, disaggregated by business/leisure, short/long haul, UK/foreign (DTp, 1991a). While being subject to any forecasts' imperfections, the national agency's forecasts offer a consistent base from which to develop a feasible range of national forecasts.

The 'Step-Down' Element

An attempt has been made (Caves, 1992b), to establish the reliability of the 'step-down' approach to forecasting UK regional and individual airport traffic. The analysis considered international short haul scheduled and charter traffic separately to each of the primary destinations in each category, and also the aggregate traffic at each airport and in each region. Three reasonably well-defined regions were chosen in addition to the London Area: the North West (NW), with Manchester (MAN), Leeds/Bradford (LBA) and Liverpool (LPL) airports; the North East (NE), with Newcastle (NCL) and Teesside (MME) airports; the Midlands (MID), with Birmingham (BHX) and East Midlands (EMA) airports. In the traffic categories examined, there are few airport access trips between these regions, though there is substantial use of London Area airports by passengers with ultimate origin/destination in these regions. The analysis is based on annual traffic between 1982 and 1989 inclusive. Airport traffic and international route traffic data are taken from the CAA's Annual Airport Statistics, domestic route data from the Annual Airline Statistics. The international scheduled destinations considered are Paris (CDG), Amsterdam (AMS), Dublin (DUB), Frankfurt (FRA); charter destinations are Malaga (AGP), Palma (PMI), Faro (FAO), Corfu (CFU).
Shares of Total Boardings

All three regions' total traffic show strong statistically significant linear relationships with total UK traffic in each traffic category. When the regional shares themselves are regressed against UK traffic (thus increasing the sensitivity of the analysis), the NW region is shown to be increasing its share of international scheduled traffic at the rate of 1.09 per cent per 10 million UK passengers (5 per cent in 1989) and its share of charter traffic at 3.4 per cent per 10 million (23 per cent in 1989). The Midlands region's growths in UK share are 0.48 per cent (2 per cent in 1989) and 0.85 per cent (9 per cent in 1989) per 10 million UK passengers for international scheduled and charter traffic respectively. The results of this analysis are given in Table 10.1.

TABLE 10.1: RELATIONSHIP BETWEEN TRAFFIC IN UK REGIONS AND TOTAL UK TRAFFIC

<table>
<thead>
<tr>
<th></th>
<th>100a Value</th>
<th>100b Value</th>
<th>(r^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>International Scheduled</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NW</td>
<td>-0.167</td>
<td>0.1090</td>
<td>0.917</td>
</tr>
<tr>
<td>MID</td>
<td>-0.0407</td>
<td>0.0484</td>
<td>0.875</td>
</tr>
<tr>
<td>NE</td>
<td>0.377</td>
<td>-0.0002</td>
<td>0.001</td>
</tr>
<tr>
<td><strong>Charter</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NW</td>
<td>13.30</td>
<td>0.340</td>
<td>0.867</td>
</tr>
<tr>
<td>MID</td>
<td>6.49</td>
<td>0.085</td>
<td>0.408</td>
</tr>
<tr>
<td>NE</td>
<td>3.39</td>
<td>-0.0009</td>
<td>0.038</td>
</tr>
</tbody>
</table>

The constants are defined by the equation in the text.

The relationship is:

\[ y = a + bx \]
\[ y = \text{regional share of passengers} \]
\[ x = \text{UK passengers (millions)} \]
The 't' statistic
> 1.94 indicates 10% significance
> 2.45 indicates 5% significance
> 3.71 indicates 1% significance.

It can be seen that the NE region traffic shares calibrate much less well in terms of $R^2$ and the relations with UK traffic are very weak. However, the NE constant terms are significant, indicating that its shares of scheduled and charter traffic are remaining constant at 0.38 per cent and 3.4 per cent respectively.

It is noticeable that there is a much higher penetration of charter into the regions than is achieved by scheduled services. While this may be explained in part by the easier acquisition of charter route rights, the main reason is likely to be the charter airlines' ability to control load factors in the lower density markets by offering relatively low capacity. This is not available to scheduled airlines on most routes at reasonable fare, because low levels of service drive down the demand for direct service; the resultant higher fares drive demand down further.

It is also noticeable that NW and MID shares of UK traffic are increasing at approximately the same relative rate, while NE shares are only constant. These trends result from longer term trends in the economies of the regions and the airlines' responses to the potential market. Success appears to breed success, once some viable minimum network of routes can be supported. It may well be that the success comes not only from increasing economies of station density but also from stimulated demand, the latter coming from the release of latent demand among the existing population as their total disutility of travel falls and also from demand induced as new economic activity is drawn to the improved services. There is anecdotal, and some empirical (Caves and Ndoh, 1990) evidence that improved supply does stimulate demand.

The step-down method incorporates these effects implicitly. It clearly cannot distinguish between the factors causing the changes of regional share, and presumes that the regional
economies and airline reactions will continue to change in the same direction at the same rate. There may, of course, be long term changes in regional status whose effect would have to be treated judgementally, but, in general, the relative economic changes in any well-defined region are quite stable.

There may well, however, be the possibility for individual airports within a region to influence their competitive position, or role. Individual airports' rate of change of national traffic share are given in Table 10.2 for all the sampled airports which showed statistically significant relationships at the 5 per cent level. The major airport in NE is NCL, but correlations for NCL traffic were not statistically significant. (1989 passengers: 0.17 million international scheduled, 0.80 million charter). In almost all cases, the individual airport shares are rather less predictable than the total regional share of national traffic. In every case, the minor airports' shares grow less rapidly, or fall faster, than the major airport in each region and their statistical explanation is worse than the major airports' shares.

Since the regions do not, in general, encompass areas greater than two hours access travel time by car, it is possible that smaller airports could gain share if they could induce a change of attitude by the airlines. Otherwise, a direct step-down analysis shows that all the smaller airports are likely to capture a decreasing share of regional traffic; indeed, in the case of MME, there is a statistically robust falling national share. These trends are reinforced by an analysis of the small airports' share of the regional markets. The statistical fit of the NW airports' shares is very poor; the MID and NE airports' fit is much better, but still give $R^2$ less than 0.7. Thus, even if the smaller airports were prepared to accept the implications of declining market share, the statistical quality of the second stage of a two stage step-down model does not allow much confidence in its use.
TABLE 10.2  REGIONAL AIRPORTS' GROWTH IN SHARE OF UK TRAFFIC (PER CENT PER MILLION UK PASSENGERS)

<table>
<thead>
<tr>
<th>Region</th>
<th>Type</th>
<th>Change</th>
<th>1989 Passengers (10^6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NW International Scheduled</td>
<td>MAN</td>
<td>0.0963</td>
<td>2.21</td>
</tr>
<tr>
<td></td>
<td>LBA</td>
<td>0.0068</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>LPL</td>
<td>0.0056</td>
<td>0.12</td>
</tr>
<tr>
<td>NW Charter</td>
<td>MAN</td>
<td>0.3220</td>
<td>5.93</td>
</tr>
<tr>
<td></td>
<td>LBA</td>
<td>0.0248</td>
<td>0.25</td>
</tr>
<tr>
<td>MID International Scheduled</td>
<td>BHX</td>
<td>0.0457</td>
<td>1.03</td>
</tr>
<tr>
<td></td>
<td>EMA</td>
<td>0.0027</td>
<td>0.14</td>
</tr>
<tr>
<td>MID Charter</td>
<td>BHX</td>
<td>0.0781</td>
<td>1.57</td>
</tr>
<tr>
<td></td>
<td>EMA</td>
<td>Indeterminate</td>
<td>0.92</td>
</tr>
<tr>
<td>NE International Scheduled</td>
<td>MME</td>
<td>-0.0014</td>
<td>0.02</td>
</tr>
<tr>
<td>NE Charter</td>
<td>MME</td>
<td>-0.0081</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Shares of Route Traffic

The step-down analysis has so far been concerned only with total traffic growth at a regional airport in a given category. The total traffic growth, in fact, consists of growth per route and also new route starts. The growth per route can itself be analysed on a 'step-down' basis. It would be expected that, as the regional penetration of the national market matures, the growth in share would tend asymptotically to zero. The market share at the point of zero growth would be the maximum likely penetration, reflecting the best likely supply of direct service from the
region, whether concentrated at the main airport or shared between airports. The average growth in share (i.e., growth in total traffic at a given airport) would tend to be greater than growth on mature routes due to the higher growth in share on emergent routes and the addition of new routes.

When this analysis is carried out for four of the most common destinations in each traffic category, the growth in share is inevitably seen to be very variable, with rather poor statistical significance. Taking the international scheduled category first, the NW route shares do indeed show much lower growth than its share in the total traffic and the intercepts' 't' tests are very robust, implying maturity on these dense routes. However, the MID shares to the same destinations are still growing strongly and robustly, indicating that maturity of penetration has not been reached even in the densest markets. Estimates of the average maximum UK market penetration for mature routes is given in Table 10.3, these providing a cut-off point when growth in market share is used for prediction. The growth in total share is actually lower than the average growth in the four top markets because one of the top markets performed very badly: i.e., even the top markets from most regions are rather fragile. This suggests that it would be optimistic to take the penetration of the densest markets as indicators of likely long term penetration. In the NE, there is actually negative growth in share to two of the three destinations, having historically established an artificially high penetration of the market to AMS due to Air UK's route network.

In contrast to the scheduled routes, all the top charter destinations from all the regions appear to have reached mature shares: all the regressions show very low and statistically insignificant growths in share and the $R^2$ are very small, while the intercept 't' tests are very robust. Despite this maturity on the densest routes, the rate of growth in share of total charter traffic in NW and MID is considerably greater than for the total scheduled traffic (Table 10.1), indicating the importance of new charter route starts in the regions. This relative paucity of destinations...
TABLE 10.3  ESTIMATES OF MAXIMUM UK MARKET SHARES ON MATURE INTERNATIONAL SHORT HAUL ROUTES

<table>
<thead>
<tr>
<th>Region</th>
<th>Total Flow, 1989 (millions)</th>
<th>Regional Share of UK Total</th>
<th>Minor Airport Share of Regional Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NW Scheduled</td>
<td>2.5</td>
<td>0.12</td>
<td>0.20</td>
</tr>
<tr>
<td>NW Charter</td>
<td>6.3</td>
<td>0.25</td>
<td>0.10</td>
</tr>
<tr>
<td>MID Scheduled</td>
<td>1.2</td>
<td>0.07</td>
<td>0.30</td>
</tr>
<tr>
<td>MID Charter</td>
<td>2.5</td>
<td>0.13</td>
<td>0.45</td>
</tr>
<tr>
<td>NE Scheduled</td>
<td>0.20</td>
<td>0.01</td>
<td>0.20</td>
</tr>
<tr>
<td>NE Charter</td>
<td>0.9</td>
<td>0.05</td>
<td>0.18</td>
</tr>
</tbody>
</table>

from the regions is likely to continue into the medium term future, so, if total rather than route-by-route market shares were to be used for prediction some estimates would have to be made of the maximum likely penetrations of the total UK market which would be lower than those reported in Table 10.3.

Attempts to analyse the smaller airports' shares of their regional markets on a route-by-route basis fail to establish any consistent patterns or any statistically significant correlations. However, inspection of market shares over time indicates a consistent tendency to converge to values which reflect the historic balance between the attractions of the major regional airport, the spatial distribution of demand and the airlines' supply strategy. The resulting estimates of likely maximum minor airport shares are given in Table 10.3.

The Airport Choice Element

Whereas it is rather unlikely that the balance between regional and national interests will change other than slowly and rather predictably, regardless of airport and airline managerial initiatives, this is less true of the balance
between airports within a region. It is often felt that it would be possible to attract airlines and their passengers by investment in improved facilities, eg extended runways, provision of airbridges, competitive fuel tendering. There also exists the possibility of changes of spatial economic distribution within a region, of airlines setting up competing services (possibly even a hubbing operation) without head-on competition from an incumbent airline at the major airport, of there being an easier environmental or land use situation for expansion at the minor airport or, finally, of the major airport approaching capacity so that lower cost airlines begin to be displaced. An analysis of the implications for the smaller airport of any of these potential scenarios cannot rely on the 'step-down' approach which, by definition, assumes that those factors which are already changing will continue to change at the same rate and, further, that no new factors will enter the situation.

Certainly, there is room within the market share method for some exercise of judgement to allow for limited changes from the status quo, but it would be very risky to rely only on that when major changes in the role of an airport are anticipated. In these circumstances the analysis of intra-regional competition requires a modelling tool which is sensitive to local spatial changes in demand patterns, access times and the supply of service on a route-by-route basis. In other words, a local version of the CAA's airport choice model, but ideally with local demand being a function of air service available, would be one viable approach. Despite some reservations with respect to the choice of independent variables in the utility function, similar logit models have been used to good effect in many varied studies (Alamdari and Black, 1992; Ashford and Benchemam, 1988). Other UK uses of the model are referenced elsewhere (Caves, 1992c).

Just such a model has been developed for trips by short haul scheduled services from the Midlands region of the UK where Birmingham (BHX) is the major airport and East Midlands (EMA) is the minor airport (Caves et al, 1992). A CAA survey of passengers at the region's airports (CAA, 1986) was used to define the set of approximately 100 zones from which
passengers might travel to use the region’s airports and to identify individual trips to a set of destinations jointly served by both airports. These trips were used to calibrate a standard logit model whose utility function took the form:

\[ U_{ijm} = a_{ij} + bF_j + cP_j \]

where \( a_{ij} \) = access time (minutes) for a passenger in zone \( i \) to airport \( j \)

\( F_j \) = share of weekly flight departures for airport \( j \), ie departures at \( j \)/(departures at \( j \) + k)

\( P \) = full economy fare from airport \( j \) to destination \( m \) (£ sterling)

\( U \) = utility of a passenger in zone \( i \) using airport \( j \) to reach destination \( m \).

Separate models were calibrated for business and leisure passengers, each to the same four high volume destinations. The calibrations were very successful in each case. The fare variable added no additional explanation in the business model and was dropped when the model was used for prediction.

The utility function in the business passenger model, based on 1525 observations, was calibrated as:

\[ U = -0.0757 A + 8.695 F \]

\(-19.7\) \( (11.8) \)

the values in brackets denoting the 't' test results. The leisure passenger utility function, based on 720 trips, was found to be:

\[ U = -0.0769 A + 4.898 F - 0.0808 P \]

\(-14.7\) \( (3.1) \) \( (-3.0) \)

The signs and relative sizes of the coefficients are all in
agreement with intuition. Frequency is more important to the business traveller, while cost is the predominant concern of the leisure passenger. This is borne out by the utility functions when average values of 30 minutes, 0.5 and £90 are substituted for A, F and P respectively. (£1.00 is approximately equal to $1.70 during the period under analysis.) The implied direct elasticities, averaged over BHX and EMA airports, are:

A: -0.59 for business, -0.52 for leisure
F: 0.62 for business, 0.30 for leisure
P: -0.73 for leisure.

In fact, since leisure passengers will have paid perhaps only 50 per cent of full economy fares, their real fare elasticities are probably nearer to -1.4.

In view of the small differences in fare and frequency between BHX and EMA shown in Table 10.4 on the four jointly-served routes in the 1983 calibration year, the coefficients are surprisingly reasonable as well as being intuitively correct. All the EMA services were operated by British Midland with turboprops, while the BHX services were almost exclusively by British Airways using BAe 1-11 jets. The market shares to EMA in 1983 from the observed set of zones were 29 per cent and 49 per cent respectively for business and leisure passengers.

<table>
<thead>
<tr>
<th>TABLE 10.4 AIR SERVICES OFFERED IN 1983 AT BIRMINGHAM (BHX) AND EAST MIDLANDS (EMA) AIRPORTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency per week</strong></td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>AMS</td>
</tr>
<tr>
<td>CDG</td>
</tr>
<tr>
<td>GLA</td>
</tr>
<tr>
<td>BFS</td>
</tr>
</tbody>
</table>
Although the model fitted the 1983 data very well, it was not so successful when predicting 1987 market shares. By then, EMA had only approximately a 33 per cent frequency share due to more airlines serving BHX, though not always with jet service. This resulted in an actual average market share to EMA of 30 per cent on routes served twice a day, CDG obtaining 17 per cent on a once-daily service. The models overpredicted these shares by some 7 per cent.

The discrepancy could be due to a mis-specification of the frequency function, either in its nature (eg ratio or difference rather than share) or in its shape (eg log or exponential rather than linear). However, it is also true that the situation changed substantially between 1983 and 1987. In favour of East Midlands sub-region, there was differential growth in population and the economy relative to the West Midlands sub-region, the increased services at BHX were mostly by foreign airlines and were with turboprop aircraft. Furthermore, British Midland began to establish an image as an international airline as well as being able to compete with BA on the major domestic ('shuttle') routes from Heathrow. In favour of Birmingham, an impressive new terminal for British Airways services was opened in 1984 and the introduction of new destinations began to create a hubbing synergy. Unless the model's frequency function is very much in error, it appears that the changes favouring EMA have had a greater effect than those favouring BHX. A short term expedient is therefore to adjust the model with a positive constant (dummy) for EMA. When this is done, and the model is used to investigate the effect of changes in airline policy and access routes, it suggests that, if EMA services matched BHX frequencies, EMA would take approximately a 50 per cent share of the market from the zones selected, even without a matching jet service. This is due to the lower density but spatially larger natural catchment area of EMA. Further, improvements to the roads linking the two airports favour EMA at equal frequency because the dense Birmingham population then becomes available, whereas less of the natural catchment of EMA is vulnerable to BHX. The model suggests that reducing the trip time between airports from 50 minutes to 40 minutes, as has
happened in 1991, increases EMA's market share at equal frequencies by some 5 per cent.

Work is ongoing to improve the frequency function, as well as to include flight timing and examine the implications of closely timed flights. There is evidence that the specification of the frequency function on travel choice models has a profound effect on the utilities at the extreme range of frequency, and also on the implied value of time for schedule delay relative to time on mode, schedule delay being some function of the interval between services. Table 10.5 shows a normalised comparison of calibrations of several choice models, together with the form of frequency function assumed (Aroesty et al., 1990).

The implied premium for schedule delay varied from 1.0 to 1.8, and the implied value of main mode travel time varied from $7.1 to $44.6, even when the two most extreme results are ignored. Another comparative study also shows that, while some models give a coefficient for the natural logarithm of frequency difference, greater than 1.0 (implying a greater market share than frequency share), not all models even display this characteristic (Alamdari and Black, 1992). It is suggested that the models might have given more consistent results if they had also considered the mutual interaction between demand and frequency offered, the influences of computer reservation systems and frequent flyer programmes, and also the relationship between the flight time and the desired flight time. The assumptions on travellers' value of time are also important: a log-normal distribution gives a lower price elasticity than assumed average values (Ben-Akiva et al., 1993).

Other areas under further investigation are the nationality mix of the airlines, the aircraft technology and the importance of fares, using new data on fare actually paid. The effect of replacing turboprops with jets was estimated by comparing turboprop predictions with jet outcomes, after having recalibrated the dummy on EMA routes which continued to be operated by turboprops. The improvement in market share due to jet service appeared to be less than 10%; indeed, it
may have been less, because no attempt was made to disassociate the changes in type from the increase in aircraft size of the jets. (85 seats, rather than 50-65 seats). Studies in the US suggest that the equipment factor in the Quality of Service Indicator (QS1) increases by 0.1 purely because of the jet propulsion, whereas the total difference in QS1 would be 0.35. The QS1 is based on ridership, and hence any effect of aircraft size is more likely to be due to airlines matching demand than to passenger preference. Many in the airline industry believe that it is capacity rather then frequency which defines market share. However, other evidence suggests that a balanced market with both operators using turboprops would change to 80%/20% if one operator used jets at the same frequency (Aroesty et al, 1990). The fundamental difficulty with both the effect of frequency (Kaemmerle, 1991) and of aircraft size (Russon and Hollingshead, 1989) is that, without lagged variables or some other method of inferring causality it is not possible to distinguish between these effects and the tautological relationship of demand with capacity.

A further avenue for research arising from the choice modelling is that, while it is not possible to calibrate a nationwide model which can give sufficient accuracy at local airport level, it may be possible to develop a model which distributes traffic from a defined region simultaneously between the major airports and the local airports by careful specification of the frequency function. This would call for the 'step-down' method to be applied directly to trip generations in a region rather than to the trips revealed through the region's airports, the differential growth in regionally-based trips being established via the ongoing series of CAA surveys.

STATUS OF PASSENGER PREFERENCE MODELLING

The 'step-down' procedure for forecasting regional airport demand has been investigated in a UK case study. The approach is shown to be valid when it is possible to define regions which are sufficiently free-standing for there to be
little inter-regional competition for air traffic. It has been shown that, where substantial competition between airports exists within a region, the 'step-down' procedure is inappropriate to define market share within the region even when 'status quo' assumptions can be made. When it is necessary to analyse the implications of new competitive scenarios, it has been shown that logit models can be used to distribute intra-regional demand between airports in response to changing quality of service. It is, of course, not possible within that methodology to predict the extent to which airlines will provide that quality of service. The 'step-down' procedure can still provide the total regional traffic predictions as an input to the logit models, though more work is necessary to take account of the effects of improved coverage of supply within a region on the regional share of UK traffic.

More work is required in the specification of the choice models and the appropriate scope of their application. Nesting of decisions on access choice, mode choice, destination choice and generation (ie choice of whether to travel), with simultaneous estimation of model coefficients has been used in Sweden to build a complete integrated model for the whole country (Algers, 1993), but it is not clear how well the model copes with dominant hub frequencies. It may be that the heuristic learning approach of neural network models (McNally and Lo, 1993) may overcome some of these difficulties, as well as the assumption of random utility maximisation implicit in logit models, but they are far from transparent and not easily capable of sensitivity analysis.

The choice models require a prior assumption of level of service. They can predict very little about the likelihood of the service being offered, although pointers could be obtained by paired comparisons of the airline behaviour and resultant airport choice behaviour in situations reflecting major/minor pairings.

Finally, it is important that the market being shared is also understood, if correct traffic predictions are to be made. This requires a rigorous disaggregate approach to be taken to
the modelling of trip generation, including long term saturation effects (Shaw, 1979), and of the multi-modal nature of transport. Unfortunately, the latter analysis awaits a ground mode data base commensurate with that provided in the UK for air transport.

TABLE 10.5: CHOICE MODEL PARAMETER COMPARISON

<table>
<thead>
<tr>
<th>Model</th>
<th>Year</th>
<th>Parameter</th>
<th>Parameter</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grayson</td>
<td>1977</td>
<td>-0.018</td>
<td>-0.200*Y</td>
<td>-0.0244*Y</td>
</tr>
<tr>
<td>Morrison &amp; Winston</td>
<td>1977</td>
<td>-0.0020</td>
<td>-0.051</td>
<td>-0.276</td>
</tr>
<tr>
<td>Kanafani et al</td>
<td>1970</td>
<td>-0.014</td>
<td>-0.10</td>
<td>0.021*F</td>
</tr>
<tr>
<td>Kanafani &amp; Ghobrial</td>
<td>1980</td>
<td>-0.0201</td>
<td>-0.087</td>
<td>0.239*F</td>
</tr>
<tr>
<td>Hansen</td>
<td>1985</td>
<td>-0.0043</td>
<td>-1.45</td>
<td>1.29*In(F)</td>
</tr>
<tr>
<td>Harvey</td>
<td></td>
<td></td>
<td>-9.96</td>
<td>(0.94-0.55*F)F</td>
</tr>
<tr>
<td>Gosling</td>
<td></td>
<td></td>
<td>-1.10</td>
<td>same</td>
</tr>
</tbody>
</table>

NOTES:

1. Y = Household income/2000 ("wage rate")
   FCI = Household income per capita/1000 (children counted as 0.5 adults) = 0.7*Y (approx.)
   F = Daily departures

2. Morrison & Winston included party size variable (auto mode only) = 1.366*N

3. Morrison & Winston based schedule delay on average time in minutes between departures over 24-hour day. Parameter adjustment for schedule delay in hours for a 15-hour day:
   \[ p = \frac{15\times 7}{2\times D} = p_{15} \times 10080/d, \text{ where } D = \text{weekly departures} \]
   \[ p = -0.276 \]

4. Schedule delay parameter for Harvey model based on (15 + F) daily departures in market and series expansion of relative frequency ratio

5. Gosling & Harvey model parameters for Bay Area residents.

Source: Aroesty et al, 1990

There are hints, in the development of the air transport demand and choice models described above, that the specification of the models leaves much to be desired. They may calibrate quite well, but they are less secure in prediction, particularly of the effects of changes in supply.
Aircraft technology, airport characteristics, the effect of capacity per se and the adjustment of travellers’ time budgets to available flight timings may be more important than the traditional variables, though harder to isolate. The impression is quite intuitive, as it is with other authors: “These considerations lead me to suspect that current mode choice models as well as models of other travel choices are seriously mis-specified in ways that have nothing to do with the random effects and covariance parameters of multinomial probit” (Horowitz, 1991). The feeling is that not only comfort, reliability and safety are important, but also that choices are ‘state dependent’ (i.e. they depend on past choices) and that perceptions of service quality may be very different from the objective measurements normally used in the models. Other work suggests that serial correlation is even more important than state dependence, again indicating that previously ignored variables may be strong determinants of trip generation (Kitamura, 1989). Also recent work has shown that “different individuals use different decision-making processes in choosing travel modes”, pointing to the need for really effective segmentation of demand (Chou, 1992).

It may be that the concept of ‘satisficing’ or of making decisions which are ‘good enough’ for the situation as understood (Simon, 1955) needs to be developed. Another approach would be via the idea of ‘value stretch’ (Mansfield, 1992). The traveller is presumed to have a highest level of preferences defining realistic maximum goals as well as a lowest level tolerance reflecting minimum basic travel needs. The level of last experience will be situation within that band of preference or ‘value stretch’. The range between the ‘tolerated’ and ‘last experience’ levels will indicate the ‘satisfaction gain’ and that between the ‘last experience’ and the ‘highest preference’ levels will indicate the ‘reconciliation gap’.

A third approach would be to distinguish between cognitive, affective and conative behaviour (Michie, 1986), where the latter is the overt activity of making reservations and travelling, or the revealed demand which is usually modelled.
Cognitive behaviour is the acquisition of the information which will be used to formulate beliefs and patterns of psychological activity. Affective behaviour evaluates the activity in the light of the cognitive structures to develop an attitude towards its desirability.

All of these approaches are relevant to improving the understanding of the behaviour which has been investigated by the generation (Brooke, Caves and Pitfield, 1993) and the airport choice models described above. Clearly, some combination of Stated Intention and Stated Preference surveys (Fowkes and Preston, 1991) will be required to test the validity of the models' specification, particularly in the areas of demand-constrained leisure travel and of new travel opportunities.
AIRLINE PREFERENCES

Network Strategies

Of the many pointers from US experience to European planners described in Chapter Five, the tendency towards decentralisation is one of the most pertinent, at least to the UK, where regional traffic has been growing more quickly than national traffic for some time. The regions are very interested in promoting airport growth with new routes unless the environmental costs become too great. If they can show that they have the conditions for local traffic growth and the available airport capacity for local plus transfer traffic, they are in a strong position to negotiate with the carriers. Fruition of the regions' plans will, however, depend on national and EEC attitudes to route negotiation, and will require increased participation of the regions and their airports in external air policy (Wassenbergh, 1991). The process could be difficult, because many intrastate conflicts will require resolution, such as the interests of Shannon in Ireland which are presently catered for by requiring all transatlantic flights to call there.

Improved regional air transport services, whether direct or indirect, should go some way to reducing the disparity in wealth between the central and peripheral regions in Europe and hence increase traffic to these areas. However, the main traffic demands will continue to be in the central axis from Manchester to Rome. Hubbing in this market would be unable to compete with existing direct connections. The demography will certainly allow the possibility of existing 'hinterland' hubs strengthening their services to secondary cities and of bypass hubs like Birmingham being set up at, say, Hanover or Lyons or Basle (Gialloreto, 1992). There is also the possibility of 'gateway' hubs at the periphery of Europe providing services into secondary cities, such as Rome for South East Asia and Madrid/Lisbon for Latin America (Flint, 1991).

The majority of the major hubbing points in Europe are certainly congested (SRI, 1990), giving further encouragement
to regional fragmentation. However, even if flag carriers merge and EEC competition rules are not strong enough to force them to release runway slots and gates, the 'hard' local traffic will remain strong at most major hub cities.

There will therefore be a strong incentive for competing carriers to set up hubs at secondary airports within the same metropolitan areas, where those airports can offer the right conditions. The difficulties should not be underestimated. A study of the rise and fall of British Caledonian shows that building hubs from secondary airports is very difficult in the face of uncontrollable external factors, particularly when regulatory protection is withdrawn (Cronshaw and Thompson, 1991) though this is not the conclusion that the authors choose to draw. Also, the balance between economic benefits and environmental disbenefits is likely to be drawn differently in the major metropolitan areas. This is, however, an additional method to those considered earlier of making efficient use of a fragmented metropolitan airport system, if the incumbents at the primary airports do not opt for fragmentation in order to protect themselves against just such a raid on their territory. It has been pointed out that the European majors' strategy appears to be to dominate a whole region rather than raiding the traditionally difficult area of another major airline, even merging for this reason, eg Air France/Sabena (Jenks, 1992). This is very different from the raiding which has provided the route competition in the US, but follows the former US local carriers' success in developing hubs from the advantageous position of local loyalty and sunk costs (Bailey and Williams, 1988).

Experience in the US suggests that not more than two major airlines can hub successfully at a single airport, however large the airport. Since there is relatively little room for expansion at any of the London airports, a new hubbing operation is likely to need a new runway. However, there are few UK airlines with the financial capacity to launch even the sort of medium-sized hub that could be supported by a single runway: the natural assignment in today's conditions would be BA and British Midland at Heathrow, Air UK at Stansted, Britannia Airways at Luton (though Britannia denies
any aspirations to develop a range of scheduled services) and the rebirth of Air Europe at Gatwick, and on these grounds the industry would not appear to require new runways specifically to allow hubbing. However, a delicate post 1992 question is the UK government attitude to any attempt by a non-UK carrier to take advantage of new London runway capacity to create a major hubbing operation in competition with British Airways. This threat already exists now that United Airlines and American Airlines have Heathrow route rights which they can use to connect with their fifth freedom European services, and the latter may soon be augmented as the EEC/US negotiations proceed. Similarly, Delta has increased its operations markedly at Frankfurt, thus giving a significant American presence at the two busiest and congested airports in Europe. American Airlines has already conducted an aborted attempt to serve London from Stansted as well as Heathrow.

**Competition Effects**

The EC Competition Commissioner will certainly be active in air transport and may well overreact to claims that hubbing leads to dominance of local markets. The less dense European routes may well have fewer carriers after liberalisation, according to a study which transferred the US relationship between route density and number of carriers to the European setting (Pryke, 1991). However, a second carrier on thin routes at the moment is more likely to be in pool than offering genuine competition. Also, if seat miles rather than number of routes is used as the output parameter, the effect is small (Barrett, 1991b). The EC itself recognizes the need to protect new thin routes. Meanwhile, it is undeniable that non-hubs are benefitting from more competition as more airlines extend their own hub's feeders to them. A regional UK airport may not have competitive service to any given hub, but there will usually be indirect competition to each hub, while the choice of hub to onward destinations must increase the passengers' potential utility.

The conversion of potential service into fact is more debatable. The early history of domestic and international
liberalisation in Europe is not promising. A comparison of the history of liberal with less liberal routes between the UK and the European mainland certainly shows that more routes have opened due to liberal bilaterals and nominal discounted fares fell, but, with the exception of the Irish-UK routes (Barrett, 1991a), there is no evidence in Chapter Three that the supposed extra travel opportunities were converted into long term traffic growth (Caves and Higgins, 1993). The primary problem, at least as far as UK traffic is concerned, is that shortage of capacity, particularly at Heathrow and Gatwick, is already stifling competition.

There has, therefore, already been advance warning in Europe of the need to plan infrastructure with the consequences of deregulation in mind; a lesson only learned in hindsight in the US:

"We did not initiate an airport plan that aligned well with the new freedom for rates and routes. ... I think this lack of systemwide perspective was a strategic error. Certain requirements must be met for deregulation to yield its full benefits: competition and enforcement of measures by legal action to sustain competition; merger policy that does not foreclose meaningful access to airports; policies to deal with overcrowding of terminals, gates, runways and other facilities, and to provide for new capacity where warranted: and policies to add air traffic controllers and to introduce modern control technologies so that the system functions safely and efficiently. In sum, officials must look at the whole system, as opposed to just looking at the problem that was within the CAB domain." (Bailey, 1989)

**LIKELY NETWORK DEVELOPMENTS IN EUROPE**

The balance between hubbing and fragmentation has been redrawn at a higher level of activity after deregulation in the US. It is likely that strong historic 'hinterland' hubs, generated under international regulation, will grow even stronger in the central areas of Europe, to the extent that physical and environmental capacity allow. The existence of
'hard' local traffic at these existing hub cities will encourage alternative hubs to develop at secondary airports in the major metropolitan areas, dependent on the communities' attitude to the balance between the economic benefits and environmental disbenefits, but also on the financial health of the secondary carriers and the extent to which liberalisation really allows hub raiding, either by EEC or foreign airlines.

Provincial cities in the central area of Europe, with their own strong economies and 'hard' traffic, should expect to be chosen as by-pass hubbing points (given the difficulties of expanding the main hubs), especially if they have the ability to develop second runways. Many of them may decide that their continued success as cities does not depend on extra accessibility to the air transport system, and hence decide not to expand their airport capacity and not get involved in the bidding for non-EC route rights. It has been shown that their GDP and employment is likely to increase in any case due to overspill from the major metropolises (Steinle, 1992).

Peripheral regions in the EC, and their airlines, will mostly wish to enhance their share of EC air traffic in order to boost their economic health. There is some evidence that local demand can be stimulated by extra service, both at hubs and at spokes (Caves and Ndoh, 1990). Cities in these regions are likely to favour economic growth, despite the resulting peaky nature of the airport operations and the increased environmental effects caused by catering for transfer as well as local traffic, since hubbing will produce substantial increases in accessibility. The locations are likely to result in either 'gateway' hubs or 'hourglass' hubs being possible.

Gateway hubs are unlikely to divert existing traffic from existing hubs unless they offer the passenger greater utilisation in completing their trip. They are also unlikely to entice passengers away from direct service to the main European cities except by charging very low fares. They therefore have three potential markets:
i. intercontinental line-haul transferring to secondary EC cities;
ii. intercontinental line-haul transferring to those secondary and tertiary EC cities situated between the gateway and the major EC hubs;
iii. intercontinental secondary cities transferring to EC hubs and secondary cities.

Option iii. implies competition with the hubs in the foreign countries, and is less likely to be successful for North America than elsewhere in the short term. Option i. is likely to be a higher cost solution than carrying the intercontinental line-haul further into Europe. Option ii. has the best chance of success, but will tend to be a relatively small market. Everything will depend on the cities' influence in persuading the EC/national negotiators to grant route rights and persuading the airlines to take them up. Those with strong local traffic and the required airport attributes will best persuade the airlines. It is most unlikely that any city will succeed in selling itself as a 'waypoint', i.e., as a remote transfer hub.

The remaining hubbing possibility, for cities who wish to boost their economic potential, is to act as an 'hourglass' or by-pass hub, feeding traffic from cities in its regional sector to main EEC hubs. This is the role adopted by Eurohub at Birmingham with some success, but Birmingham is anxious to obtain long-haul route rights so as to enhance the by-pass operation with a gateway status, allowing it to compete with the similar, but larger interline operation at Manchester. As the negotiators allow the present and future by-pass hubs to take a gateway role, so the requirement for peripheral gateways will reduce, and the spiral of comparative advantage towards the centre of the EEC will continue.

The consumers' dream of direct service between all city pairs, encouraged by the EEC legislation, is unlikely to become reality in the face of the hubbing opportunities outlined above. However, as the hubs develop within the settings defined by the stance of the negotiators, the local communities and the airport/airspace capacity limitations,
there is every prospect that many more city pairs will obtain direct services.

The above qualitative analysis of the way in which airline managerial preferences might affect the shape of the European air transport network, and hence the role demanded of the airports, follows the approach taken by a recent non-governmental study in the US (ASRC, 1990). It is, however, possible that the quantitative modelling of passenger preferences could be extended to include airline objectives. Whereas passenger behaviour is presumed to have the objective of minimising the disutility of travel, airlines in a liberalised and privatised setting could be presumed to be profit-maximiser. This approach has been attempted in the US in order to predict the equilibrium proportion of hubbing under a profit-maximising assumption, using a 'n'-player, noncooperative game method. Due to the many simplifying assumptions which had to be made (the use of prevailing fares, nondiscretionary aircraft size, total demand inelastic with respect to price and service level), and the a priori indeterminacy of the equilibrium properties of the game, the behaviour of hubs in multi-airport regions and those with relatively weak markets were not well-predicted. The approach is none-the-less promising. Similarly, so is the attempt to optimise the air transport network, including the effect of slot pricing, using a two-stage game theoretic approach (Hong and Harker, 1992). Again there is no variation of total demand with fare or level of service, and airlines are presumed to attempt to maximise their revenue share on each sector. The results of its application to a simplified network show clearly that oligopoly total profits are much greater when the slot allocation is endogenous ie determined by the airlines' ability to pay with the same fee for each airline rather than by prior allocation: the airline with the larger aircraft of course gains profit relative to the others. The principles developed in these two studies could well be merged and extended to hierarchical structures and multi-airline interactions (Shaw, 1993) to study the impact of airline and regulatory policies with respect to hubs in Europe, using decision-process algorithms.
The real-world outcome of the application of the models will depend crucially on the relationships which result from mergers and alliances. A fertile field for research is that of the power relationships and processes by which an airline chooses its partners, there being no universal structural models which can guarantee the success of the partnerships (Flanagan and Marcus, 1993). The relationship is often prompted by the acquisition of slots, which changes the nature of air services when the minor partner finds itself redundant (Moorman, 1993).

Finally, it is just possible that hubbing is old news. It has been shown (Chapter Five) that the cost efficiency of hubbing is debatable. The last three years experience in the US have shown that the marketing advantages have been unable to protect profits in the face of competition and recession. All the majors have lost a great deal of money. Either they have cut back on the number of hubs or, in going into bankruptcy, have left airports without competing services. The only carrier of any size to make consistent profits, Southwest Airlines, is a low cost operator. Although based on two down-town airports (Dallas Love Field and Houston Hobby), it relies more on the economies of density in selected short-haul point to point markets rather than in enticing passengers through its hubs (Sorenson, 1991). Since only profitable airlines can grow, either generically or by acquisition, Southwest's example may set the pattern in Europe, breaking the power of the traditional market leaders by price leadership with adequate quality of service. A new generation of models will need to be developed to explore this phenomenon.
CHAPTER 11: AIR TRANSPORT AND SOCIETY

INTRODUCTION

The previous chapter has indicated the likely preferences of the users of airports in a liberalised and competitive setting, or at least shown the direction in which research should proceed to improve the understanding of those preferences. This chapter concerns itself with drawing the user preferences together with the societal view of air transport discussed in Chapter 6, in an attempt to carry out the type of societal evaluation suggested in Chapter 9 while taking account of the aircraft technology options discussed in Chapter 7. The process developed in the second part of this chapter is intended only as a notional demonstration of the full process, which would, of course, have the inputs of all the major actors themselves. It is hoped, however, that this notional evaluation is sufficiently realistic at least to offer a promising candidate for a synergistic set of policies which might lead to a 'win-win' solution for all the major actors in the system.

One of the most important aspects of the societal view of air transport is the relationship between the provision of air service and the local economy. The first part of the chapter demonstrates a methodology for investigating the direction of causality in this relationship. Unfortunately the data only allowed the relationship between air accessibility and local demand to be analysed, with the presumption that the demand could in some way be associated with stimulation of the local economy. The effect of supply on demand is itself important to the production of traffic forecasts, as indicated in Chapter Four. Yet there is extreme confusion as to its existence. It has been pointed out elsewhere (Grigson, 1978) how the government view varies: it is stated that when deciding national policy the effect definitely does not exist, for regional policy it probably does not exist, yet it definitely does exist in the autonomous term of econometric forecasting models. The work which follows is intended to throw some light on both the economic and the forecasting
SUPPLY AND DEMAND RELATIONSHIPS

Methodology for the investigation of causality

The first requirement for the unravelling of the causal linkages between variables is the assumption that effects will always be felt downstream in time from the cause. The second requirement is a data series sufficiently close-spaced relative to the time span over which the event occurs for the effect to be detectable. Most earlier studies which have successfully shown correlation between service quality and demand have not shown causality because either the time series had too coarse an interval, or the effect was too gradual, or cross-sectional data were used which preclude the consideration of causality. If the data conditions are fulfilled, it is then possible to establish leads and lags by comparison of two or more data series. This may be done in either of two ways. One way is the comparison of alternative lagged multiple regressions, picking the best statistical results to identify the direction of causality and the lag involved. This method was used to study demand on a single sector route in the USA (Kumar and Stephanedes, 1988). Competing airlines were excluded from the analysis due to lack of data, and the search for causality was limited to a three month lag within 48 monthly data points. An almost immediate effect on demand of both fares and available seats was detected: in the reverse sense, increased demand caused more seats to be made available one month later.

In effect, lagged multiple regressions of this type correspond to the cross-correlation analysis which forms the causative element of the second main approach. This second approach involves time series causality testing based on the works of Haugh (1976) and Pierce (1977). It involves the determination of Univariate Autoregressive Integrated Moving Average (ARIMA) models for each series in turn from which the residuals or 'white noise' of each series is obtained. Causality is then determined based on the shape of the cross-correlation functions between pairs of prewhitened series as
well as the dynamic-causal structure between the series. In this way it is possible to develop transfer functions of the relationship between the variables, taken two at a time (Makridakis, Wheelwright and McGee, 1983).

The ARIMA process has been used before to forecast air travel demand in a univariate manner and also with a fare intervention, but no other measure of supply quality was used (Oberhausen and Kappelman, 1982). Intervention analysis using ARIMA models was also used to model the effects of rail/air competition between London and Scotland (Jenkins, Abbie, Everest and Paulley, 1981). It was found that only one in five price changes affected air travel demand and then only temporarily: indeed, the competitive effects were very small, most of the changes to air demand coming from changes in Real Average Earnings on a two month lag with an elasticity of 1.0 and changes in the Index of Manufacturing Production also on a two month lag with an elasticity of 0.3. Most recently, the method has been used to investigate competitive effects between airlines on single sector domestic routes (Pitfield, Jones, Caves, 1989). Again, there was little evidence of cross-influences, one of the difficulties being the small size of changes in the independent variables. The considerable scope in this method for uncovering causal relationships and using them for forecasting encourages its use for the analysis undertaken here.

Data availability and constraints

Given the nature of the hypothesis and the chosen method of analysis, it was considered necessary to identify a set of airports where the change in supply had been sufficiently large and rapid that the effect on demand would have been large enough to measure and to be identifiable in time. A long time series also had to be available, to allow for the loss of data points inherent in the differencing processes within the ARIMA method.

It was initially supposed that these conditions would be met at those smaller airports in the USA recently chosen as hub
locations by one or more airlines. Examination showed that this was not always the case, particularly once those locations having unique economic characteristics and/or those close to major hubs (Kanafani and Abbas, 1987) had been eliminated. Three hubs which had experienced high growth in services were therefore chosen, ie Charlotte, Dayton and Nashville, together with three non-hubs which had experienced large increases in service, namely Austin, Lubbock and Syracuse. It had originally been hoped to examine many more airports, including economically similar cities which had not experienced strong growths in air service and could therefore be used as controls, but data acquisition costs would not allow this.

The socio-economic data, particularly population of the Standard Metropolitan Statistical Area (SMSA) containing the airport and the income per capita of the relevant State were collected manually from the US Bureau of Economic Analysis and the US Bureau of the Census publications.

The hypothesis to be tested was to have been that increased air service stimulated a local economy. It would therefore have been ideal to investigate this relationship directly. However, it was felt that quarterly data, which was the finest disaggregation available of air travel demand, was already the coarsest level acceptable for illuminating the issue of causality (see the above results quoted by Kumar and Stephanedes, 1988): the economic data were only available annually and for regions which were not necessarily the complete or unique catchment of the airports. The local, rather than total (which would have included transfer and transit), emplanements were therefore taken to indicate the stimulation of the economy: after all, if the economy has been stimulated by air service, it is reasonable to expect the air service would have been more used. Certainly, a recent case study approach to the influence on their cities' economies of three small airports in California took local boardings as the indicator (Kanafani and Abbas, 1987).
Measures of accessibility

Apart from the monetary cost, the changes in accessibility could be interpreted as the ability to:

- make day return trips to more markets;
- access more destinations directly;
- access major hubs.

The high connectivity of the USA air transport network made it impossible to calculate the changes in integral accessibility to all destinations and the literature is of little help in deciding whether it is more appropriate to use the alternative integral measure of direct destinations or the relative accessibility to preferred hubs (Caves, 1983). It was therefore decided to measure all of them and choose between them on the basis of the resulting models. It was established that all locations had adequate early and late flights (given time zone constraints) so that the ability to access hubs easily and to make day returns could be interpreted by the number of weekday departures. A rate of less than two departures per day was considered not to make a destination viable, as was the presence of more than one stop en route. This is common practice in the literature, based in Quality of Service Indicators (QSI). All of the supply indicators were obtained by manual analysis of the ABC guides, after checking that the advertised services agreed closely with the Official Airline Guide (OAG): the latter would have been preferable, but no uninterrupted time series of North American OAGs was available in the UK.

The IP Sharp data base was therefore used to provide quarterly local emplanements from 1974 to 1987, both for the sum of all routes served by the airport and also on two important local sectors, ie to the nearest hub and the next most important hub. The information was drawn initially from the 10 per cent ticket sample of Certificated Air Carriers, so Commuter/Regional passengers were excluded unless they used the airport to transfer to certificated service. The 'local' emplanements included return portions of the return journey of non-local residents as well as outward portions of
local residents' trips.

Fares could only be provided from 1981 and on the two sampled sectors. They were available as the total yield per local passenger. The Standard Industry Fare Level (SIFL), ie the average yield on all domestic sectors of the same length, was also available. The price indicator used was the ratio of actual yield to the SIFL. Although the fares' time series were too short for effective ARIMA modelling, it was necessary to include this variable to retain confidence in using emplanements as a proxy for the stimulation of the economy: passengers could easily be influenced by rising local fares at hubs and falling fares at non-hubs with competing service.

Analysis and results

In the analysis that follows results are presented in full for Austin as a case study. The hypothesis under investigation can be formally stated as:

$H_{01}$: supply variable $x_{it}$ does not affect local demand at Airport A.

$H_{11}$: supply variable $x_{it}$ does affect local demand at Airport A.

where the test statistic is given by Pierce (1977):

and since the above test is unidirectional, the alternative hypotheses tested are:

$$
\chi^2_{01} = N \sum_{k=1}^{M} \frac{r_x^2}{s_y^2} (k) \quad ........... \quad (1)
$$

$H_{02}$: local demand $Y_{it}$ does not affect supply variable $x_{it}$ at Airport A.

$H_{12}$: local demand $Y_{it}$ does affect supply variable $x_{it}$ at
with

\[ \chi^2_{02} = N \sum_{k=1}^{M} r_{a_x a_y}^2 (k) \] \hspace{1cm} (2)

where \( k \) is the lag, \( r \) the cross-correlation coefficient between the residuals and \( a_x, a_y \) are the residual cross-correlated series.

The adopted procedure was to calibrate parsimonious univariate Box-Jenkins models for each supply and demand time series at each airport and obtain the residuals or white noise components of these models. The residuals from the supply variable and corresponding demand residuals were cross-correlated to determine the magnitude of the bidirectional correlation between the two series. The above calculated test statistics (\( \chi^2_{01} \)) only confirm the presence versus the absence of a causal relationship between two cross-correlated series over a time span \( M \), where \( M \) is the largest lag in the calculation of \( \chi^2 \) within which any influences are to be expected. Where strong influences exist, the sign of the influence can be observed from the residual's cross-correlation plot while a transfer function analysis is required to confirm the lags and strength of any such influences defining the dynamic relationship between the two series.

The demand/supply history of the airport at Austin, Texas, is given in Figures 11A and 11B. They show that the number of destinations served changed rather gradually, as one might expect at an airport where no strong attempt had been made to locate a hub. The frequency of service, on the other hand, shows two substantial and rapid changes. The first, in 1978, was a temporary near doubling of frequency. The second was a tripling of frequency over a two year period, combined
FIGURE 11.1: HISTORY OF SUPPLY AND DEMAND

A Austin Supply

B Austin Demand

C Charlotte Supply

D Charlotte Demand

NB (1) non-hub departures, (2) total departures, (3) the number of frequently served destinations, (4) the number of total destinations, (5) local demand.
with a doubling of destinations over a later and rather longer period.

Visual inspection of the local demand history suggests that both of the large changes in supply affected demand approximately a year later. The temporary increase in supply in 1978 appears to have had a permanent effect on top of an underlying growth in demand.

At Charlotte, as illustrated in Figure 11.1 C and D, the reduction in supply in 1978 appears not to have had any effect on demand until 1980, and the massive increases of supply associated with the hub growth beginning in 1981 did not appear to affect local demand until 1993.

The quantitative analysis was carried out by first prewhitening the demand and supply variables.

The ARIMA models selected as best interpretations of the historic data at Austin were:

Demand (ie log of local emplanements):

\[(2,1,0) (2,1,0) 4 \quad \ldots \quad (3a)\]

Non-hub Frequency (ie log of weekly departures to non-hubs):

\[(0,1,1) (0,1,1) 4 \quad \ldots \quad (3b)\]

Total Frequency (ie log of total weekly departures):

\[(0,1,1) (1,1,0) 4 \quad \ldots \quad (3c)\]

Destinations (ie log of destinations served at least twice per day):

\[(0,1,1) (0,0,0) 1 \quad \ldots \quad (3d)\]

where the models are expressed in standard notation \((p,d,q)\) \((P,D,Q)\) indicating parameter components of the ARIMA model such that:
p and P are the non-seasonal/seasonal Autoregressive (AR) components
q and Q are the non-seasonal/seasonal Moving Average (MA) components
d and D are the order of non-seasonal/seasonal differencing to obtain stationarity
S indicates the seasonality period.

In particular the demand model can be expanded in the following form to allow prediction:

\[(1 - B^1)(1 - B^4)(1 + 0.2305B^1 - 0.2743B^3)(1 + 0.5184B^4 + 0.2847B^8)\text{ demand } = \delta_t \ldots (4)\]

\[(-1.68) \quad (2.01) \quad (-3.53) \quad (-2.03)\]

\[(t-values)\]

where \(\delta_t\) is the noise component and B the Back Shift operator,

\[Bz_t = z_{t-1}\]

The cross-correlation of demand residuals with the residuals of all the supply variables was carried out after this prewhitening. Negative lags in Figure 11.2 indicate the influence of demand on supply while positive lags indicate influences of supply on demand. It is also possible to see when the effect begins to occur (2 lags, ie 2 quarters of a year) and the likely sign of the elasticities.

The full results on causality for Austin are given in Table 11.1, where

L denotes natural logarithm
TFREQ denotes total departures per week
OFREQ denotes departures per week to non-hubs
NDES1 denotes total number of destinations served
NDES2 denotes number of destinations served at least twice daily
HUBF 1,2,3, denotes departures per week to major hubs 1,2, and 3.
FIGURE 11.2: CROSS-CORRELATION OF RESIDUALS FOR AUSTIN
(Demand and destinations served at least twice weekly)

| LAG | CORR. | +--------+--------+--------+--------+--------+--------+--------+--------+--------+--------+--------+--------+--------+--------+--------+--------+--------+--------|
|-----|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| -16 | -0.041| +       | XI      | +       |
| -15 | 0.064 | +       | IXX     | +       |
| -14 | 0.222 | +       | IXXXX   | +       |
| -13 | -0.314| XXXXXXXXI | +       |
| -12 | -0.049| +       | XI      | +       |
| -11 | -0.079| +       | XXI     | +       |
| -10 | 0.111 | +       | IXXX    | +       |
| -9  | 0.112 | +       | IXXX    | +       |
| -8  | 0.088 | +       | IXX     | +       |
| -7  | -0.041| +       | XI      | +       |
| -6  | 0.124 | +       | IXXX    | +       |
| -5  | -0.019| +       | I       | +       |
| -4  | -0.245| +XXXXXI | +       |
| -3  | 0.071 | +       | IXX     | +       |
| -2  | 0.022 | +       | IX      | +       |
| -1  | -0.031| +       | XI      | +       |
| 0   | 0.202 | +       | IXXXX   | +       |
| 1   | -0.171| +       | XXXXI   | +       |
| 2   | 0.308 | +       | IXXXXXXXX  |
| 3   | -0.070| +       | XXI     | +       |
| 4   | -0.182| +       | XXXXI   | +       |
| 5   | 0.001 | +       | I       | +       |
| 6   | 0.079 | +       | IXX     | +       |
| 7   | -0.054| +       | XI      | +       |
| 8   | -0.085| +       | XXI     | +       |
| 9   | 0.176 | +       | IXXXX   | +       |
| 10  | -0.179| +       | XXXXI   | +       |
| 11  | 0.044 | +       | IX      | +       |
| 12  | -0.255| +       | XXXXI   | +       |
| 13  | -0.007| +       | I       | +       |
| 14  | -0.158| +       | XXXXI   | +       |
| 15  | 0.013 | +       | I       | +       |
| 16  | -0.014| +       | I       | +       |
The confidence limits at which the hypotheses can be accepted are shown; for example, it can be accepted that total frequency (i.e., total departures per week to all direct non-stop or one-stop destinations) influences total local boardings with 90 per cent confidence. If a more normal approach of deciding beforehand that anything less than, say, 95 per cent confidence would be rejected, only the departures to non-hubs would be accepted as significant.

This is a clear example of the difficulty of conducting visual inspections of the data—the destination variables appeared insignificant in Figure 11.1 due partly to the relative scales, but, more importantly, it is difficult to judge the cross-correlations consistently over the whole time period, not least because the information in Figure 11.1 has not been prewhitened.

The evidence for the effect of changes of spatial and temporal accessibility on demand at Austin is rather thin: on the other hand, the causality tests of demand on supply are substantially poorer.

Charlotte demand and supply variables show almost no causality in either direction, except that the frequency into O'Hare causes changes in total boardings at the 95 per cent level. The effect builds up over four quarters. Visual inspection of the graphs would tend to suggest that non-hub departures caused the only major change in traffic, with an 18 month lag.

The results for the other airports is given elsewhere (Caves and Ndoh, 1990), and is only summarised here. At Dayton the frequency to St. Louis appears to affect total local boardings at the 97.5 per cent level, this time with a lag of three months; local demand in turn affects total frequency offered, after one quarter. Visual inspection of the raw data suggests that reduction on all measures of departures may have caused the massive loss of traffic in 1980, while the recovery in traffic was simultaneous with increases in supply.
### TABLE 11.1: RESULTS OF RESIDUAL CROSS-CORRELATION CAUSALITY TEST FOR AUSTIN AIRPORT

#### A Test of influence of supply on demand

<table>
<thead>
<tr>
<th>SUPPLY VARIABLES</th>
<th>M LAGS INCLUDED IN TEST</th>
<th>CALC. CHI-SQ. VALUES $\chi^2_{01}$</th>
<th>LEVEL OF ACCEPTANCE</th>
<th>M LAGS INCLUDED IN TEST</th>
<th>CALC. CHI-SQ. VALUES $\chi^2_{01}$</th>
<th>LEVEL OF ACCEPTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTFREQ</td>
<td>8</td>
<td>14.61</td>
<td>90%</td>
<td>12</td>
<td>12.93</td>
<td>50%</td>
</tr>
<tr>
<td>LOFREQ</td>
<td>4</td>
<td>9.68</td>
<td>95%</td>
<td>12</td>
<td>12.0</td>
<td>50%</td>
</tr>
<tr>
<td>LNDES1</td>
<td>6</td>
<td>3.72</td>
<td>0.5%</td>
<td>12</td>
<td>14.33</td>
<td>50%</td>
</tr>
<tr>
<td>LNDES2</td>
<td>4</td>
<td>7.95</td>
<td>90%</td>
<td>12</td>
<td>15.35</td>
<td>75%</td>
</tr>
<tr>
<td>LHUBF1</td>
<td>6</td>
<td>9.74</td>
<td>75%</td>
<td>12</td>
<td>12.75</td>
<td>50%</td>
</tr>
<tr>
<td>LHUBF2</td>
<td>4</td>
<td>5.8</td>
<td>75%</td>
<td>12</td>
<td>13.49</td>
<td>50%</td>
</tr>
<tr>
<td>LHUBF3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

#### B Test of influence of demand on supply

<table>
<thead>
<tr>
<th>SUPPLY VARIABLES</th>
<th>M LAGS INCLUDED IN TEST</th>
<th>CALC. CHI-SQ. VALUES $\chi^2_{02}$</th>
<th>LEVEL OF ACCEPTANCE</th>
<th>M LAGS INCLUDED IN TEST</th>
<th>CALC. CHI-SQ. VALUES $\chi^2_{02}$</th>
<th>LEVEL OF ACCEPTANCE</th>
</tr>
</thead>
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<td>9.23</td>
<td>50%</td>
<td>12</td>
<td>11.87</td>
<td>50%</td>
</tr>
<tr>
<td>LOFREQ</td>
<td>4</td>
<td>3.83</td>
<td>50%</td>
<td>12</td>
<td>4.4</td>
<td>2.5%</td>
</tr>
<tr>
<td>LNDES1</td>
<td>6</td>
<td>9.12</td>
<td>75%</td>
<td>12</td>
<td>12.14</td>
<td>50%</td>
</tr>
<tr>
<td>LNDES2</td>
<td>4</td>
<td>3.13</td>
<td>25%</td>
<td>12</td>
<td>5.95</td>
<td>5%</td>
</tr>
<tr>
<td>LHUBF1</td>
<td>6</td>
<td>5.76</td>
<td>50%</td>
<td>12</td>
<td>16.62</td>
<td>75%</td>
</tr>
<tr>
<td>LHUBF2</td>
<td>4</td>
<td>3.27</td>
<td>25%</td>
<td>12</td>
<td>13.74</td>
<td>50%</td>
</tr>
<tr>
<td>LHUBF3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
There are no really significant interactions at Lubbock, except for some evidence of demand affecting the total number of destinations served three years later and of frequencies to El Paso affecting total local boardings three quarters later. This is a strange result, given the almost step nature of the 150 per cent increase in traffic in the last quarter of 1979: the only visual clue is the large temporary increase in frequency to DFW during 1978 as well as to El Paso at the same time.

Nashville shows an altogether more positive influence of number of destinations served on demand, while categorically denying any such effect from total departures. The results also disallow any confidence in local demand affecting supply, which is in keeping with a hubbing situation. The affect on demand appears five quarters after a change of supply. The graphs of raw data offer no clue to this effect.

In the case of Syracuse, the number of departures to New York as well as those to non-hub destinations show very strong evidence of affecting demand after one quarter. The clear evidence of causality at one quarter lag is illustrated in the cross-correlation of residuals in Figure 11.3.

The cross-correlation analysis between total local demand and air transport accessibility had to be performed without the benefit of information on fares: this despite the fact that there have been many changes in fares policy associated with changes in the network, and also despite the undoubtedly significant role of price in the travellers' perception of accessibility. However, fare data were only available from 1981, so invalidating their use in the ARIMA modelling due to shortage of data.

The sector data were graphed and subjected to a visual examination in an attempt to gain some understanding of the role of fares. The traffic was indexed to the first quarter of 1981. Of the seven sectors examined, only two (AUS-DFW and DAY-ORD) showed any consistent relationship over time between fares and traffic, both showing relatively small changes simultaneously. In the two cases where significant
and rapid changes of relative fare occurred (CLT-ATL and BNA-ATL), there was very little response from traffic, perhaps due in the case of CLT to simultaneous frequency changes masking the effect. There were two cases (AUS-LAX and SYR-LGA) where large-scale changes of traffic occurred. The effect may have been due to frequency change in the case of AUS, but there is no similar explanation at SYR for variations of 30 per cent in traffic being associated with changes of 40 per cent in relative fare in the counterintuitive sense. There is certainly no clear evidence that traffic on a sector is strongly influenced by the relative cost of that sector. It is also the case that relative fares often rise on one route while falling on another route serving the same city. It is therefore assumed that fare changes do not alter the overall generation of boardings at an airport sufficiently to interfere with the changes caused by level of service variables. Additional credence is given to this assumption by the evidence here and elsewhere in the literature that response to fare changes is almost instantaneous, while virtually all the causal relations found here displayed a lag of at least one quarter.

Since the economic data were only available annually, it was not possible to carry out similar cross-correlation analysis. Data were collected on total employment, employment in transport, earnings in transport, income per capita, and population. The data were graphed and visually examined for correlation with local boardings.

In all cases except Austin, the population was almost constant; income per capita increased by 150 per cent between 1974 and 1984; transport earnings grew roughly in line with income per capita; transport employment and total employment both stayed roughly in line with population.

There have been no substantial discontinuities in the data. Austin differs in that there was a smooth growth in population of 50 per cent and the income per capita has risen by 200 per cent, giving a 300 per cent change in economic activity compared with the less than 200 per cent experienced elsewhere. The local boardings at all six cities show
FIGURE 11.3: CROSS-CORRELATION OF RESIDUALS AT SYRACUSE  
(Demand and total departures to non-hub destinations)

<table>
<thead>
<tr>
<th>LAG</th>
<th>CORR.</th>
<th>-3.0 -3.1 -3.2 -3.3 -3.4 -3.5 -3.6 -3.7 -3.8 -3.9 -4.0 -4.1 -4.2 -4.3 -4.4 -4.5 -4.6 -4.7 -4.8</th>
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</thead>
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<td>-16</td>
<td>0.081</td>
<td>+ IXXX + XIX + IXX + XXXI + XXXX + XXI</td>
</tr>
<tr>
<td>-15</td>
<td>-0.151</td>
<td>+ XXXX + IXX + IXX + IXXXX + XIX + XIX</td>
</tr>
<tr>
<td>-14</td>
<td>0.039</td>
<td>+ XIX + IXX + IXX + IXXXX + XIX + XIX</td>
</tr>
<tr>
<td>-13</td>
<td>0.089</td>
<td>+ XIX + IXX + IXX + IXXXX + XIX + XIX</td>
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<tr>
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<td>-0.004</td>
<td>+ IXX + IXX + IXX + IXXXX + XIX + XIX</td>
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<tr>
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<td>-10</td>
<td>0.058</td>
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<td>-9</td>
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<td>+ IXXXX + XIX + XIX + IXXXX + XIX + XIX</td>
</tr>
<tr>
<td>-8</td>
<td>-0.082</td>
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</tr>
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<tr>
<td>2</td>
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</tr>
<tr>
<td>3</td>
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<td>10</td>
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<td>+ IXXXX + XIX + XIX + IXXXX + XIX + XIX</td>
</tr>
<tr>
<td>12</td>
<td>-0.160</td>
<td>+ IXXXX + XIX + XIX + IXXXX + XIX + XIX</td>
</tr>
<tr>
<td>13</td>
<td>-0.235</td>
<td>+ IXXXX + XIX + XIX + IXXXX + XIX + XIX</td>
</tr>
<tr>
<td>14</td>
<td>0.165</td>
<td>+ IXXXX + XIX + XIX + IXXXX + XIX + XIX</td>
</tr>
<tr>
<td>15</td>
<td>-0.213</td>
<td>+ IXXXX + XIX + XIX + IXXXX + XIX + XIX</td>
</tr>
<tr>
<td>16</td>
<td>0.170</td>
<td>+ IXXXX + XIX + XIX + IXXXX + XIX + XIX</td>
</tr>
</tbody>
</table>
significant and rapid changes over the period considered: these changes do not appear to be reflected in the local economy with the possible exception of Dayton.

Discussion

The time series analysis indicates clear but rather variable evidence that the number of departures at an airport has an effect on the local boardings, i.e. local demand is induced by an increase in air transport accessibility. At the non-hub airports, weekly departures were the only supply measures which gave clear evidence of this effect: at Austin and Syracuse the important variable was departures to non-hub locations, while at Lubbock and again at Syracuse the frequency to a near interchange point was the causative variable. The effect was apparent usually within one quarter.

Two of the hub airports' results also appeared to indicate that increased frequency to a near major hub induced local demand, Charlotte and Dayton experiencing this within three or four quarters lag. At Nashville, it was the total number of destinations served which gave the strongest evidence of inducing demand, with a lag of five quarters. Intuitively it might have been expected that improvements in accessibility would take longer to influence local demand at the hubs than at the spokes, because they would not have been targeted at the local market.

Most of the effects detected by this methodology could not be predicted by purely visual examination of the time traces, though it did prove possible at times to observe similar results in response to large and rapid changes in the dependent variables.

The analysis clearly does indicate the causality link that was the objective of the investigation. The development of the transfer functions required to refine the degree of lag and to estimate elasticities is the next step in the process.

Clearly price is a part of the accessibility equation and
reductions in price can well lead to the release of latent demand. A separate multiple regression analysis showed that fare tends to have more influence than frequency in these markets, but the limited analysis possible on sector data suggests that the changes are fairly random over space and time, and is therefore unlikely to have had much influence on the analysis of spatial and temporal accessibility variables.

These conclusions of the effect of supply variables on local demand cannot immediately be interpreted as causing changes in the underlying local economy. The available data were not sufficiently compatible with the demand and supply data to allow adequate tests of this hypothesis; particularly due to the availability of only annual economic statistics.

One of the drawbacks of the causal time series analysis is the availability of only quarterly data on demand. Results of other authors (Kumar and Stephanedes) suggest that demand responds almost immediately to changes of fare and capacity, while capacity increased within a month of demand increases being detected. However, the situation of one airline's traffic on a single multi-airline sector is a very different matter from the total markets being investigated here.

There is much less clear-cut evidence of demand influencing supply, either at spokes where it may have been expected or at hubs where the effect would be less likely to occur. If the apparent influence of demand on total destinations served at Lubbock is rejected due to its counter-intuitive three year lag, the only cases left are effects on destinations served at least twice a day at Syracuse and on total departures at Dayton, both with lags of one quarter, ie in agreement with Kumar and Stephanedes. However, most of the tests on six variables at six airports gave indications of supply --> demand causality. It should, however, be noted that aircraft capacity was not considered as one of the supply variables, yet the use of larger aircraft may often be the response to high demand.

In summary, the investigation shows a substantial amount of evidence for induced demand resulting from improvements in
spatial and temporal accessibility. This result cannot immediately be tied to stimulation of the local economy, though it does appear to be relatively independent of fare.

Further research work is being undertaken to better understand the dynamic relationship between demand and supply variables using the Box Jenkins modelling approach as contrasted with more conventional econometric models which use multiple regression.

This rather complex methodology avoids most of the criticisms of other attempts to determine the economic benefits which can flow from improved air service, and this limited application of the methodology does demonstrate that air service can stimulate demand. Only with this degree of rigour will it be possible to persuade policy makers of the causal reality of the relationship. An adviser to the US National Governors' Association has stated that the calculation of economic impact says little about how airports influence the type of economic development that takes place around them. He also states that, while airports are no doubt an integral part of economic development, it is hard to generalise on causality (Cooper, 1990). Similarly, the summariser of a Transportation Research Board conference on Transportation and Economic Development in 1989 said: "The need for a causal-based methodology has been stressed over and over again during this conference. Unquestionably, there is a relationship between transportation and economic development. .... However, transportation .... is only one of many elements. With the current state of knowledge, it is impossible for public policy makers to establish reliable, measurable, causative relationships between given levels of transportation investments and resulting economic development." (Drew, 1990) The UK CAA and Department of Transport appear to hold this view. The EEC, on the evidence of the Regional Development Fund grants for regional airports, needs less convincing, but the response of air carriers to funded improvements at Dundee and Leeds-Bradford may cause them to re-assess their views.

The attitude of a city like Sheffield, in fearing the
economic consequences of being without an airport when all other similar cities have one, is understandable. A tracking study of changes in the local economy with the opening of its new airport should certainly be undertaken. However, there is evidence that cities in the shadow of a hub fare just as well by relying on the hub (Kanafani and Abbas, 1987). Even if there is net economic stimulus, it may result in the major economy becoming even more dominant (Evers et al, 1991; Bonnafous, 1991). Historically, improvements in transport have served to concentrate economic activity, transport being a symbol rather than a cause of growth (Hart, 1983).

Care must therefore be taken when using arguments based on economic contribution or stimulation of development to use only justifiable impacts and to realise not only that any benefits will be limited to some sectors of the economy but also that some groups within the community may be losers rather than winners.

**A NOTIONAL SOCIETAL EVALUATION OF AIR TRANSPORT**

The TRB study described in Chapter 9 goes some way to setting air transport acceptably into society, but probably does not take sufficient account of the need to "find political support locally and nationally". In the climate of the next two or three decades, this will only be done by demonstrating that the planned system will be:

- more efficient
- more 'green'
- more appropriate.

A very experienced aviation professional has called for a 'civil aviation benefit impact statement' for all new aeronautical projects, since 'the global market test of a transport vehicle must be how safe, economical, environmentally benign it is, not just how technically efficient or fast it is' (Halaby, 1990). Assurances along these lines can only flow from a full EIA rather than an industry-based technology assessment, the EIA being done transmodally. Certainly, as pointed out elsewhere (Yosef,
1991), a far more rigorous analysis than that suggested by the FAA is necessary if the US Executive Order 12291 of 1981 is to be followed correctly: the order directs agencies to focus on cost benefit implications to society. These studies could form the basis of a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis in future scenarios. This analysis, in turn, would indicate the areas where air could best compete with, and where it could best complement, other modes, so giving the lead to both the industry and the government decision makers as to which possibilities to pursue and which developments to approve. An example outline of such an analysis now follows.

**Aviation Strengths**

It would be entirely wrong to prejudge the results of this analysis, but aviation has inherent strengths which should stand it in good stead. The EEC admits that air is "hardly contestable for journeys over 500 kilometres" (Frohnmeyer, 1991). It is also relatively flexible in the quantity, location, routing and timing of seats supplied. It has the potential for innovative solutions at least the equal of other modes though it is unlikely that plans for systems of vertiports based on tiltrotors will gain aviation many friends in Europe or gain much market share (Aroesty, Rubenson, Gosling, 1991; Street, 1990). Aviation can provide speed at relatively low cost even on thin routes, giving it a natural advantage for improving regional accessibility (Caves, 1983). It can, if needed, produce very large aircraft, and, more easily, increase average aircraft size so allowing two-thirds of new capacity to be provided by size (Beyer, 1989) rather than the one-third predicted by the industry (IATA, 1990).

In the short term, ducted or unducted fans might well assist in controlling emissions (Morris, 1989), but it is their use to further the natural development of Chapter 3 RTOL which could lead to the greatest benefits at least cost by increasing airport throughputs per metre of runway (Caves, 1989). At the same time, a developed RTOL would bring other benefits: such synergistic benefits seem to be the key to the
adoption of policies and hence to their implementation (May, 1991). The synergy is shown in Figure 7.3 (page 203), and is illustrated by the fact that some 150,000 of Heathrow's annual aircraft movements could be served from a 1,600 metre runway without limiting their payload, while allowing full payload operation of a 757 to all domestic and 98 per cent of European destinations (Figures 11.4 and 11.5).

The exercise of attempting to locate a third runway at Heathrow, as reported in the Annex, illustrates the delicate balance between industry benefits and community costs. A longer runway might offer greater freedom of aircraft choice, but also might result in a much lower environmental limit on movement rates and times. Even a 2,000 metre runway, which would give full unrestricted European operations for a 767-300 even in Cat.III conditions, might be enough to trigger off an adverse balance, as well as giving problems with the eastern Public Safety Zone in Harlington. The environmental consequences of the local ground traffic associated with a free-standing terminal for the new runway might also be too great to be tolerable, compared with a remote satellite linked underground to the probable Terminal Five. The balance might similarly be tipped towards refusal at a public inquiry by the local disruption due to a linking taxiway and the consequent ground noise and emissions impacts between the new runway and the main site, rather than accepting the operational restraints of a remote runway, but integrated passenger, operation. On the other hand, the Annex results also show that full compensation for the local direct environmental disbenefits associated with a full length runway amount to only some £2 per passenger. Only a lengthy and complex analysis by the industry could clarify the values they would attach to these choices. Unfortunately, there is no equivalently comprehensive and accurate way of valuing the wider environmental and economic consequences of the choices prior to the acid test of a public inquiry and the subsequent ministerial decision. Any earlier feedback to the industry of the likely reception of the options could only be obtained from an early and ongoing discussion with environmentalists, planners and decision-makers.
FIGURE 11.4: CUMULATIVE PERCENTAGE OF DEPARTURES PER WEEK AT HEATHROW

FIGURE 11.5: EFFECT OF RUNWAY LENGTH ON RANGE
In any such discussions, the industry could help its own case by enhancing the benefits of Reduced Take-off and Landing (RTOL) capability. The advent of high bypass engines has allowed Stage III aircraft not only to have low noise but also to move towards RTOL performance. A natural consequence of RTOL is slower flight, allowing steeper approach paths. It would take few modifications to any Stage III twin-engined aircraft to allow it to approach at four degrees rather than three degrees, at the weights appropriate for the short fields and short sectors envisaged in the above discussion. This would reduce the Leq footprint areas from a 1,600 metre runway by between 15 and 20 per cent.

It is entirely possible that a combination of improved RTOL with new approach aids could allow steeper approach and climb-out, so offering the type of improvements which are being proposed for Stage III and a half regulations. Perhaps more importantly, the noise of the larger aircraft could be reduced in this manner, so allowing them to meet Stage 3 plus certification requirements and single event noise limits. Only detailed research can verify these suggestions. Any such benefits would apply to shorter runway operations at any chosen site, in a similar way to the Heathrow example, but the adoption of the concept at Heathrow would provide a 'champion' demonstration of the synergistic benefits which the industry could not ignore as easily as it can the example of London City Airport.

If a full societal evaluation showed it to be the best solution, advanced short take-off technology already exists in the Circulation Control wing (Englar et al, 1984), which is capable of limiting environmental impact almost entirely within conventional airport boundaries (Albers and Zuk, 1988).

**Aviation Weaknesses**

Aviation's principal weaknesses appear to be its image and its ultimate reliance on portable energy. The question of image arises from concerns of lack of access by the poor, heavy use of scarce resources, safety, and lack of concern
for environmental damage. Most of these questions are best tackled by public, and self, education via EIA exercises, including economic and social spin-offs. The evaluation may well show that portable energy is not less efficient, nor more polluting than piped energy, though the high altitude emissions will remain a difficult area. Aviation will have to conform to the acceptable face of liberalised capitalism.

There are grounds for believing that non-aviation interests have already succeeded in some degree of regulatory capture. The EC appears to have adopted a far-from-level playing field in assessing air against rail (EC, 1992a; EC, 1992b), which the aviation industry is attempting belatedly to correct (AACI, 1992b), as evidenced by Figure 11.6. The EC had only taken a B 727 as an indication of aviation fuel efficiency, with no account of the other modes' circuity, primary energy consumption, energy for track construction, land take and spoil disposal or the variability in comparative results depending on the route length, route density or terrain considered. For example, Figure 11.7 suggests that aviation costs rise less rapidly than do those of ground-based modes as route length and density fall (Caves, 1976). Reports from the EC's consultants seem similarly to claim rail benefits as though air did not exist, ie "These opportunities, or accessibility benefits, are generated from two principal sources:

- a reduction in journey times, particularly below certain critical thresholds and
- the linking of population centres within a single high speed rail network"

and also "smaller cities are not so well served by air, with few and infrequent flights, whereas high speed rail would provide a minimum two hour service frequency". In fact, using hubbing, a huge number of small city pairs are already connected by air, and liberalisation will bring many more into the network. Frequency is less important than timing for day-return capability, as the consultants themselves admit. Also, it is one thing to be on a rail network, but quite another to have direct intercity service available, and
FIGURE 11.6: MODAL COMPARISON OF FUEL EFFICIENCY

<table>
<thead>
<tr>
<th>Mode</th>
<th>Total seating capacity per unit</th>
<th>Energy use</th>
<th>Final energy per 100 km</th>
<th>In MJ primary energy/vehicle km</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gasoline car</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 1.4</td>
<td>4</td>
<td></td>
<td>7.5.</td>
<td>2.51</td>
</tr>
<tr>
<td>1.4 - 2.0</td>
<td>4</td>
<td></td>
<td>8.5.</td>
<td>2.98</td>
</tr>
<tr>
<td>&gt; 2.0</td>
<td>4</td>
<td></td>
<td>13.4.</td>
<td>4.65</td>
</tr>
<tr>
<td>2. Diesel car</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 1.4</td>
<td>4</td>
<td></td>
<td>5.9.</td>
<td>2.25</td>
</tr>
<tr>
<td>1.4 - 2.0</td>
<td>4</td>
<td></td>
<td>7.2.</td>
<td>2.76</td>
</tr>
<tr>
<td>&gt; 2.0</td>
<td>4</td>
<td></td>
<td>9.6.</td>
<td>3.65</td>
</tr>
<tr>
<td>3. Railways</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercity</td>
<td>563</td>
<td></td>
<td>1,527.7 kwh</td>
<td>160.9</td>
</tr>
<tr>
<td>Super sprinter</td>
<td>147</td>
<td></td>
<td>459.6 kwh</td>
<td>48.4</td>
</tr>
<tr>
<td>Suburban electrical line</td>
<td>300</td>
<td></td>
<td>749.1 kwh (249.7)</td>
<td>78.9</td>
</tr>
<tr>
<td>High speed train 300 km/h</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>type: Brussels-Paris</td>
<td>375</td>
<td></td>
<td>2,500 kwh (832)</td>
<td>268.65</td>
</tr>
<tr>
<td>High speed train 300 km/h</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>type: London-Paris</td>
<td>700</td>
<td></td>
<td>4,150 kwh (1383)</td>
<td>437.08</td>
</tr>
<tr>
<td>High speed train 250 km/h</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>type: ICE-Germany</td>
<td>650</td>
<td></td>
<td></td>
<td>=340.00</td>
</tr>
<tr>
<td>4. Bus/car</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double decker</td>
<td>100</td>
<td></td>
<td>45.8</td>
<td>17.40</td>
</tr>
<tr>
<td>Bus</td>
<td>48</td>
<td></td>
<td>36.7</td>
<td>14.02</td>
</tr>
<tr>
<td>Minibus</td>
<td>20</td>
<td></td>
<td>18.5</td>
<td>7.08</td>
</tr>
<tr>
<td>Express car</td>
<td>46</td>
<td></td>
<td>29.9</td>
<td>11.43</td>
</tr>
<tr>
<td>5. Air</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A 320-200) Distance 773 km</td>
<td>134</td>
<td></td>
<td>509.2</td>
<td>178.88</td>
</tr>
<tr>
<td>A 321-100) = Hamburg-Munich</td>
<td>167</td>
<td></td>
<td>604.8</td>
<td>207.24</td>
</tr>
<tr>
<td>B 767-300</td>
<td>269</td>
<td></td>
<td>852.7</td>
<td>292.15</td>
</tr>
<tr>
<td>Boeing 727 Distance?</td>
<td>167</td>
<td></td>
<td>760.7</td>
<td>242.82</td>
</tr>
<tr>
<td>6. “Soft” transport</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cycling</td>
<td></td>
<td></td>
<td></td>
<td>0.06</td>
</tr>
<tr>
<td>Walking</td>
<td></td>
<td></td>
<td></td>
<td>0.16</td>
</tr>
</tbody>
</table>

Source: AACI, 1992b
FIGURE 11.7: MODAL COMPARISON OF OPERATING COSTS

Source: Caves 1976
many people do not wish to travel from city centre to city centre. Further, it is possible to argue with the assumption that it is easier to achieve a longer productive day with a train journey because of the greater ease of working during the trip, both on grounds of shorter travel time and reduced check-in times for air in a single market. Yet the EC has been advised that these 'new' factors in cost-benefit analysis are at least as great as the conventionally accounted savings in travel time and operating cost (Allport and Brown, 1993). Similar distortions also exist in the comparison of emissions and noise.

The actual safety record of aviation is already good enough for assessors to argue that a modal switch to road incurs a safety cost for passengers, but it is also possible to argue that a switch to rail incurs safety benefits over aviation. Only a concentrated commitment to further improvements in air safety can counter this situation.

The fatalities per flight and per passenger km continue to fall, and there is no evidence that deregulation has had an adverse effect on these trends. The total numbers of passengers killed per year remains constant. Despite the percentage survival rate from a fatal accident showing a continued improvement, the use of ever larger aircraft must increase the possibility of a large number of people being killed at one time, which would result in public disquiet even if the fatalities per year remain constant. Safety expectations appear to rise with income. The factors which tend to control the fatality rate per million flights are the airline and the culture of the world region where it is based, the size of the aircraft and the size of the airline (Caves, 1988b).

The EC regulators can take action to reduce the variation in safety between small and large carriers, to harmonise the standards throughout the EC and to set up a strong inspection and enforcement directorate. However, European flag carriers are already among the safest carriers in the world. Further improvements in safety can only come from a concerted effort by the operators to avoid accidents and increase the
probability of survival. This will require even greater emphasis on personnel selection, on training, on a safety culture and organisational structure, and on judicious spending to improve the infrastructure, the pilot/aircraft interface and the post-crash cabin environment. In this area of increasing the spend, the regulators' role is crucial, since competing airlines have not, since the 1930s, felt it wise to use safety as a marketing factor. There is, however, some evidence that consumers are beginning to require more safety information, and that they are prepared to pay for improved safety and security. Ultimately, of course, the market will be the judge, whether expressed through litigation, insurance or the airlines' share prices, but it would be prudent to take advance action so that the market's judgement remains favourable.

Air's third party safety record is superior to almost all other modes, but the Amsterdam accident will force a reassessment of this issue. Table 11.2 shows a theoretical analysis of third party risk at a representative UK airport with four million passengers per year. The present risk of ground fatalities is of the order of one in 250 years. It is likely to be much worse at larger cities with more traffic in larger aircraft.

Aviation Opportunities

The main market opportunities appear to be the development of direct services in long haul and in low density short haul settings. In these cases, the economic and social benefits can be demonstrated. Some of the less contentious ones are the maintenance of ethnic links, promotion of tourism, and the value of time saved (perhaps the most precious of all resources for the individual), given the preference for direct flights with adequate frequency (Ndoh, Pitfield and Caves, 1990). Hubbing, on the other hand, can easily (though perhaps not correctly) be seen to be socially divisive (Caves, 1992d).

The main opportunity to improve the mode's effectiveness in dealing with physical and environmental capacity may be to
TABLE 11.2: NOTIONAL THIRD PARTY RISK CALCULATION

<table>
<thead>
<tr>
<th>Distance from threshold (km)</th>
<th>PSZ</th>
<th>1.37-3</th>
<th>3-80</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accidents per 10 million movements</td>
<td>1.54</td>
<td>0.46</td>
<td>1.0</td>
</tr>
<tr>
<td>Residents per zone</td>
<td>20</td>
<td>7,000</td>
<td>700,000</td>
</tr>
<tr>
<td>Persons per hectare</td>
<td>N/A</td>
<td>21</td>
<td>8.0</td>
</tr>
<tr>
<td>Persons affected per 767 crash</td>
<td>N/A</td>
<td>10.5</td>
<td>4.0</td>
</tr>
<tr>
<td>Persons killed per 767 crash</td>
<td>N/A</td>
<td>5.25</td>
<td>2.0</td>
</tr>
<tr>
<td>Risk of 767 crash per year (x 10^-4)</td>
<td>N/A</td>
<td>1.84</td>
<td>4.0</td>
</tr>
<tr>
<td>Risk of fatality per year from 767</td>
<td>N/A</td>
<td>9.66</td>
<td>8.0</td>
</tr>
</tbody>
</table>

Assumptions

1. 767 crash site occupies 0.5 hectares.
2. The death rate among affected persons is 50 per cent.
3. 4,000 767 movements per year.

N.B.
Tower blocks could be incorporated by presuming that they throw a shadow onto the ground plane equivalent to 50 times their height. If a block forces the adoption of a dispaced threshold, its upper floors must be presumed to be at PSZ risk levels (PSZ is a declared Public Safety Zone).
readjust the relationship of the aircraft to the infrastructure by tending towards RTOL/STOL performance, as indicated above. In the first instance this could be introduced with modifications to conventional turbofan aircraft, later versions economising on planform area by adopting fan-powered augmented lift technology. These developments could only be obtained at some cost, but these costs will in any case increasingly be imposed on the industry in one way or another.

Aviation Threats

The main threats, other than capacity capping induced by noise and emission impacts, are competition from rail and telecommunications. The Head of the European Commission's Airport Policy Unit in DG VII wants to see the environmental capacity problem alleviated by a shift from air to rail (AACI, 1992b). High speed rail will certainly reduce air traffic on dense short haul routes, if the TGV experience (Bonnafous, 1991) and US transport models (Gomez-Ibanez and Pickrell, 1987) are good general indicators, assuming approximately equal factor input prices and return on investment. Airbus Industrie suggests that a one hour advantage increases market share by 20 per cent (Reed, 1990). Rail will, however, find it difficult to compete with air on thinner and indirect routes, while, on the routes where it does compete well, it can serve to reduce the strain on air capacity.

As for telecommunications, it is generally accepted that, over short haul distances, any substitution effects are compensated by stimulation of travel (Salomon, 1986), though there is some evidence that teleconferences obtain 11 per cent substitution and only 1 per cent stimulation (Khan, 1987). Any suggestion that the wider use of advanced telecommunications will prove to be a more effective way of equalising the spatial distribution of settlements than aviation appears to be groundless (Nijkamp and Salomon, 1989; Robins and Hepworth, 1988; Goddard and Gillespie, 1986).

The future threat from telecommunications is more likely to
affect long haul air travel. Leaving aside all thoughts that virtual reality may compete with actual experience of tourism, the differential advantages of teleconferencing must be greater at long distances, particularly with the falling prices as the large capacity of fibre optic cables comes on stream (Khan, 1987). Already, with only conventional telephones, the traffic between the USA and Europe and between the USA and the Far East has grown by 23 per cent and 27 per cent respectively on an annual basis since 1970 (Owen, 1991). Video conferencing may not yet have grown up as quickly but this can be explained by the network externality problem ie that the usefulness only becomes realised when sufficient users exist (Maggi, 1992). This is one area where technology may improve more quickly than in aviation, while the lower telecommunication fuel consumption will also exacerbate the price differentials as well as avoiding high altitude pollution. The danger for aviation would be that a relatively small impact on the high yield business market might exert a pressure for increased fares in the highly elastic leisure market. However, social and economic benefits of aviation would still exist, even if in smaller quantities.

CONCLUSION

Aviation holds a legitimate place in today's socio-economy. The balance is now struck uneasily between the users and those suffering from the environmental costs. Aviation has done much to reduce its pollution, but still retains the image of being reluctant to meet its commitments to global 'good housekeeping' policies. Inevitably, it will be asked to do more to tip the scales away from the user and towards the environment.

Aviation can help itself to balance the scales in a culture of full social cost recovery by:

- adopting non-confronting tactics in agreeing policies for ameliorating environmental disbenefits
- carrying out in-depth evaluation studies over the full range of social and economic issues to
compare its capabilities against a range of planning policy factors

- developing novel managerial and technological solutions to the problems which emerge from the evaluations

- educating policy makers and the public to the positive results of the evaluations and the effort going into beneficial technological change

- expanding marketing in those areas where it has strong natural advantages

- being prepared to withdraw from those areas which give rise to the highest social costs for the least system benefit.

Thus it should be possible to achieve a 'win-win' situation where aviation can continue to expand while creating incremental benefits greater than incremental costs.
CHAPTER 12: A FRAMEWORK FOR PARTICIPATIVE PLANNING

THE PRESENT FRAMEWORK

The planning process as presently practised in the UK has been reviewed extensively in the Annex and in Chapter 9. It consists of two phases. The first is a technical evaluation internal to the air transport system of alternative developments, resulting in the choice of a preferred option. There is strong government involvement in the London area but only local interests are involved outside London. At this stage there is usually strong emphasis on the quantification of demand, but often this is not forecast much beyond the start date of the project. Relatively little consideration is given of the way in which the system will develop in order to reveal and to satisfy that demand i.e. in terms of airline strategies; international agreements; technological developments; the nature and effect of airline and airport competition. There is often only a very rudimentary attempt to allow for the possible difficulties which might arise in the second phase.

The second phase consists of an application for a change of land use to accommodate only this preferred development. The Secretary of State (SoS) calls the request in to a public inquiry, the alternative course of action being to introduce a Private Member's Bill to the House of Commons. Given BAA's and British Rail's experience with this method for the Paddington-Heathrow rail link, any advantages over a public inquiry are questionable. Eventually, the inquiry inspector makes recommendations to the SoS, and, usually after a further year's delay, the SoS will give a ruling. The ruling, if in favour, is almost always hedged around by constraints on capacity and methods of operation.

Investments in air traffic control systems do not have significant land use implications, so the adequacy of the NATS response is only monitored by industry pressure (not well known for long term planning) and the attentions of
Select Committees and the Monopolies and Mergers Commission.

It is not possible to judge the efficiency of the processes in terms of the balance that results between national and local interests or between the industry and the non-users. It is not even possible to judge how much better off the industry would be if the balance had been struck more in favour of expanded capacity, bearing in mind that, if there is no capacity constraint, the market should settle theoretically at zero economic rent (Brander and Cook, 1986). It is precisely the inability to answer these and similar questions that suggests that the systems approach, ie a simultaneous appreciation of all the system elements and their interactions, might be at least a useful adjunct to the process, even if the attempted application of it were to confirm that the only feasible process is one of disjointed incrementalism practising the art of the possible and so aiding the identification of what it is possible to get.

AN AVIATION INFRASTRUCTURE FORUM

It was suggested in Chapter 11 that air transport policy should derive from a full societal evaluation, incorporating the transparent involvement of all affected parties in a cooperative search for solutions, suggested by planning theory as being appropriate for turbulent and high risk settings. If the societal evaluation and the systems analysis approaches were to be adopted, a very different framework for planning and decision making would be needed. Firstly, a permanently appointed body, called, let us say, the Aviation Infrastructure Forum (AIF) would be needed to define the system being managed, to set up the methods for generating goals for the system, to collect information pertinent to the system's planning, to monitor the achievement of the goals and the continuing validity of the assumptions underlying the policies themselves (Masser, 1987), and to give early identification of the need for change. The previous airport policy review (HMSO 1985) promised that two standing committees would be set up, one for London airports and the other for the regions, to provide this sort of monitoring. Until the recent round of deliberations in response to the
CAA's advice (CAA, 1990b), the published actions of these bodies have been perfunctory. The London committee has undergone a metamorphosis into a task force (RUCATSE) with six sub-committees, to consider some of the broader issues not included within the CAA brief in its search for new runway capacity. Real adherence to the principle of monitoring, with the biennial production of a rolling plan as required of the FAA, would provide an earlier alert to problems, and tighter control of their resolution.

The AIF would have to have a sufficiently wide field of influence to include all those factors which have a major impact on the airport system, without overlapping too much with any other similar bodies which may be formed. Its appreciation of the interconnectedness of the system would have to extend at least to a number of concerned bodies and organisations, and it would have to embrace a wide range of specialisms and concepts. The system boundary should include all UK airports and the major European airports, as the Dutch have done in considering Schiphol's future development. The specialisms should include:

- the UK and European planning and decision processes;
- worldwide demand forecasting for passengers and freight;
- the understanding of passenger utility maximisation;
- worldwide airline strategy;
- technological forecasting of the vehicle and the ATC hardware.

Conceptual methodologies should be developed to consider formally:

- the balance between environmental nuisance and user benefit;
- the balance between national and local economic benefit and the cost of expansion of the system;
- the acceptable delay and its distribution within the system;
- the role of scarce resources;
- the consequences of changes in technology.
It should have the means to commission research in those areas where more information is considered necessary. It must also identify and maintain the necessary links with those other bodies whose decisions influence the air transport system, eg road, BR, regional planning tourist boards.

The AIF would be responsible for drawing together goals for the system, for interpreting them as objectives and for developing performance indicators with criteria against which to measure the success of the system. The relevance of the objectives and the criteria themselves should be monitored. These are the most important part of any systems analysis, and where public participation is most vital in a participative democratic society. It would therefore be necessary for the body's deliberations and their outcome to be available to the public in some disciplined manner, probably following Select Committee practice, even though there be also formal representation through organisations representing user and non-user interests.

It would also be a responsibility of the AIF to ensure that projects offered for entry to an evaluation process be realistic: this implies that some preliminary facility planning be performed. It would then rehearse the evaluation which would eventually be performed in a public inquiry. The AIF would formally select the most appropriate evaluation methodology in the light of the its defined responsibility. In doing so, it should bear in mind that evaluation methods which involve public participation call for interactive evaluation reflecting individual's perceptions of their problems, their goal preferences and the alternatives available: the methods should not, therefore, simply be borrowed from those developed for non-participatory planning (Hill, 1986). The AIF should then apply the methodology to all offered projects and to those generated internally by the body. This would not be to preempt the subsequent inquiry but rather, to educate it, to shorten it, to attempt to account for wider national issues prior to the local debate, to ensure adequate quality of information, to provide a forum for 'out of court' settlements. Despite all these inputs
which the AIF could make, its primary value would rest in its role as a forum for informed debate, in which it would offer the best opportunity for cooperation and consensus. In other words, it would allow the adoption of Checkland’s soft system methodology (Khisty, 1993), orchestrating a process of learning, recognizing, the differing world views of the actors and that all the possible accounts of the human activity system are valid: there is no single ‘testable’ account. The recent initiative between IATA, the AACI and the environmental lobby to generate a methodology to determine a reasonable level of noise nuisance for a given user benefit (Logan, 1990) is seen as a prototype for this sort of activity. Other prototypes might be the agreement between the developers of London City Airport and the owners of other property developments in Docklands prior to the formal planning Inquiry, the mediation procedure which is being used at some US airports to resolve conflicts between noise nuisance and airport capacity (Johnson, 1989); the appointment by Austin City Council of an Airport Advisory Board of 11 citizens and a Citizens’ Conversion Task Force representing a cross-section of the city (Austin, 1991) and also the example of the airport research foundation coordinated by the city of Nagoya for the development of a new airport (Knibb, 1991). It is to be hoped that the discussions in the AIF would be able to move from conflict, through a compromise stage to a new high ground of ‘integrative’ solutions: this type of solution, by changing the way in which the situation is regarded and valued, has the characteristics of commanding the assent of all the participants (Vickers, 1965).

A simulation of debate is proposed, to test the validity of the AIF concept. An important aspect of the simulation would be the representation of power relationships and strategies. This is not entirely original. A ‘mock’ negotiation between the US and the EC was held in the International Institute of Air and Space Law at Leiden to study bilateral politics (Feldman, 1992). Some long time ago an elaborate simulation was performed by the State of Connecticut with teams representing legislators and evaluators (the latter representing society at large); one set of legislators
attempted to optimise Connecticut quality of life, the other
to maximize State per capita income.

Perhaps the most fruitful of these simulated 'game'
approaches (not to be confused with programmed 'game'
methods, eg of the n-player, noncooperative, maximum pay-off
type used by Hansen (1990)) is the MACTOR method (Godet,
1991). This has been used by both the Paris Airport
Authority and the French Electricity Authority to examine
future strategies. It focuses on the analysis of the balance
of power between the actors, in terms of constraints and
means of action. A realistic view of each actor's potential
strategies is obtained by synthesising them from other
actors' views of the others' strengths and weaknesses. In
particular, each actor's prioritization of objectives is
identified and used to determine the significance of
alliances and the potential for adopting particular tactics.
The MACTOR method does, however, stop short of presuming that
concensus is possible, except by deferring to dominance.

Attendance at the AIF would be voluntary, but would not
necessarily lose its value if there were some absentees. The
same simulation technique which is proposed for testing the
principle of the AIF could be used in the real situation to
fill in the roles of absentee actors.

A combination of MACTOR with other conciliation methods may
be more desirable; several methods have been suggested in the
literature for taking full account of social information
(Wilson and Neff, 1983). A particularly promising one is
Social Information Generation (SIG). It is claimed that the
public, when involved in a SIG, feel that the activity is
meaningful and important to them, as well as being acceptable
and understandable. Using small group discussion, with
feedforward of information on the known implications of
changes of technology, the group members help each other in a
peer situation to generate information which it would be
difficult to produce in any other way. If necessary, the
results can be recycled with further feedforward of
information, leading to a gradual change induced by education
rather than a perceived revolution.
As described here, the AIF would complement the strengths of private enterprise, rather than supplanting or stifling it. It would do this by making the planning methodology more transparent for decisions of national interest, and by easing the path through that process for worthwhile projects. In particular, it should help to avoid the dilution during the passage through the clearance points of projects deemed to be of the appropriate scale, thus helping to ensure maximum benefit from that which is possible.

This would reduce the risk element in the larger problem that privatised suppliers of transport infrastructure may have inadequate incentives to invest: the other elements are monopoly regulation and the difficulty of charging efficient short run prices (Helen and Thompson, 1991). It would, of course, be possible to by-pass AIF and go directly to enquiry if that were judged to be in a projects' interest. However, it would allow the terms of reference for the inquiry stage to be set by consensus rather than by the same authority (the government) which will take the final decision (Farrington, 1984). In contrast, the expert-oriented RUCATSE first phase may shorten the subsequent inquiry (Sunderland, 1992), but is unlikely to reduce the later confrontation with local and national environmental lobbies.

Finally, planning is inexpensive compared not only to the ultimate project cost but also to the cost to the nation of wrong decisions: the ongoing project/planning cost ratio could easily be of the order of 200:1, in which case it is a very good buy if it improves the resulting system by one percent. An even greater cost might be avoided if participative strategic planning served as a warning that, at some future date, the marginal returns from the development of the present system reduce to zero, so pointing to an alternative method of proceeding which would have been identified by the correct application of systems analysis to the longer term state. The greatest danger of the continual application of disjointed incrementalism is that it is necessarily short sighted and could easily direct the user into a blind alley.
CONCLUSION

The UK air transport infrastructure planning has been examined by learning from the present state of the system and adapting advances in planning theory appropriate for the context in accordance with Schon's preference for an existential approach as explained in Chapter 9, pages 270 and 271. It is concluded that, in this liberal and private enterprise setting, many mistakes could have been avoided by adopting a 'shadow planning' forum which would formalise the actual process and, as it were, simulate it in advance of the 'real time' events. It would also provide an open forum where balances would be weighed, cheques would be written and the limits of what could be obtained would be explored. The onus would be on the forum to select appropriate techniques to achieve each stage of the simulation, having, by its makeup, access to all the latest techniques from goal description through to system monitoring. It would put extra research out to tender where it was considered appropriate to gather more information. It would be open to some disciplined form of public participation. Most importantly, it is seen as a tool for the service of the private enterprise infrastructure industry, rather than an attempt to further centralise planning, in an era when even those closest to the decision process have achieved only very diluted permission for their projects through the public inquiry process.

If the existential stance is retained, it is not theoretically possible to transfer the UK learning process to the EC, similar though its liberalised setting may be to the EC's intended state. However, the paper has identified some pointers which may help to counterbalance the industry's pessimism as evidenced by the outgoing chairman of the CAA, who recently predicted that the European mould of infrastructure inadequacy and government interest in airlines is not going to be broken (Tugendhat, 1991).

The Air Transport Directorate of the Transport Commission is already showing more interest in the provision of infrastructure capacity than many of the individual nations.
It is a strong candidate to host an EC version of the proposed UK forum with similar responsibilities and with a similar information-providing role. Its first task would be to design and describe the processes whereby the EC will involve itself in the area. To be effective, the processes will need to be set up in a way which will allow their effects to be monitored. The same benefits of self-learning should accrue from the discipline of systems analysis and from the simulation of the clearance points of the planning process.

The main difficulty in adapting the suggested improvements in UK planning to the EC is that most member states have their own systems of planning. The appropriate methodologies would also be different in each state, particularly if the pessimists have their way. The first area to require attention is this complex one of the relation between each country's planning law and the EC's power to control adequate intra-state infrastructure.

The next step in the development of an improved planning process in the UK may be to use a genuine multidisciplinary forum to construct an inventory of the techniques available to perform each stage of systems planning, rather than the notional attempt made here. This, together with an assessment of their relative strengths and weaknesses, should provide the essential platform for the first debates of the proposed forum.

The process into which these techniques would fit should also be simulated dynamically, with its clearance points and its lags, so that the design of the 'shadow planning' methodology can be made to avoid resonance with the 'real' system.
CHAPTER 13: CONCLUSIONS

FINDINGS

Within the jet aircraft era, air transport in the western world has moved from being a highly regulated industry valued for its economic and social functions to being a largely unprotected, competitive and privatised industry faced with pressing capacity problems. The problems arise from shortage of airspace and land for airports, and also from hardening attitudes of the environmental lobbies.

Airport entrepreneurs now face increased risk due to uncertainties arising from

- the behaviour of airlines and their users in a liberalised and competitive setting

- the capacity and cost implications of environmental protection

- the unpredictable results of the airport planning process.

However, the more the industry competes and planning is discarded and collusion is frowned on, the more the consequent adoption of fragmental planning will require enormous insurance policies as well as resulting in inefficient competition for scarce resources. This wide-ranging review of airport system planning has demonstrated that some form of voluntary collusion together with concerted efforts to further understand the actors and their interrelations could complement the 'relaxation' achieved by liberalisation and privatisation to produce an appropriate path to a sustainable future aviation infrastructure. It has been suggested that these risks be covered by planning to provide insurance policies (de Neufville, 1990). The uncertainties, and their consequences for the inefficiency of planning are illustrated by the appended comprehensive case study of the UK airport planning process, particularly in relation to the provision of runway capacity in the London
area. Difficulties associated with the satisfaction of airlines' needs, with the lack of a total system approach, with the need to judge the acceptable balance between environmental impact and societal benefit, and with the inability of the present planning process to lead to appropriate implementation are all highlighted.

The case study concludes that a broader systems analysis of the London area airports would allow a more appropriate solution than those apparently preferred by the government. A possible solution developed in the case study is an extra short runway at Heathrow. This might be judged by a political decision maker to offer an appropriate balance between the interests of the UK, the local and regional communities, the users, the airlines, the airports and the environmentalists. The consequences of a longer third runway are also investigated for comparison, the indication being that the local environmental costs would be small compared with the likely benefits to the airlines. The case study also draws the conclusion that the framework for airport planning needs to be changed so that the ground rules are known, the decision processes are transparent and the final result bears a strong resemblance to the project as planned.

These conclusions are taken as hypotheses to be subjected to a more theoretical analysis in the body of the thesis. Part 1 develops the context for the study, reviewing air transport systems and their planning in a liberalised and privatised setting. Comparisons of air transport system and their planning shows the extreme range of methodologies employed, their relationship to their setting and the generally poor record of plan implementation.

Then the development of liberalisation in Europe is described, together with the development of networks and the changes in revealed demand. The intentions of the EC liberal regulators are compared with the preliminary out-turns. It is found that very few of the expected benefits of liberalisation have so far been forthcoming. There has been little real competition between airlines, probably because of lack of capacity at Europe's premier airport ie Heathrow, as
indicated in the case study.

The broader systems approach is then applied to a liberalised setting in Part II by examining in turn the make-up of the important actors and their preferences. Frameworks for planning are also examined, particularly in the areas of evaluation, participation and decision processes.

The examination of passenger behaviour using discrete choice logit models based on surveys shows that passengers appear to have strong preferences for airports close to their ultimate trip origin, and for direct flights. Trade-offs can be made between access and direct flights on the one hand and frequency on the other hand, depending on trip purpose. Very high frequencies are necessary on indirect flights if a significant share of passengers is to be captured. Lower fares available at or through hubs, which may not be purely cost-related, are shown in the US to greatly modify this behaviour, but it is not currently possible to include fares accurately in analyses of European air passengers. This behaviour is also distorted in the case of a small airport in the shadow of a major airport: a much higher frequency and lower fare appears to be necessary at the smaller airport if it is to draw more than purely local traffic.

Airlines are seen to have cost structures which favour increased concentration and density of service. Hubbing appears to achieve these characteristics but, more importantly, allows domination of local markets and other marketing advantages which deny any significant contestability for its traffic. Freedoms which come from liberalisation are likely to reinforce the fortress hubs which already exist, resulting in powerful local monopolies and oligopoly on a European scale. This may not be compatible with passengers' preferences. Airports in the shadow of major hubs will find it difficult to convince an airline based at the major airport to fragment service by serving both airports, unless it needs to defend its market share.

The balance between environmental impact and the benefits of
Air service which flow to users and communities has become a rather standardised battlefield. Many of the commonly quoted economic benefits are seen to be of dubious veracity and unlikely to impress an independent decision-maker, though further research may show genuine causative effects of supply on demand and economic activity. The advantages of air transport accessibility for communities require much more detailed research. Meanwhile, there are other wider societal benefits which are overlooked, perhaps due to the difficulty of including them convincingly in evaluation exercises. Many of the disbenefits are of real concern. The impact on the local community may lead to capacity capping or financial penalties, in order to control noise and emissions. Society at large is likely to levy taxes to control acid rain and greenhouse emissions, as well as harmonising noise impact through legislation. There are strong implications in these policies for the size and distribution of demand, as well as for competition between airports.

Aircraft technology has been able to ease some of the environmental worries, both on communities around airports and in the wider debate about pollution and energy, partly through the inherently better airfield performance of Stage III aircraft. Also, increasing aircraft size has been able to allow traffic to grow despite limitations on runway capacity, but this will negate the frequency competition from which the benefits of competition are supposed to flow. It is likely that, as in the past, it will require a radical change in technology to cope with the competition-driven need for frequency in an era of scarce physical and environmental capacity.

Airports exhibit very strong economies of density and scale. Thus, although it is possible to be profitable with less than a million passengers per year, there is a strong incentive to increase the throughput of passengers and freight; this tendency being reinforced by the requirement under privatisation to please the shareholders. However, it is important, especially under a privatised regime, to ensure that management retain control of the expansion, even where economic rents can be forced up by keeping capacity scarce.
This is difficult if reliance is placed on the forecasting of traffic and then satisfying the predicted demand. In a liberalised setting, it has been shown that revealed demand results from a subtle blend of consumers' desires and airlines' strategies. It is necessary to take a realistic view of an airport's appropriate role in the total transport system, bearing community costs and benefits in mind as well as the airport's balance sheet and the needs of its users.

Commonly used methods of evaluation and decision-taking are shown to lead to inefficiencies in the implementation of appropriate capacity. In particular, the incrementalism and "partisan mutual adjustment" framework, which the case study shows to have been prevalent in UK airport planning, may neglect weak political groups, may limit consideration of alternatives, leads to partial solutions and tends to minimise changes of policy. Trends in planning theory are reviewed, as is the result of applying the theories both generally and in US airport planning. It is seen that turbulent free-market settings require very different planning frameworks from those which would be appropriate to more settled settings. The early participation of all relevant actors is important. There are methods available for resolving differences and creating win-win outcomes which have been used with some success in the US. The decision and implementation phases can only be predicted if the relative power of the actors and their prospects for forming alliances are given due attention. Techniques for reflecting these factors are identified.

Part III begins the process of developing improved methods to allow airport managements in particular, and air transport as an industry, to predict and control the pressures which form their setting. It also draws conclusions on which areas require more research before airports can properly define their appropriate role in the total system and proposes some research methodologies to cover these weaknesses.

Techniques are demonstrated for predicting traffic potential which blend the cost advantages, which accrue from deriving market shares of exogenously predicted national traffic with
the accuracy advantages of airport choice models applied to sub-regional traffic. The resulting predictions are crucially dependent on the supply decisions of the airlines. Some indications are given of likely developments of hubbing and competing services which can be used to assess the likelihood of an airline successfully developing networks at particular airports.

Major airport development requires societal, as well as local, approval. At the local level, the debate hinges on the economic advantages which might accrue from the project to counter the environmental disbenefits. Monetary compensation and mitigation measures may provide a partial solution to the purely local noise problem, particularly where there is a strong desire by airlines for development. There are, however, many other disbenefits to society to be weighed against the economic benefits to society. A methodology is presented which allows the causal nature of the relationship between supply and demand to be examined, so illuminating this crucial debate and indicating a degree of demand stimulation even in a developed country situation. The wider issues of national environmental and mobility policy imply an additional need for a wider-ranging and multicriteria assessment of air transport. This is particularly so, since acceptable political decisions usually are those which have synergistic benefits across a range of goals. A notional application of such a societal evaluation, recognizing explicitly the viewpoints of those who are not naturally supporters of aviation, indicates steps which aviation's managers could be taking to increase the mode's benefits at small extra cost. The case study highlights the type of action which might gain wider approval by encouraging the trend to short field performance, and which offer a gradual and low risk path to a high traffic future.

The development of fully justified policies, rather than notional ones suggested here, and their successful adoption requires a completely new planning and decision framework in a turbulent, free-market setting. There should be fewer clearance points. The more difficult accommodations should be made early in the process by much more open involvement of
all interested parties. There needs to be greater understanding of the decision rules, so that the risk is confined as much as possible to the normal commercial arena.

RECOMMENDATIONS

The steps taken during the study towards modelling passenger behaviour provide necessary tools for airport planners, but need much more development in the choice of variables and grass-root information on the decision mechanisms of passengers and how they might change.

More effort is needed to develop European versions of models of profit motivated airline decision processes.

The debate over the costs and benefits of air transport needs to be lifted onto a new plane which would be more relevant for political decision-makers, concentrating on alleviation of environmental costs and the quantification of any identifiably unique economic benefits of investment in aviation.

Aircraft technology has the ability to respond innovatively to ameliorate disbenefits, but this ability will only be tapped in response to legislation or to airlines' specifications which will have to be driven by financial considerations. The perceived need for new technology will turn on the comparison between the costs of change and the costs of environmental protection. Models for the minimisation of system costs are needed, which include the infrastructural and social costs facing the industry in the future. These might well be developed by combining economic analysis (Morrison, 1984) with aircraft design optimisation methods (Jenkinson, 1991).

The industry must play its part in evolving attitudes of conciliation and policy solutions which are perceived by society as tending to be more 'green' and appropriate. The policies will be more acceptable if they have synergistic benefits across a range of policy goals.
The necessary understanding of the goals and the ability of air transport's policies to contribute to their attainment can only be obtained by the introduction of a broad-based methodology for assessing policy alternatives, with adventurous exploration of alternative futures.

If airport planning, aided where possible by constructive industry-based policies, is to result in successful implementation, the uncertainties and delays of the traditional planning process must be avoided. This might be achieved by participation in a 'shadow' planning forum which would allow early participation by all actors, mutually agreed goals, explicit recognition of power structures, bargaining within an information-rich framework and the evolution of win-win solutions which it would be difficult for political decision-makers to overturn. The output would be a rolling plan which would be continually reviewed.

It is proposed that a voluntary Aviation Infrastructure Forum be instituted for this purpose. The intended function of the Forum would be to provide a 'shadow' of the real planning process, pre-empting as much of the process as possible by negotiation, mediation and bartering. The advantages would be speed, early compromise, the promotion of a 'self-care' philosophy and avoidance of wasteful competition. Organisation would be brought into what is otherwise likely to become uncoordinated decentralised planning, yet the essential 'hands-off' elements of the market force philosophy would be retained. Though there are dangers in totally open public debate, some structured form of public involvement is regarded as essential, since a future is only sustainable if society wants it. Possibly this form of self-care is too revolutionary for the industry to accept easily: in this sense, the confidential RUCATSE committees (Sunderland 1992) may be seen as a laudable step along the road to interactive, more open decision-making.

The RUCATSE committee is chaired from the Department of Transport. A future AIF would probably also have to be chaired by a government representative in order to avoid the problem of collusion.
The richness of the information depends on the continued development of the understanding of the characteristics of the actors and the linkages between them. The linkages exist in terms of substantive economic or physical effects and also in terms of power relationships. The latter should receive equal research attention if the iterative learning benefits of planning are to precede events.

The systemic approach to planning, with the need to agree goals and objectives, establish criteria and monitor achievement would provide an essential discipline to the Forum.

The EC should be encouraged to recognize the need for a systems study of the future of European aviation. This could build on the earlier OECD work (OECD, 1977), but consider the shape and extent of the future network under a variety of scenarios covering the implications of future policy options. Factors which need examining in the systemic methodology are:

- the accessibility needs of the UK regions as the EEC progressively centralises, and the ways in which the accessibility should be provided

- the ATC capacity needed to encourage regional links and to allow competition: airspace design requires a very long lead time; properly informed strategic planning should have been undertaken already

- the effects of an internationally agreed carbon tax and modal competition on demand

- airline strategic responses to competition and to the infrastructural limitations

- the value of aviation to regional, national and EEC economies

- the impact of aviation on the troposphere

- the establishment of Community goals for the environment,
for accessibility, for resource consumption; the testing of the air transport options against the goals.

It could soon be too late to institute the new start which some believe is needed in European aviation (Eggers, 1989), but for which no planning has yet been done because a systemic approach has not been taken. To this end, attention should be directed urgently to the opportunities and the threats of new technologies: the studies should not treat their impact as adjuncts to the present system, but assess their potential when the system has been re-optimised around them. Technology options assessed should include short take-off and landing (STOL), very large aircraft, advanced navigation concepts, closely separated runways, fuel-efficient aircraft, hydrogen-powered aircraft.

The purpose of the suggested UK AIF is the early resolution of conflict. There will also be conflicts at the EC level, particularly in the air transport relations with non EC countries. ‘The say of regions, communities and airport in the formulation and application of the external air policy is bound to increase’ (Wassenbergh 1991). An EC version of AIF would be an appropriate focus for the resolution of this conflict.

Strenuous efforts should be made to use the best available methods of predicting, not only traffic and airline behaviour, but also the technological, cultural and political settings, and the links between the settings and the airport users’ behaviour. Otherwise the planned system will always be inappropriate. Even the changes of transport policy are amenable to analysis via the understanding of power relationships between the force of circumstance and the establishment’s status quo (Starkie, 1987).
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ANNEX
"Success is: getting what you want, but happiness is: wanting what you get."
(Masefield, 1986)

INTRODUCTION

In terms of using the planning of its airports as the subject of a case study, the UK can be seen to be a special case in many ways. Internally, the centres of population are close-packed, leading to intense competition from good quality surface transport infrastructure and to competition between adjacent airports for services to common destinations. Many viable domestic routes and all international routes are over water. The growth in air travel has lagged behind the developments of good roads and the sensitivity to environmental pollution. The standard of living is low and growing slowly for a developed country, leading to a majority view that air travel is only for the rich. Regional planning goals, formulated at national level, have no complementary regional authority through which to implement them. The aerospace industry is an important employer and export earner. The regulating authority (CAA) is not charged specifically with encouraging the air mode.

There is a very strong international dimension to UK air transport. Only 7 per cent of the 70 billion passenger kilometres flown on UK scheduled airlines, and almost none of the 50 billion passenger kilometres flown on UK non-scheduled services, were flown domestically in 1989 (CAA, 1990b). Although 12 million out of a total of 60 million passengers uplifted by UK airlines were domestic, probably a half of these were flying to access (ie feeding) an international service. The total domestic air transport passengers represent less than 1 per cent of interurban passenger kilometres. Some 30 per cent of all domestic passengers at the London airports were feeding into the international services of UK and foreign airlines in 1987, of whom almost half were connecting to Europe and some 20 per cent were
connecting to North America (CAA, 1989b). Furthermore, foreign operators accounted for 30 per cent of the almost 100 million passengers handled at all UK airports in 1989 (CAA, 1990c), while just over half the passengers at Heathrow in 1987 were foreign (though only 30 per cent of Gatwick passengers and 10 per cent of Manchester passengers were foreign).

While there is a balance of international passengers between UK and foreign scheduled airlines, the same cannot be said for charter airlines, mainly because the UK does not seem to have the same attraction for Europeans that the combination of sun and snow have for UK residents.

Air transport, while becoming the preferred mode for business people at a much shorter trip length than leisure passengers (OECD, 1977), is predominantly used for non-business purposes. Even at Heathrow, with virtually no charter operations, some 60 per cent of both UK and foreign international passengers are non-business, almost half of whom are visiting friends and relatives (CAA, 1989b). On charter flights, virtually all the passengers are non-business: since approximately 85 per cent of charter passengers use UK airlines (CAA, 1990c), at least this proportion is likely to be UK citizens taking holidays abroad. Even on domestic flights, approximately a third of passengers are non-business.

The UK has more than twice the international terminal passengers per capita than France or Germany and four times that of Italy (DTp, 1991b). This reflects the historic world role of the UK, the presence of the English Channel and the ready availability of cheap holiday packages. Yet the annual 5 per cent growth matches that of other advanced countries. Within the UK industry, the distribution of traffic among airlines and among airports is very uneven: BA alone accounts for 60 per cent of the tonne-kilometres and is in the world's top five airlines. The group of airports owned by BAA accounts for 70 per cent of passengers handled at UK airports, Heathrow alone handling 40 per cent of the total. Even on a route-by-route basis the same pattern emerges.
Only four routes account for 40 per cent of domestic passengers and similarly four routes account for 20 per cent of international scheduled passengers, all from London. In contrast, 10 routes account for 20 per cent of charter passengers, four of the routes being from Manchester. Concentrations of this nature are very common everywhere except in the USA.

The regulation of the industry is as internationally based as is the traffic using the system. The industry's safety and security regulations and standards of infrastructure provision follow directly from the UK being a member of the International Civil Aviation Organisation (ICAO). If ICAO standards and recommended practices were not met, foreign airlines might refuse to enter UK airspace. The Civil Aviation Authority (CAA) not only ensures that UK standards meet or exceed these minima, but in fact contributes significantly to the formulation of the ICAO regulations. The CAA also played a major part in the formation of common European standards. Due to CAA expertise and industry conscientiousness, UK air transport has one of the best safety records in the aviation world. Similarly, minimum standards for aircraft environmental impact are set by ICAO, though the cumulative impact at any given airport is not legislated in the UK. An uneasy peace is maintained by compensating agreements between an airport operator and its neighbours and by the imposition of controls on the airlines' operations: in addition, the government can designate an interest in an airport and thus take powers to control the aircraft movements.

Economic regulation of UK international air transport is based mainly on separately negotiated bilateral agreements with other governments. While UK negotiators have, since the early 1980's, attempted to develop a liberal approach to the regulation of route access, fares and capacity along the lines indicated in the Civil Aviation Act of 1982 and now being taken for the post 1992 internal services of the EEC, the attitudes of other governments have meant that on most routes these factors remained subject to close control until 1993. The unregulated charter industry arose partly in
response to the requirement to balance scheduled capacity in an unbalanced market. Domestically, the CAA retains ultimate authority on route access and fares in order to protect thin routes and small operators against predatory action, while maintaining a liberal stance. Government control of the airlines' economic behaviour is now largely in the hands of the Monopolies and Mergers Commission (MMC) and the Office of Fair Trading (OFT), though it dictates the proportion of equity which can be in foreign hands.

Since the Airports Act of 1986 privatised BAA and required the majority of the airports owned by local authorities to be recognized as PLCs, there is also little central control of airport investment or planning. The CAA is required to monitor airport charges, as it does air fares, in an attempt to protect the consumer from any potential monopoly profits and to protect smaller independent airports from unfair competition through cross-subsidy within BAA.

The CAA itself, almost uniquely in the world, is required to be self-financing, not only in its regulatory duties but also in its provision of air traffic control. It therefore requires a 100 per cent cost recovery from the industry for any service it provides. Yet it is almost a monopoly provider, being subject to competition only in the training of air traffic controllers and the provision of air traffic services at airports.

These features make the UK different from other settings and, therefore, make it difficult to infer generalisations about specific airport policy in planning or operations. However, they do not similarly restrict the case study from the point of view of analysing the benefits of systems planning compared with isolated planning of market-force policies. They can be taken into the systems framework as specific statements of objectives or specific operating constraints.

The case study gives a brief historical perspective leading up to the formation of the Civil Aviation Authority in 1971, with its responsibility for recommending policies for the provision of airport capacity. It then offers a summary and
critique of the CAA's and the government's actions in the 1970s, when the industry was regulated and largely owned by national or local government. The critique is taken directly from a paper published in 1980 (Caves, 1980) with a view to comparing the shortfalls in planning identified in that regulated era with a similar summary and critique which follows later of the developments during the period from 1980 to the present day. The latter period saw the transition towards economic liberalisation and airport privatisation, though neither transition has been completed.

The case study traces the planning actions of the CAA during this transitional period. The main focus is seen to shift from a UK-wide concern in the 1970s to a preoccupation with the problems of providing adequate capacity in the London area in the succeeding decade. An independent analysis of the options available for expanding capacity against imputed goals leads to a rather novel potential solution. The solution is used to highlight the balance of judgements required between the benefits to the user and the environmental costs to the community, as well as the need for a new framework for planning and new planning skills.

HISTORICAL CONTEXT

Of the 133 airfields generally available for civil use in 1980, 50 per cent had runways longer than 4000 ft. This is in complete contrast to France, where the comparable figure was only nine per cent out of 330 airfields covered by their plan, and the USA figure of 20 per cent. Whilst there are clearly other factors to be taken into account, the UK appears to be over-equipped with airfields to cater for short haul jet aircraft. The position in relation to Third Level and General Aviation (GA) is rather contradictory, in that there are only some 50 readily available licensed airfields under 4000 ft available (ie airfields more or less matched to their needs), whereas the many large airfields available tend to have better facilities than are required for this sort of operation.

This situation is the product of a long history of changing
views as to the importance of air transport and the ownership of airfields. It is also a product of standardised airfield building during the war with runways suitable for bombers (6000 ft) and for fighters (4500 ft). As early as 1929, the Air Ministry was encouraging towns to build their own airfields (Dyos and Aldcroft, 1974). In 1945, the government decided that all scheduled air service airfields should be owned and managed publicly because air travel should be within the reach of all and airports would not be profitable (HMSO, 1970). However, some private airfields provided scheduled services profitably and the Government gradually agreed to let other corporations retain ownership of their airfields. By 1955-56, the Estimates Committee was recommending that municipalities be encouraged to own and operate their own airports. This view was partially accepted by the Government, with the proviso that the State should continue to provide the airports forming the "vital" pattern of scheduled air services. However, by 1961, the Estimates Committee was worried by the lack of financial success of the London airports. The Government agreed with the Committee that these airports should be managed by an independent authority, which led directly to the birth of the British Airports Authority (BAA) under the Airports Authority Act of 1965. The BAA was to manage Heathrow, Gatwick, Stansted and Prestwick, providing necessary services for the development of air transport with efficiency, economy and safety. The BAA was to be a financially viable commercial undertaking. The Government intended that the other airports under its control should be handed over to municipal control where possible and that the remainder should come under a separate management agency.

1980 CRITIQUE OF 1970'S PLANNING

The beginning of planning

The historical perspective presented above is almost entirely a discussion of ownership which, with some exceptions in London and the Highlands and Islands of Scotland, has led to uncoordinated planning of a purely local nature. Appeals were made frequently for some cohesive national policy
planning (e.g. Doganis, 1967; Masefield, 1972). Most importantly, the individual airport managements were calling for such a policy, because they could not risk taking action on their long term plans if they were to be overtaken by future Government action and also because, where expansion was needed, they would welcome the powerful argument of a national plan. These arguments were coordinated in the evidence to the Edwards Committee in 1969, (Edwards, 1969) including a suggestion from the BAA of a plan based on four categories of airport (as seen in the French and USA plans) and a common administrative policy. Edwards summarised the objectives of a National Airports Plan as:-

1) to achieve a distribution of airports which will meet the need of economically viable or socially-supported air services in every part of the country, without wasting scarce resources in view of the large amounts of capital and areas of land required for airport development;

2) to prevent proliferation of airports serving the same traffic areas, and thus to strengthen the economics of the airports themselves, and to provide the basis for a stronger network of air services than would be possible if airlines served two or three airports where one would suffice;

3) to ensure greater coordination between airport development and the provision of air services so that investment decisions in neither field are made without the knowledge of decisions in the other;

4) to establish forward plans for meeting future requirements - particularly those arising from the rapidly changing operational characteristics of civil aircraft;

5) to coordinate airport development with the means of access to airports.

Edwards deals with the wider problems of the aviation system,
the transport system and the socio-economics by emphasising the role of the air services and the need to develop strict commercial competition between the modes; he also suggests that clear objectives for aviation need to be developed. Other recommendations he makes are:–

a) it is desirable to fit the ownership and management of airports to their function, ie - control should be by the “interested community”;

b) that the body set up to control routes should also control airport licensing and planning, and that it should work closely with the BAA and with the Regional Councils, Regional Boards and local authority airports, “since national planning should be built up from and in turn influence regional planning”.

The Civil Aviation Authority (CAA) was born directly out of these proposals by the Civil Aviation Act of 1971, under which it was given the duties:–

- to consider what aerodromes are in its opinion likely to be required from time to time in the UK in addition to or in place of or by way of alteration of existing aerodromes;

- to make recommendations to the Secretary of State for Trade and Industry arising out of its consideration of that matter.

Note that the CAA can only recommend policy, and then only in consultation with government bodies, ie - as Goodison (1973) says, it has “responsibility without power”.

The actions taken by the government and the recommendations made by the CAA between its inception in 1971 and 1978 in the field of airport planning are examined below. It will be seen that they stem almost entirely from the fundamental philosophy expressed in the Edwards Report with regard to:–

- the objectives of a National Airport Plan;
- the principle of "control" by the interested community;
- the liaison with regional planning.

Summary of 1970's policy planning

Detailed examinations of the government's actions are presented in the report from which this critique is drawn (Caves, 1979) and also Doganis, Pearson and Thompson (Doganis et al, 1978) in order to discuss the validity of cost-benefit analysis in airport planning. The issues of system analysis and cost-benefit analysis are similar, in that both are concerned with which factors to include and how to weight them: both also imply an understanding of the effect of these factors on the system. Doganis, Pearson and Thompson argue that the government's decisions, embodied in the White Paper (DoT, 1978) imply a rejection of cost-benefit analysis as too narrow and its replacement by a balanced judgement over a wider base. A systems approach would attempt to formalise both the factors and the judgements.

The recent policy planning initiatives are summarised in Table A1 in the context of their relevance to a system's approach. Reference should be made to the source report for detailed critiques of the evolution of the methodology and the framework. The table serves to point out the response of the CAA and the government, from an early attitude of laissez-faire planning, to continued pressure for a national level, multi-sector planning framework. Their approach has been characterised by its learning with hindsight and by the workman-like way in which it has grappled with problems to which there are not short or easy answers. The progress made during the 1970s is now discussed, to judge whether advantages might have accrued from the application of a more complete systems philosophy from the outset. The discussion deals first with the details of the method, and then turns to the framework.

Discussion of the method

The details of the method are not always pertinent to systems
<table>
<thead>
<tr>
<th>Report Description</th>
<th>Date</th>
<th>Conclusions</th>
<th>Comments</th>
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<tbody>
<tr>
<td>1. Airport Planning: an approach on a national basis, CAA.</td>
<td>1972</td>
<td>Use of national plan, as an overview to cover areas omitted from commissioned regional studies.</td>
<td>Rather cynical attitude to national planning, but identifies crucial question of balancing accessibility with airport viability.</td>
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<tr>
<td>2. Maplin: review of airport project, Dept. of Trade</td>
<td>1974</td>
<td>Maplin abandoned because access costs exceeded noise costs savings.</td>
<td>Some attempt to consider multi-sector effects, but confined to South East.</td>
</tr>
<tr>
<td>3. Airport strategy for Great Britain: Part I, the London airports, Dept. of Trade.</td>
<td>1975</td>
<td>Consultation document: Self-evident conclusion that diverting London-based traffic is nonsense.</td>
<td>National context limited to possibility of diverting London traffic to regions. No feedback of stimulated regional demand on the future state of demand in the London area. No indication of strategy after 1990, i.e. at the shortest lead time for a new airport.</td>
</tr>
<tr>
<td>4. Advice to the Secretary of State for Trade on airport development in the Central England Area, CAA.</td>
<td>1975</td>
<td>No new airports or closures. Manchester for long-haul and Birmingham for major short-haul international traffic.</td>
<td>No attempts at airports other than major hubs to justify laissez-faire policies, to consider how they may integrate with other air services and airports, or to consider whether their service role to their communities might justify subsidy.</td>
</tr>
<tr>
<td>5. Advice to the Secretary for Trade on airport development in the Northern Region, CAA.</td>
<td>1975</td>
<td>Natural growth at all airports with mute licensing protection of new services.</td>
<td>General philosophy of airport system stated in terms of functional categories and unstable nature of free competition. No national context; no consideration of domestic air service importance in multi-modal and multi-sector planning; no consideration of future aircraft technology, legislation on travel habits; no mechanism for public participation.</td>
</tr>
<tr>
<td>6. Airport development in South Wales and the S.W. Region of England, CAA.</td>
<td>1975</td>
<td>No economic justification for any airports in the study area.</td>
<td>No feedback of effect of implementing policy on forecasts at individual airports. Cargo treatment perfunctory. No attempt to coordinate policies or demand between airports. No consideration of airports as industries qualifying for regional grants. Content to plan without an overall policy for transport to provide objectives.</td>
</tr>
<tr>
<td>7. The development of the U.K. airport system, CAA.</td>
<td>1975</td>
<td>Separate policies needed for international growth airports from the majority of provincial airports. Protection needed for chosen development airports.</td>
<td>General philosophy of airport system stated in terms of functional categories and unstable nature of free competition. No national context; no consideration of domestic air service importance in multi-modal and multi-sector planning; no consideration of future aircraft technology, legislation on travel habits; no mechanism for public participation.</td>
</tr>
<tr>
<td>8. Airport strategy for Great Britain, Part II: the regional airports, Dept. of Trade.</td>
<td>1976</td>
<td>Consultation document: suggested a three-tier classification assisting natural growth with financial assistance at nationally important airports, little diversion from London, few new facilities required outside London.</td>
<td>No feedback of effect of implementing policy on forecasts at individual airports. Cargo treatment perfunctory. No attempt to coordinate policies or demand between airports. No consideration of airports as industries qualifying for regional grants. Content to plan without an overall policy for transport to provide objectives. Nodefinition of nationally-important airports.</td>
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evaluation, but the chief points are enumerated briefly:

i) The geographical study boundaries are not clearly justified and little attempt is made to bridge them.

ii) Categories of operation used are not always suitable for long-term planning, nor do they always relate to the facilities required.

iii) The relationship between demand generation and supply is not admitted, which may lead to low estimates of traffic for domestic, UK charter and foreign originations.

iv) The basic problem of dividing low traffic density between too many airports requiring a graded hierarchy of facilities, is crucially dependent on the allocation model. Any lack of accuracy in the model is not too important to the London airports, but small errors in total UK traffic could cause serious discrepancies at some smaller regional airports. In the latter case the model may be inadequate because:

- traffic growth from third level service entry is not admitted
- it appears that the domestic contribution to the viability of feeder services is not examined
- the modus operandi of charter airlines and passengers is not adequately considered
- foreign origins need more individual attention: in view of the trend for the more seasoned traveller to seek non-London markets, the British and Regional Tourist Authorities should have explicit roles to play
- service frequency is derived from an exogenous determination of aircraft size
- the use of a total journey generalised cost means that the airport choice is a poorly represented small part, easily swamped by other factors
- the calibration and testings were carried out on
the same data set, which was dominated by South East traffic
- the basis for the costing of time delays with variation of frequency is debatable.

v) The basis used for the evaluation of alternatives is Cost/Benefit Analysis, which is losing favour with transport assessors because of the technical difficulties (those associated with accounting for noise are conceded) and the relevance to social goals (Doganis et al, 1978).

vi) Having derived a hierarchical structure from the analysis, this is not followed through in terms of individual airport forecasts, economic viability or system implications of the interactions between airports, nor is it related to arguments for equity in accessibility between the regions.

vii) Similarly, suggestions for solving problems at locally competing airports are only partially followed up.

viii) Designing to capacity shows extreme optimism. Tolerances should be allowed for the effect of aircraft size on Gatwick’s single runway capacity, for inefficiencies in passenger flow during a continuous process of construction, for the inability to shift traffic peaks and airlines between four airports in exact synchronisation with capacity availability and for the probability that the planned capacity will not be provided. In particular, there seems to be little consideration of the serious consequences for airlines in denying them security of tenure at established bases, nor is there any mention of the need for the proposed Airlink helicopter service between Gatwick and Heathrow.

ix) The inclusion of the development of a fourth terminal at Heathrow in the government’s policy before a public enquiry on it, still leaves doubts in the
minds of the non-air interests as to the government’s impartiality both in airport planning and in the value of public enquiries (RAeS, 1978). This is compounded by the apparent lack of real alternatives to the ultimate development of Stansted as the fourth London airport. Suspicions of this sort indicate clearly a lack of success in the consultative process - a point reinforced in the discussion of method which follows.

x) The latest Government interpretation of the traffic forecasts appears to be a compromise between continuing public misbelief of the compound growth rates in the air transport industry, the industry view that new fare policies will generate new demand to allow historic long term trends to continue and the government’s embarrassment in supporting growth rates which show a definite lack of capacity before the arbitrary study limit of 1990. This again shows faults in the consultative process and serious shortcomings of the forecasting techniques and methods of planning for uncertainty.

Discussion of methodological framework

Even if these points of detail were met, it would still be worth questioning the effectiveness of the methodology in leading to a long term policy for airport development in the UK. A systems approach, expressed through a strong methodological framework, should allow improved rationalisation of the system relative to isolated market-force strategies. Similar views have been expressed by organisations both within and outside the air transport industry. The CAA, on the other hand, has argued that the political and technical difficulties make a “bottom up” approach much more practical and that it covers almost all of the real problems. Their philosophy and their studies have been consistent with this practical point of view, although their General Aviation study showed initiative in its close involvement of the local authorities, its attempt to match requirements over a relatively wide region and its desire to
represent the air mode positively to the community. (Standing Conference, 1976). It has been left to the government to interpret the CAA’s advice in a broader systems fashion. It has done this to some extent with its suggestions of a hierarchical system of airports, the introduction of "assessment" levels of demand, the mechanism of overt consultation and statements on subsidy.

The CAA’s planning actions have been close interpretations of the recommendation of the Edwards Committee, except in their lack of consideration of contingencies for changing aircraft technology and their low-key approach to the questions of supporting air services. Edwards did take a more positive and broader view of the air transport system and its interaction with other sectors of the economy, but neither he nor the CAA re-examined the role of air transport per se.

While the CAA has been concentrating on intra-mode problems, the planners at local and regional level, who have continuously argued for airport planning to be carried out inside a multi-sector framework, have had to take the intra-mode conclusions for granted. It is certainly possible in this way to cover all the necessary planning at local, regional and national levels in all the modes and all other pertinent sectors of the economy, ie by a long series of uni-dimensional studies interspaced with discussion and negotiation. UK airport planning to date has been very much in keeping with this approach. This form of planning is simply mimicking the growth of the system, and it may be claimed that similar advantages ought to accrue from adopting a more inclusive systems approach. In particular, internalising the planning process by continuous consultation should reduce the suspicion generated when interested parties may only react to previously conceived suggestions. Post consultation is being shown to be non-productive in the planning of road schemes, largely for this reason.

Despite their reservations on the issue of comprehensive planning, the CAA and the government have yielded to pressure to produce a national plan for airports. This has been formulated out of the CAA’s implicit consideration of the air
transport system as a whole (subject to the limitations identified in the detailed criticisms above) and of the post-study consultation phase with other interested parties. It may be argued that the complete transport system should have been studied, but most air travel is international in nature and has little interaction with surface travel except in the airport access phase: this latter area has been considered and opened to community consultation. A remaining difficulty is that the government directives imply that the government does not intend to fund those improvements. Similarly, environmental effects are mainly local and open to community consultation. On the other hand, the interactions with other sectors of the economy may well be significant; indeed, on several occasions the CAA has implied that there may be a case for selective subsidy. The government has dismissed these suggestions rather arbitrarily. This presumably follows from lack of consideration of the interactions between the airport and the industry and commerce of its region. The CAA's study framework and their position of having "responsibility without power" (Goodison, 1973) does not allow them to quantify these implications or to suggest whether the subsidies should be granted to airports, airlines or some regional development authority.

Since there are strong arguments to support the view that the firm foundation offered by established and based operators is a pre-requisite for long term viable airport operations, perhaps grants may be made available to relocate airlines - as an extension of existing government policies for the relocation of industries to depressed regions (Wilson, 1977). Direct spending on regional incentives to industry has been about £600m per year, so that the net cost of subsidising some regional air services appears small in comparison. Presumably the same argument could be applied to support for airports. The whole matter of subsidies for air transport is hampered by the misconception that it is nonsense to subsidise the rich. Not only does this fail to allow for the multiplier effect which the "rich" person may not be willing to subsidise, it also overlooks the large indivisible capital requirements which the "rich" have no mechanism for providing as well as the representative nature of much of their
business travel. Since the CAA is not specifically charged with encouraging the air transport industry the examination of this argument is considered to be outside its brief.

The question of subsidy, and the control of different levels of airport hierarchy, is also muddled by the concept of "national importance". There seems to be an implicit assumption that only international connections qualify as nationally important, but other national economies have already learnt that weak links spoil the whole system - that the contribution of each sub-region is important to the efficiency of the whole network.

Timescale is another dimension which could usefully be extended in national strategic planning. It could well be argued that there is little value in planning beyond the date when the degree of uncertainty in the demand forecasts is large relative to the expected traffic, and that the present discount rate does not give any weight to costs and benefits beyond 15 years, hence, no forecasting is attempted in the UK study beyond 1990. But the time to half life for airports and for regional development initiatives may well be 40 years, with little or no impact in the first 15 years from the beginning of planning. Rather than accept passively the lack of ability to forecast, it would be better to formalise the long term influences on a broad system framework and to allow explicitly for uncertainty by carrying out sensitivity and risk analyses and by actively planning to leave open the maximum number of options. In the latter case, the principle of the White Paper is correct, but the timing is wrong.

The CAA has attempted to achieve a compromise between isolated airport planning and the multi-sector central planning as practised in France, by considering just the complete air transport system. In this, they are in agreement with the view expressed earlier that the interaction between the vehicle and the infrastructure is a sensible place to begin to apply a total systems approach to planning. However, the comments on the detail of their method show that they have not in practice considered the system to be made up of a hierarchy of levels of route
density and airport throughout. Rather, they have inferred that, as a central authority, their concern is primarily with the trunk operator and the major international airports. Also, they have based their studies in arbitrarily defined regions without the regional legislation and financial support available to the FAA from the largely autonomous State Assemblies. The allocation model with its minimum route density, exogenous determination of aircraft size, fixed destination areas and crude treatment of the charter operations, does not allow interactions between levels of the system. The complementary nature of these levels in providing cost-effective transport (Caves, 1976) cannot then be exploited, nor can the essential flexibility of the mode. It should also be noted that the inclusion of the air services is not part of an attempt to plan the whole system, but only a method of representing the interests of the rest of the system in airport planning. Perhaps it does not need too much precision to serve this purpose, but the methodology is not really that of systems planning. It does not respond to renewed requests for some sort of equality of accessibility or the economic viability of supporting such policies (ABCC, 1977a). Nor does it consider the implications of the differing sensitivity between traffic categories which is indicated in the survey results (CAA, 1975): in general, it appears that business and 'other leisure' traffic is more sensitive than inclusive tours (IT), foreign than UK resident and domestic than international traffic to airport accessibility, though it is not possible to say how supply-constrained these effects are. No policies with regard to these traffic categories can be formulated, other than those implicit in the cost benefit analysis. The ability to frame these policies to conform to regional and national socio-economic goals is also lost. This is a particular loss to those who feel that the long-term interests of the country are better served by encouraging UK exporting industry than the influx of foreign tourists.

There is, however, little incentive to adopt either a multi-sector framework or one which allows impact analysis to be carried out on the effect of the various policy options. Just as the individual airports and authorities are in need
of a national plan to give their own plans a stable framework, so the CAA needs clear statements of national and regional objectives to which it can relate its priorities and a national planning framework within which it can react with other sectors of the economy. Such a framework might prevent successive planning agencies resorting to arguments which confuse ownership with planning. For example:

"put all airports into the hands of a central authority and then that authority will be able to interact efficiently with all other national authorities" (ABCC, 1977b).

A national authority does not ensure the best interests of the local communities. Edwards was in favour of ownership by the most interested party.

In fact, ownership is largely independent of the planning framework. If the framework were to include all interested parties and were to give them the opportunity for real-time participation, then the parties could interact in a system of free bargaining. The importance of this continuous participation in planning is not lost to the FAA (FAA, 1975). As yet, the non-air interests in the UK still seem to feel excluded. Roberts feels that the community is only allowed to respond (RAeS, 1978). In fact, the present degree of consultation is only a small advance on the Edwards Committee evidence - at which time the BAA first proposed the idea of a standing policy advisory council. This would provide the necessary forum for the continuous participation. Though much weaker on the demand side than the air transport studies, the GA airport study does provide a good example of the coverage which can be obtained by real-time inter-action between interested parties (Standing Conference, 1976).

TRANSITION

The above critique summarised the state of planning at the end of the 1970s. There was then a national framework for airport development, and standing committees (one for the South East and one for the rest of the system) which were to monitor the state of the system and bring forward suggestions
for further development. It soon became clear that the framework was not very helpful. The designated status of the airports could easily be challenged, because the UK does not have a formal regional administrative structure. The government has only a permissory function over local infrastructure planning, though its power to grant route licenses certainly gave a powerful indirect method of influencing an airports role during the regulatory era.

The end of the 1970s also saw the first fruits of deregulation in the USA and the birth of the Thatcher-style free market philosophy in the UK. The early 1980s were characterised by a hiatus in planning, as the laissez-faire policy setting began to gain strength.

However, the working groups set up the 1978 White Paper, commonly referred to by their acronyms ACAP and SGSEA, concluded that there was going to be a need for more capacity in the South East by 1990 (DoT, 1979a) and that the best site would be Stansted (DoT, 1979b). On the basis of these conclusions, the government invited BAA to submit plans for the development of Stansted. BAA accepted the invitation, and in 1980 requested permission for a two-runway airport, having previously been sufficiently far-sighted to buy up the required land.

The application was called in to Public Inquiry. In an unprecedented move, British Airways encouraged Uttlesford District Council to make a counter-application for the necessary capacity to be provided at Heathrow by developing Terminal five on the site of the Perry Oaks sewage farm. The government decided to hold a joint enquiry of the two sites, and appointed Graham Eyre, QC as the Inspector. The inquiry convened in September 1981, and ran on for two years. The Inspector’s report (Eyre, 1984) took almost a year to write.

The first paragraph of the summary of Eyre’s overall conclusions endorses the conclusions formed in the critique of 1970s planning:

"The history and development of airports policy on the part
of administration after administration of whatever political colour has been characterised by ad hoc expediency, unacceptable and ill-judged procedures, ineptness, vacillation, uncertainty and ill-advised and precipitate judgements. Hopes of a wide sector of the regional population have been frequently raised and dashed. A strong public cynicism has inexorably grown. Political decisions in this field are no longer trusted. The consequences are grave. There will now never be a consensus. Other important policies which do not countenance substantial expansion of airport capacity or new airports have been allowed to develop and have become deeply entrenched. Somewhat paradoxically, such policies are heavily relied upon by the thousands of reasonable people who strongly object to airport development. The past performance of Governments guarantees that any decision now will provoke criticism and resentment on a wide scale. I do not level this indictment merely as gratuitous criticism nor in order further to fan the fires of the long history of controversy but to set the context for current decisions which will shape a future that must enjoy an appropriate measure of certainty and immutability”.

In attempting to promote a solution which would satisfy the aims stated in the last sentence of the quotation, Eyre made it clear that the issue was not Stansted OR Heathrow, but that the two sites could form short and long term solutions to the same problem. For the first time, a view was taken of the long term need. The preferred solution was not to develop another major airport at Stansted: the environmental disbenefits were judged to be too strong, as were the airline and user benefits of Heathrow. In Eyre’s view, only the timescale required to relocate Perry Oaks justified any development at Stansted.

The government embodied its interpretation of the Inspector’s recommendations in its June 1985 White Paper (HMSO, 1985), as well as bringing forward plans for privatising BAA, making larger regional airports into Companies Act organisations (even though all the shares would be in the hands of the former local authority owners, and hence the airports would still be subject to public borrowing limits) and raised the
issues of how to control private airport monopolies. The subsequent 1986 Airports Act gave effect to these measures, BAA being left intact but being required to form separate PLCs for each London airport and for the Scottish Group (by then including Aberdeen, Edinburgh and Glasgow as well as Prestwick).

Encouragement was given to improve airport ground access generally, for Manchester to develop as a regional hub, and for Gatwick to become an independent scheduled airline hub, aided by limiting access at Heathrow to airlines previously operating there. It was expected that Stansted would soon develop its own range of scheduled services, as well as capturing some of Gatwick's charters, due to runway capacity limitations at Heathrow and Gatwick. Luton would fill in any shortfalls of capacity until Stansted's eight million passenger per year terminal became available.

Even while the Act was being written, it began to be obvious that the plans embodied in it were being outmoded by the consequences of reduced regulation of route entry, frequency and fares, both on domestic routes and those international routes where liberal air service agreements (ASAs) had been signed. Air Transport Movements (ATMs) rose much faster than had been expected, almost as fast as passenger numbers, giving severe aircraft access problems at Heathrow and in London Area Airspace. As the decade progressed, British Caledonian failed at Gatwick, British Airways was privatised and grew in strength, American carriers' demand for access to Heathrow became strident. Meanwhile, Terminal Four opened at Heathrow, Terminal Two at Gatwick and then the Stansted terminal, each adding approximately eight million passengers to the system capacity. In parallel with all these changes in airline operation, a series of exchanges was provoked between the government and its CAA advisors (CAA 1985a, CAA 1985b, CAA 1986b, CAA 1988a, CAA 1988b, CAA 1991c). The trends in passengers per ATM and runway capacities were reviewed, as were the effects of resulting capacity shortfalls on regional air services and on the ability of airlines to compete on a route-by-route basis at Heathrow. Various policies to cap movements were examined, ie to
continue the existing bans on airlines, to ban other classes of service (eg thin domestic routes) and changes in pricing policy. After a great deal of vacillation, the Secretary of State for Transport agreed early in 1991 to take the CAA's advice to lift all restrictions on access to Heathrow for passenger airlines, and not to interfere with any of the present practices for determining entry and slot allocation (the CAA had hinted that it might be in favour of a European Commission suggestion to limit frequencies on dense routes to four per day per airline). British Airways immediately declared that a third runway would be necessary at Heathrow. The CAA's decision to advise the lifting of access restrictions, together with its decision not to interfere with BAA charging policy except at the aggregate level, led it to review its position with respect to regulating runway slots in such a way that regional services are protected. It has decided that "it can identify no reasons of aviation policy why airports and airlines should be prevented from putting scarce resources to their most productive use" (CAA, 1993a).

PLANNING IN THE 1990s

Introduction

Thus, as the era of European liberalisation dawns in the 1990s, the industry continues to have to make do with the infrastructure it could get, rather than getting what it wants, largely because the advice given by the Civil Aviation Authority (CAA) to the Government has been rejected, or only partially accepted. In some cases this has been due to the CAA or its forerunners being given too narrow a remit, the CAA's responsibilities being centred primarily on the industry and its consumers. At other times the Public Inquiry processes or the relevant Secretaries of State have judged longer term aviation benefits to be less important than the effects on the environment and on local economies; there have also been times when world crises, or changes of the political flavour of the Government, have overturned decisions. All of these effects appear to be evident again in the current investigations into the need for, and the
location of, a fifth major runway for London.

The CAA has conducted a series of demand-led and airspace-constrained studies of the industry's requirements (CAA, 1989a; CAA, 1990a) again severely constrained by the study objectives as formulated by the Secretary of State for Transport and by its responsibilities as defined by the Civil Aviation Act 1982 and the Airports Act 1986. It was not invited to consider political, environmental, social and other considerations, leaving these for the later consideration of the government. Any ranking of preference for the sites therefore was given solely on the basis of passenger utility, airspace efficiency and the promotion of competition between airlines.

Thus, although the studies firmly established that, if it were provided, more capacity would be used, the options examined for fulfilling the need were unrealistic. This was due partly to the constraints on the study, partly to some apparent lack of coordination between the economic and airspace planners within the CAA, partly because no attempt was made to take the options to a preliminary design phase before undertaking the economic and airspace analyses, and partly because no attempt was made to anticipate the behaviour of the airlines as well as the passengers.

Some four months after the CAA's advice to the Secretary of State was published, a conference was convened to debate the consequences (RAeS, 1990). The conference could make little progress, because the Minister of Transport, giving the keynote address, had only just set up a Working Party, Runway Capacity in the South East (RUCATSE) to examine the wider issues. The Chairman, summing up the conference, was of the opinion that those efforts were only short term tinkering with the problem.

The RUCATSE Committee has been working in six sub-groups:-
- Development and Environment, basically concerned with planning issues
- Surface Access
- Noise
- Airport Development, concerned with the airport design possibilities
- Regional Airports, concerned with the role of those airports outside the South East
- Appraisal Methodology

with wide representation of interested groups. The subgroups report to the main committee (Sunderland, 1992). Sensible though the deliberations of the Working Party have been, the amount of resource devoted to the exercise is very small relative to the national economic importance of the issue. It seems clear that the quality of information on which decisions must be taken will be limited; further, the final balance between the various interests will, as before, be struck using a methodology known only to the Secretaries of State for Transport and the Environment.

Starting from the same premise as the CAA and the Working Party, the case study continues by inferring the aviation-specific and the wider objectives. It then examines the characteristics of the site options relative to expansion of Heathrow, particularly with respect to passenger preferences, after which attention is concentrated on the airline and airport interests. Cost models for the industry, developed in Chapters Five and Eight of the main text, are used in order to shed some light on the often emotive arguments aired by the industry in support of its wishes; implications of its management and marketing strategies are also considered. On the basis that it would take some time to develop more substantive objectives and to introduce them into the evaluation methodology, an attempt is made to generate a short-term solution which, while industry-oriented, has a strong possibility of meeting those objectives which might emerge from a fully researched application of state-of-the-art planning methodology. This solution is compared with a far more industry-orientated option which has greater planning implications.

Premises and objectives

The premises to which the CAA has been working were set out
in its report (CAA, 1990a, page 8). They were:

- a greenfield site would be unrealistic and unacceptable

the options were then:

- additional capacity at an existing major airport in the South East

- a full runway's capacity at another, or more than one, existing aerodrome

- expand the capacity of 'near' regional airports to take traffic growth from the South East.

These options were used in the examination of the airspace system but had little influence on the demand and economic analyses.

The CAA, under the 1982 Act, is to "secure that British airlines provide air transport services which satisfy all substantial categories of public demand .. at the lowest charges consistent with a high standard of safety and an economic return to efficient operators, and with securing the sound development of the civil air transport industry of the UK", and also to further reasonable interests of users of air transport services. The CAA clearly sees that the users' interests are its first priority (CAA, 1990d).

Prior to the latest round of studies, the Government had set out its policies in a White Paper on Airports Policy (HMSO, 1985) as:

- there being no case for inhibiting traffic growth

- Heathrow: all possible steps should be taken to maintain its leading position in world aviation; the possibility of a fifth terminal should be kept under review

- Gatwick: there should continue to be only one runway
- Luton: encourage to raise capacity to five million passengers per annum (mppa)

- Stansted: allow 15 mppa, with further planning permission and Parliament’s permission to raise the limit on ATM require to increase throughput to 25 mppa; no second runway: "it is very doubtful whether such a runway would be justified in the foreseeable future"

- Regional Airports: strong encouragement for Manchester to develop as a regional hub; in favour of new regional routes and approval of financially justifiable expenditure.

The Government reminded the CAA (CAA, 1990a, page A1/5) that in considering airport capacity, it should take account of the following considerations of Government policy:

- the Government's aim of promoting competition among airlines in all markets to the benefit of users, so as to encourage a sound and competitive multi-airline industry in Britain with a variety of airlines of different characteristics serving the whole range of air transport user needs

- the exploiting of the Single European Market as it comes about in accordance with Ministers' declared aims, and to this end pressing forward with the liberalisation of air traffic in Europe

- the Government's wish that regional airports should continue to develop healthily

- furtherance of the contribution of civil aviation to the UK economy

- the political implications of the environmental impact of civil aircraft operations.

The CAA noted that there was no specific mention of the earlier policy considerations associated with traffic
distribution rules ie retaining access for domestic services at Heathrow; avoiding undue dislocation to the airlines serving London's airports; retaining Heathrow's world status (CAA, 1990a, page 2).

Including some wider aspects of Government policy, and presuming that policies have not necessarily been discontinued simply because they have not been restated, it is possible to impute an unweighted listing of objectives to be satisfied by the new runway capacity. These could be:

- compatibility with airspace capacity
- suitable site development capability, including access
- promotion of competition among airlines
- promotion of competition among airports
- satisfaction of consumer demand at lowest cost commensurate with a healthy system
- minimum disruption to airlines
- promotion of regions, their airports and their feeder services
- interlining capability
- minimum environmental impact
- compatibility with local planning.

The Options

Demand Influences

No matter which strategy is adopted towards the new airport, its success will be more probable if the natural demand for its services can be accurately estimated, and if that demand can be maximised by choosing a location that maximises the utility of the largest number of people. The London area is a classic example of the emergence of a second airport (Gatwick) in the shadow of Heathrow. Its success (other than in its original role as a diversion airfield) only came with the onset of capacity problems at Heathrow. This long struggle for traffic (Figure A1) is entirely natural, given that the first airport in the system (eg Heathrow) will either have been located to provide the maximum utility for the greatest number of passengers or the
FIGURE A1a: HEATHROW AND GATWICK SHARES OF LONDON TERMINAL PASSENGERS

FIGURE A1b: STANSTED AND LUTON SHARES OF LONDON TERMINAL PASSENGERS
demographics of the city will have changed until it becomes so: indeed, the demographic change may go so far that disutilities set in (eg Congonhas airport in Sao Paulo with its net environmental disbenefits).

If the other airports in the shadow of the main ones could develop services, they might provide a greater utility for their local populations than either main airport, given the ground congestion problems. The search is necessarily continuing for the location of a fifth major runway for London (CAA 1989a, CAA 1990a), even before the fourth runway (at Stansted) is being utilised significantly. Assuming that other considerations (airspace, environmental impact) are equal, the best site would be that which gave the greatest local benefit and hence the greatest natural traffic, thus giving the maximum incentive to the airlines to set up services. A particular, but not not very successful example of this has been the London City Airport, designed to improve the utility of those using the City or associated with the Docklands redevelopment.

The experience of the airports north of London, including Stansted, shows how difficult it is to develop such a role in the shadow of Heathrow. The attraction of the major airport causes an out-migration from the local catchment area; this is not balanced by in-migration until the local airport generates a substantial amount of traffic. This is indicated by Figure A2, which compares the total passenger traffic flow per head of population for districts north of London with the traffic through several local airports per head of population within 45 minutes of the airport. The total traffic falls with decreasing distance from Heathrow, so the balance between in and out 'migration' occurs at some one million passengers per annum (mppa) at East Midlands compared with some 2 mppa at Luton. Thus the size of the local population offers little explanation for the level of traffic through the local airports. This is confirmed by the large scatter evident in Figure A3 for all airports within 100 miles to the north of London.

The explanation is not much improved by including the access
FIGURE A2: AIRPORT TRAFFIC PER HEAD OF LOCAL POPULATION

![Chart showing airport traffic per head of local population]

FIGURE A3: EFFECT OF LOCAL POPULATION ON AIRPORT TRAFFIC

![Graph showing the effect of local population on airport traffic]

FIGURE A4: EFFECT OF DISTANCE TO HEATHROW ON LOCAL AIRPORT TRAFFIC

![Graph showing the effect of distance to Heathrow on local airport traffic]
time to the next largest airport, whereas there is an improvement in the explanation when the product of population and the access time to Heathrow is related to local airport traffic (Figure A4).

Clearly there is a shadow effect on the total traffic at a local airport in the vicinity of a major one. A better understanding can only be obtained by a detailed analysis, particularly if the interest is in the ability of the local airport to develop specific services which would increase the utility for the local population, or even, to grow into a genuine competitor to the major airport. An indication of the use of the few services provided can be obtained by visual inspection of the data obtained in the CAA's origin-destination surveys. The use of these services by the local communities is shown in Figure A5 for Stansted and Luton.

Even from the raw data it is obvious that when Stansted (STN) offers a destination (particularly a scheduled one) it attracts a large percentage of those trips from locations close to it, with even a fairly rudimentary level of service. Despite the limited number of destinations and relatively poor quality of service, some 15% of all scheduled trips and 30% of all charter trips from Uttlesford, the nearest zone, are made through STN. The shaded area, showing all zones from which at least 5% of international scheduled and 5% of charter trips were made through STN (Figure A5a and A5b respectively) is contiguous and spreads out in a cone away from the airports. This is much as expected and lends a lot of confidence to the integrity of the data base at the district level. (The South Cambs. charter result is an anomaly due to the exceptionally low trip making observed there). Figure A5c shows a similar contiguous pattern of districts choosing Luton for at least 50% of charter trips (with the marginal exception of Huntingdon). The result is again to be expected, both in shape of the hinterland and the proportion of traffic - the charter offering at Luton was some 10 times the offering at Stansted in 1984. The decay with distance from Luton was much less pronounced than from Stansted in the northerly direction where there was little
FIGURE A5a: INTERNATIONAL SCHEDULED TRIPS THROUGH STANSTED FROM SURROUNDING ZONES, 1984 (PER CENT)
FIGURE 5c: INTERNATIONAL CHARTER TRIPS THROUGH LUTON FROM SURROUNDING ZONES, 1984 (PER CENT)
competition, but was considerable in the direction of Stansted - even more so than in the directions of Gatwick and Heathrow with its pseudo charters.

While the small local market for Stansted results in only an approximate six per cent share of total London area traffic on the scheduled routes which it served in 1991, Ryanair was able to increase share to over 20 per cent to Dublin with a very aggressive low fair policy in a particularly fare-sensitive market. Unfortunately, the yields proved insufficient to sustain service through the recession. The same problem is reflected in the history of services at Gatwick. Even on the densest short haul routes, the carriers have had a struggle to retain market share, as shown by Figure A6. Again, the combination of a low traffic share and the need to resort to low fares resulted in the demise of British Caledonian, Air Europe and Danair. When the Gatwick share of the total London area traffic is related to the share of the frequency offered, in Figure 7, the classical relationship is seen to hold; ie a low frequency share results in an even lower market share. Where this effect is modified by low fares, the carriers do not normally survive the next recession.

THE CIVIL AVIATION AUTHORITY'S AIRPORT TRAFFIC MODEL

The Civil Aviation Authority (CAA) has developed a model which not only considers the impact on South East demand of the geographical distribution of the suggested locations but also considers the interaction between regional and London area airports. The first attempt at this modelling was reported in 1989 (CAA, 1989a). Several useful refinements were incorporated in the methodology which led to the predictions of passengers which are being used for the analysis of the feasible locational options (CAA, 1990a).

It should be emphasised that the CAA's model is responding to a particular need to understand the future demand in the London area, and only sets out to address the demand at regional airports to the extent that their growth might influence the London situation. The influence could operate
FIGURE A6a: GATWICK SHARES OF LONDON DOMESTIC SCHEDULED PASSENGERS

FIGURE A6b: GATWICK SHARES OF LONDON INTERNATIONAL SCHEDULED PASSENGERS
either by improved service offering local competition for London's services or by the nearer regional airports' excess capacity providing a sink for demand split from London if the necessary capacity were not provided there. The CAA model's methodology allows both these issues to be addressed, though arguably it performs the latter function better than the former.

The CAA's traffic distribution model

The CAA's derivation of regional airports' shares is based on the use of a multinomial logit model which predicts the probability of a passenger choosing to fly from one of a number of airports. Choice models are discussed in Chapter Four. However, it is the application rather than the technique itself which is the cause of anxiety here. Given the availability of a rich data base of individual travel patterns from the CAA's own surveys (eg CAA, 1989b) and the behavioural nature of the airport choice, it is clearly the most logical approach.
The probability of a passenger choosing an airport depends on the relationship between the utility derived by using the chosen airport and the potential utility available throughout the airport system. As used by the CAA, the model took the general form:

$$P_{ij} = \frac{A_j e^{-\lambda C_{ij}}}{\sum_k A_k e^{-\lambda C_{ik}}}$$

where: $P_{ij}$ is the probability of a passenger in zone $i$ choosing airport $j$ out of $n$

$A_j$, $A_k$ are attraction factors for airports $j$ and $k$ respectively

$C_{ij}$, $C_{ik}$ are the utilities to be derived by a passenger from zone $i$ from using airports $j$ and $k$ respectively

$\lambda$ is a constant calibrated against actual traffic flows.

The specific form of the model varied with the nature of the traffic in four separate markets: short haul scheduled; long haul; charter; domestic. The attraction factors were represented by frequency in the short haul scheduled model, by total charter passengers in the charter model and by predetermined constants in the other two models. The utilities were represented by generalised cost of access plus a constant for each route in both the short haul and charter models, by generalised cost of access in the long haul model and by road time in the domestic model. The actual frequencies available to the passengers were adjusted prior to use in the model by a theoretically derived 'S-curve', which gave added attraction to high frequency and diminished attraction to low frequency: the theory depends on the assumption of uniform demand over the day. The constants in the utility functions represent differentials relative to Heathrow in fare, value of the air journey time and the
perception of the overall journey level of service: when calibrated, the constants were found to conform to a logical pattern, being more or less related to stage length.

The calibrations were performed by the use of individual trip data contained in the CAA airport surveys, the trips being distinguished by type of passenger (which in turn determined the value of time in the calculation of generalised cost) and the UK zone of origin or destination. 146 zones were used, covering the whole of the UK, but only English airports which had been surveyed were included in the choice set. The $\lambda$ was calibrated in a separate exercise from the relationship:

$$\lambda \times \text{value of time} = \frac{\log \left( \frac{\text{passengers to airport } a}{\text{passengers to airport } b} \right)}{\text{time to airport } a - \text{time to airport } b}$$

for all UK zones to a particular international destination. The same value (ie 0.10) was used in all the models. With that value of $\lambda$, the model was calibrated exactly for 1987 by adjusting the route-specific constants in the utility functions.

The CAA's predictions of future traffic distribution rely on the continued relevance of the calibrated constants in the models. With that proviso, predictions can be made for each of the market groups in a way which is sensitive to changes in value of time, in access time and in the ratio of frequencies offered. The predictions of traffic distribution are also, most importantly, made sensitive to capacity limitations and the total trip cost faced by passengers in each zone. Congestion costs were derived by adding shadow costs to the utility function until the traffic allocation obeyed the passenger and aircraft movement capacities assigned to each airport. The total costs, including the shadow costs, incurred by the assigned traffic were calculated. The demand from each zone was then adjusted, through the application of the same elasticities that were used in the overall forecasts, for any year-by-year changes
of cost.

The models were re-run for each year, the traffic base for each zone and the available frequencies being derived from the previous user's run. The frequencies to be offered were calculated via a model with the acronym LARAME. This took account of the airlines' behaviour with respect to size and type of aircraft and to frequency, both for the start-up of a new service and for its subsequent development. The airlines' behaviour was perceived to differ, depending if they were UK-based, scheduled, charter, less than 1000km, short haul, long haul, and also depending, in some cases, on which London airport they were to use: lack of airport capacity was assumed to result in larger aircraft and lower frequency than would otherwise occur.

The overall structure of the model is clearly sound, practical and relevant to the provision of airport capacity in the South East of England. The distribution of demand is sensitive to the supply of airport capacity and to the supply of service frequency. The overall level of demand is also sensitive to these factors via the changes in cost.

Many assumptions have been made, eg in airport capacities, in airline behaviour, in interlining, in the application of shadow costs indiscriminately to all routes, and in the subjective setting of attraction constants and keeping them constant over time. These are all capable of investigation by sensitivity analysis, but an indication of the extent to which changes in model specifications and airport capacity assumptions can induce large changes in predictions for smaller regional airports, while having a much smaller proportional effect on the London Area airports, is shown in Table 1 for two airports in the Midlands. Birmingham (BHX) and East Midlands (EMA) are both approximately 100 miles North West of London. They are two of the closest regional airports to London. They are 40 miles apart and have similar runway lengths. The table reports the results of two attempts by the UK CAA to predict regional airport traffic. The earlier attempt was published in CAP 548 (CAA, 1989a) considering four options for the possible expansion of the
London Area airport system: only Cases 2 and 4 are pertinent here. The later attempt was published in CAP 570 (CAA, 1990a), again considering several London Area options, of which only the Base and Heathrow (LHR) expansion cases are pertinent here. The four London airports considered were Heathrow, Gatwick, Stansted and Luton.

Case 2 from CAP 548 and the Base case from CAP 570 are closely comparable scenarios. A comparison of their traffic predictions shows how the model specification changes affected East Midlands' predicted traffic adversely while increasing Birmingham's long haul traffic very substantially. These changes in the model specification were mainly to the long haul attraction factors exogenously assigned to the airports. Effectively, these attraction factors imply that the distribution of traffic is supply-driven, at least while there is an overall shortfall in supply in the regions to cater for regional demand.

In comparison, the difference in predictions between Case 2 and Case 4 of the CAP 548 model, and again between the Base and Heathrow Expansion cases of the CAP 570 model, show the model predictions of spill of traffic to the regions as a result of shortages of capacity in the London system. The implications of these results in that changes in regional traffic predictions at individual airports due to changes in model specification are at least as great as those due to capacity limitations.

Relevance to regional airports

Due to the need to tailor the modelling towards the analysis of the congestion problem in the London area, the methodology has more serious drawbacks than the assumptions mentioned above when applied to the regional airports. The regional airports' traffic was only analysed to determine the extent to which they could relieve the London area, rather than to produce regionally-based forecasts: this does not, of course, hinder the regional airports' use of them when it is politically expedient, but it does make it harder for those airports which believe that the CAA has underpredicted their
TABLE A2: PREDICTIONS BY UK CAA OF AIRPORTS INTERNATIONAL PASSENGERS (MILLIONS)

<table>
<thead>
<tr>
<th>Year</th>
<th>Year 2005, CAP 548</th>
<th>Year 2005, CAP 570</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Case 2</td>
<td>Case 4</td>
</tr>
<tr>
<td></td>
<td>(a)</td>
<td>(b)</td>
</tr>
<tr>
<td>1988</td>
<td></td>
<td></td>
</tr>
<tr>
<td>East Midlands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short haul</td>
<td>1.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Long haul</td>
<td>0.0</td>
<td>0.4</td>
</tr>
<tr>
<td>Birmingham</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short haul</td>
<td>2.2</td>
<td>7.3</td>
</tr>
<tr>
<td>Long haul</td>
<td>0.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Total Non-London</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short haul</td>
<td>15.9</td>
<td>39.2</td>
</tr>
<tr>
<td>Long haul</td>
<td>1.9</td>
<td>1.6</td>
</tr>
<tr>
<td>Total London</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short haul</td>
<td>36.9</td>
<td>69.7</td>
</tr>
<tr>
<td>Long haul</td>
<td>16.7</td>
<td>40.2</td>
</tr>
</tbody>
</table>

The scenarios examined were:

Case 2: assumed Heathrow, Gatwick and Luton all capacity limited at 55, 30 and 5 million passengers per year (mppa) respectively, but Stansted able to take full London Area demand, ie 33 mppa at Stansted.

Case 4: also assumed capacity limits, but at all London Area airports, including 20 mppa at Stansted.

Base: assumed capacity limits of 50, 30, 30 and 5 mppa at Heathrow, Gatwick, Stansted and Luton respectively.

Heathrow expansion: assumed the full natural demand of 86 mppa at Heathrow could be met, no other airports then reaching capacity.
traffic to justify their own forecasts.

There are several aspects of the CAA's methodology which are debatable when used for the estimation of regional airport market share, though the essential form of the model and the structure of the modelling process are completely suitable. In particular, it is correct that the process should embody a year-on-year assessment of market opportunities and their likely fulfillment by the airlines. Equally, it is correct that the supply-led aspects of the demand generation should be recognized and that the airport choice should depend primarily on access generalised cost and relative frequency. However, problems arise in the form and calibration of the models, and also in the indiscriminate treatment geographically of trip generation. These problems are discussed in turn.

The form of models

The form of the short haul international scheduled model is restrictive in the way it treats frequency. It implies, as noted by the CAA, that it is only the ratio of frequency that is important. However, other studies, more restricted in scope, indicate considerable differences in the predictive capability of models using absolute frequency, frequency difference and frequency ratio (Caves et al, 1992) and also that, in the choice between airports with very large and very small frequencies, it is better to consider frequency to be an airport-specific, rather than generic, variable (Caves, Ndoh and Pitfield, 1991). The device of factoring by the 'S-curve' makes some allowance for the latter problem, but being based on the theoretical assumption of constant demand over the day, makes no allowance for the possibility that those travellers who particularly value good access might arrange their travel around available schedules and also making too little allowance for the fact that low frequencies can cover peak periods relatively well. It is more usual to include the frequency variable within the utility function and to establish its coefficient by calibration simultaneously with the coefficients for access and other variables. It is then possible to identify explicitly any interrelationship between
access and frequency effects rather than, as the CAA approach does, throw all the onus of calibration onto a route-specific 'cost' variable.

The CAA demonstrates, when considering the costs incurred by a passenger, that its model can be rewritten so that frequency becomes part of the utility function. The function then becomes:

\[- \lambda (C_{ij} - \frac{\ln F_j}{\lambda})\]

so that, in cost terms, having a frequency of $F_j$ at an airport is equivalent to reducing costs by $[\ln F_j]/\lambda$. However, this does not avoid the difficulty, because its coefficient is determined exogenously rather than being subject to calibration.

The CAA's long haul and domestic models do not include frequency explicitly; instead, it is subsumed into a subjectively determined airport attraction factor. Other work on long haul airport choice shows that, while cross elasticities of demand with respect to frequency are low, Prestwick displayed a weekly frequency elasticity of 0.59, Heathrow 1.01 and Gatwick 0.83: quite substantial, even though they are smaller than the access and trip cost elasticities (Brooke and Caves, 1993). Again, a model of domestic trips through Stansted from zones in the natural Stansted catchment, indicates that domestic passengers valued access to Stansted rather more highly, but frequency much more highly, than even non-UK international passengers (Caves, Ndoh and Pitfield, 1991).

Several models of airport choice including Stansted were calibrated. One was based on 1312 scheduled international trips to Amsterdam, Brussels and Paris, distributed as:

- Heathrow (LHR) 620
- Stansted (STN) 615
- Luton (LTN) 17
- Gatwick (LGW) 60
Calibration of the equation:

\[ \text{Utility} = B_1 \times A + B_2 \times F + B_3 \times D \]

gave

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Std. Error</th>
<th>T ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B_1$</td>
<td>-0.05592</td>
<td>-78.6</td>
</tr>
<tr>
<td>$B_2$</td>
<td>-0.10520</td>
<td>-18.2</td>
</tr>
<tr>
<td>$B_3$</td>
<td>0.01076</td>
<td>9.0</td>
</tr>
</tbody>
</table>

where

- $A$ = access time in minutes
- $F$ = one way full economy fare (£)
- $D$ = weekday departures per week.

The implied direct elasticities were:

<table>
<thead>
<tr>
<th></th>
<th>LHR</th>
<th>STN</th>
<th>LGW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access</td>
<td>-0.962</td>
<td>-0.701</td>
<td>-3.423</td>
</tr>
<tr>
<td>Fares</td>
<td>-1.882</td>
<td>-2.561</td>
<td>-6.734</td>
</tr>
<tr>
<td>Frequency</td>
<td>0.186</td>
<td>0.048</td>
<td>0.235</td>
</tr>
</tbody>
</table>

\[ \rho^2 (o) = 0.314 \quad \rho^2 (c) = 0.497 \]

where $\rho^2 (o)$ indicates the fit based on observed share and $\rho^2 (c)$ indicates the fit produced by the model. A value greater than 0.2 is regarded as adequate (Hensher and Johnson).

The LGW results are rather spurious because of the intervening opportunity of LHR in the majority of cases and the small data base. The access and fare elasticities for LHR and STN are consistent with expectations, showing passengers to be rather more sensitive to access at LHR and more sensitive to fare at STN. The frequency results are interesting and could be interpreted as indicating that STN had no chance of matching the LHR frequencies and that the choice of STN was largely independent of the low frequency. The LHR result is also much lower than the literature would lead one to suspect, but the frequency base for the routes examined from LHR was so high that it is not surprising that doubling or halving the frequency appears likely to change the traffic by 18.6% - assuming that the elasticity remains constant over that large range of frequency.
A similar model was calibrated on just the 452 non-UK based passengers out of the original 1312 trips. The elasticity results were:

<table>
<thead>
<tr>
<th></th>
<th>LHR</th>
<th>STN</th>
<th>LGW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access</td>
<td>1.129</td>
<td>0.758</td>
<td>3.304</td>
</tr>
<tr>
<td>Fare</td>
<td>1.618</td>
<td>2.597</td>
<td>5.721</td>
</tr>
<tr>
<td>Frequency</td>
<td>0.586</td>
<td>0.186</td>
<td>0.738</td>
</tr>
</tbody>
</table>

The statistical tests were very similar to the model for the combined data set. The results show that the foreign travellers have a slightly greater interest in reducing access time but a far greater sensitivity to frequency than the UK-based traveller when choosing an airport (or a route).

A domestic scheduled model was also calibrated, based on 253 trips to Edinburgh (EDI), distributed as:

LHR 63; STN 181; LGW 9

with an average grossing factor of 354.

Calibration:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Std. Error</th>
<th>T. Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B_1$</td>
<td>0.0445</td>
<td>0.00028</td>
</tr>
<tr>
<td>$B_2$</td>
<td>0.549</td>
<td>0.00027</td>
</tr>
<tr>
<td>$B_2$ was statistically non-significant.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$\rho^2$ (o) = 0.233 $\rho^2$ (c) = 0.620

The implied direct elasticities were:

<table>
<thead>
<tr>
<th></th>
<th>LHR</th>
<th>STN</th>
<th>LGW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access</td>
<td>-0.544</td>
<td>-1.007</td>
<td>-2.984</td>
</tr>
<tr>
<td>Frequency</td>
<td>0.599</td>
<td>0.557</td>
<td>0.775</td>
</tr>
</tbody>
</table>

On the limited data set available, the domestic passengers behaved as though access to STN was rather more important and frequency at STN of much greater interest than it was to even the non-UK international passengers.
Another model was calibrated on only domestic business passengers in order to make some use of other domestic destinations despite all the non-Edinburgh trips in the sample being made at weekends. There were 251 trips to Edinburgh, Jersey and Guernsey, distributed as:

LHR 68; STN 173; LGW 10

The $\rho^2$ tests were rather lower: $\rho^2(o) = 0.065, \rho^2(c) = 0.552$, but the fare variable was statistically significant. The implied direct elasticities were:

<table>
<thead>
<tr>
<th></th>
<th>LHR</th>
<th>STN</th>
<th>LGW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access</td>
<td>- 0.555</td>
<td>- 1.055</td>
<td>- 2.049</td>
</tr>
<tr>
<td>Fare</td>
<td>- 0.950</td>
<td>- 0.293</td>
<td>- 3.059</td>
</tr>
<tr>
<td>Frequency</td>
<td>0.558</td>
<td>0.536</td>
<td>0.513</td>
</tr>
</tbody>
</table>

The elasticities show little difference over the EDI model as far as STN was concerned, the fare term probably explained by business being combined with pleasure in the Channel Isles. A further calibration on all 406 trips to all three destinations for both business and leisure gave results similar to the Edinburgh business-only model.

An International Charter model was also attempted, based on 1488 trips to Malaga (AGP), Faro (FAO), Gerona (GRO), Ibiza (IBZ), Palma (PMI) and Tenerife (TFS), distributed as:

STN 232; LTN 982; LGW 274

with an average grossing factor of 259. The following three utility functions were calibrated, using only an access term because of difficulties with collecting data on fares and with the concept of frequency in the charter market.

\[
U = B_1 \times \text{Access for STN}
\]
\[
U = L + B_1 \times \text{Access for LTN}
\]
\[
U = M + B_1 \times \text{Access for LGW}
\]

with constants $L$ and $M$ for LTN and LGW respectively designed to reflect the power of their large availability of flights.
without being able to identify the specific availability of a particular destination at a particular preferred schedule for each sampled passenger, or indeed, the extent to which each passenger was prepared to trade destination, airport, price, tour company and timing. The parameters of the calibrated utility function were:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Std. Error</th>
<th>T. Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>2.684</td>
<td>0.0556</td>
</tr>
<tr>
<td>M</td>
<td>3.804</td>
<td>0.083</td>
</tr>
<tr>
<td>$B_1$</td>
<td>-0.0312</td>
<td>0.001</td>
</tr>
</tbody>
</table>

with $\rho^2 (c) = 0.0539$  
$\rho^2 (c) = 0.3552$.

The implied direct elasticities were:

<table>
<thead>
<tr>
<th>Access</th>
<th>STN</th>
<th>LTN</th>
<th>LGW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-1.590</td>
<td>-0.512</td>
<td>-1.681</td>
</tr>
</tbody>
</table>

The results reflect the evidence of Figure A5 that charter appears more sensitive to access than scheduled traffic when using Stansted. From north of the Thames, choice of Gatwick is also very access-dependent. The dummies account for approximately 50% of the average utility when Luton or Gatwick are chosen rather than Stansted. The overall explanation of choice for charter is inevitably lower than scheduled, as indicated by the standard errors and the $\rho^2$ tests, due to only employing the access variable.

Both the long haul and short haul frequency effects, indicated by Brooke and Caves (1993) and by Caves, Ndoh and Pitfield (1991) respectively, seem to be intuitively correct when the initial long haul competition may well be between once weekly and twice daily, and when the domestic competition is with almost hourly air and train services. No prediction of regional airport market share which does not explicitly consider frequency in these long haul and domestic markets can be expected to be reliable, however much effort is put into adjusting other variables. It is unlikely that accurate predictions of traffic at the minor airports can be
made without paying the detailed attention to the local access/frequency effects captured in the modelling described above, even if it does lead to difficulties in calibration.

Finally, on frequency, the CAA allows for the effect of UK or foreign airline ownership in calculating the likely frequency for a given level of demand, and is continuing to develop LARAME to allow for effects of competition on frequency offered. However, no account is taken either of competition or country of ownership when estimating an airport's market share from the resulting total frequency on a route. Yet in many ways, traffic is dependent on these factors: passengers are often directed to the national carrier, marketing the home product is always easier, the flow to regional airports is almost invariably unbalanced in favour of the home market and competition is generally considered to stimulate traffic.

Model calibration

The calibration problems relate to the zonal system used and the airports included in the choice set. Both these factors were dictated by the need to give full coverage to the South East airports. Only 164 zones were used compared with some 131 administrative districts in the South East and a further 238 in the rest of England, with a further 37 districts in Wales and 60 in Scotland. Given that most of the 131 South East districts would have had to be used as individual zones, a maximum of perhaps 50 zones would have had to cover the 238 English districts, even if Wales and Scotland were considered as single zones because their airports were not in the choice set. This would severely limit the discrimination of access times to the smaller regional airports. Yet there is a difference of some 50 per cent for international scheduled, and 75 per cent for charter trips per capita using Stansted from its own district (Uttlesford) compared with the trips per capita from those zones immediately contiguous to it (Caves, Ndoh and Pitfield, 1991).

Road times were estimated for 14 airports but only 11 airports are quoted as having constants in the short haul scheduled utility function. Assuming that fares and
frequencies were collected as well as road times, Teesside and Liverpool airports were in the former set but not in the latter. They could have thus been included in the rejected choice set for those passengers using the London airports and Newcastle or Manchester respectively, even though passengers using the minor airports themselves were not included in the calibration data. Any failure to include the local rejected choice, on the grounds that the airport had not been surveyed and that the airport could not be an accepted choice, will seriously distort the choice calibration locally within the region. Thus, passengers near the East Coast may have chosen Stansted by rejecting Norwich or Southend rather than Heathrow; similarly, Exeter, Plymouth or Cardiff may have influenced the choice of Bristol more than Heathrow or Birmingham, or Humberside may have influenced Leeds/Bradford more than Manchester. Certainly any attempt to use the model to assess the prospects for a new regional airport could only succeed if considerable extra effort were put into reducing zone sizes and accounting for the smaller airports.

Zonal trip generation

The final area where the CAA model is inappropriate for rigorous forecasts of regional airport traffic is in the lack of geographic discrimination in its treatment of trip generation. It is implicit in the CAA's treatment of domestic traffic from Stansted and Luton that, as the volume of domestic traffic at those airports rises to the levels at Heathrow and Gatwick, so the propensity to fly (ptf) per head of population at zones near those developed airports will rise to similar levels those now observed near the mature airports. Indeed, their evidence of the increased ptf near Heathrow and Gatwick shows at least a fourfold increase between those zones one hour away and those zones closest to the airports; admittedly, much of that effect will be due to inward commuting to employment close to the mature airports. Yet there is no investigation for a similar effect in the other market groups, nor is similar reasoning applied to other emerging airports. Further, while admitting the relationship between access to service and ptf, no attempt is made to assess the complementary inward migration of housing
which accompanies airport expansion, thus providing a larger base for a given ptf to generate trips. Thus the regional airports' traffic generation is underpredicted, and the distribution of traffic to those airports is further underpredicted by the early and strong competition from the emerging South East airports. This is compounded by the use of overall UK traffic forecasts for the annual estimate of new trip generation per zone, regardless of any expected differential changes in population or economic activity. The bias towards the South East is compounded yet again by not reducing the differential of the attraction factors in the long haul model between the regional airports and the major London airports as the regional airports' route synergy grows: this is incompatible with the frequency-based attraction factor in the short haul model and the airport traffic-based attraction factor in the charter model.

The CAA's demand analysis does make it clear that any solution based on developing the airports on the periphery of the region will 'lose' just as many South East passengers, perhaps 16 mppa by 2010, as by doing nothing. Prices at the London airports will still rise and traffic will continue to spill to the more developed regional airports unless some substantial bribes are offered to passengers. An additional difficulty with allowing the proliferation of peripheral airports is that they will demand more of the limited airspace capacity without contributing very much to the movement of passengers.

NEW RUNWAY OPTIONS

Site-specific factors

Although Sir Peter Masefield's suggestion for a single large airport on the Isle of Sheppey (Masefield, 1989) may be the best answer for London if the system could be designed with a clean sheet of paper, it will be politically impossible to resist the temptation to make the most of the present infrastructure: indeed, the Secretary of State explicitly instructed the Civil Aviation Authority (CAA) not to bother to investigate green field sites in their search for new
runway capacity.

In view of the probable continued shortage of runway and airpspace capacity and if there is indeed no case for inhibiting traffic growth, the preferred solution must be one which concentrates the new demand sufficiently to allow the same high ratio of passengers per ATM enjoyed by the other major airports, contrary to the situation at London City Airport. One option is then to develop Luton to a full 40 movements per hour. There is a private sector interest in this solution, and Luton may be one of the first local authority airports to release the majority of its shares. If a substantial and early investment were made at Luton, it could certainly draw more traffic than predicted in the CAA studies, particularly if longer haul bilaterals were liberalised to include this airport. The CAA prediction is in fact a policy decision based on the airspace incompatibility with full development of Stansted's runway. Yet Luton is near central London; a dedicated rail link could be provided; airport competition would be provided since it is not owned by BAA; airline competition would be enhanced; its based airline has a substantial fleet of modern large aircraft; it has the advantage of different weather conditions from the other major airports. On the other hand, further fragmentation of services would be necessary; the single runway configuration would once again limit long term expansion and the possibility of hubbing operations; most of the benefits would fall to Bedfordshire, while a substantial proportion of the environmental cost would be borne by Hertfordshire; there must be some doubt on safety at the west end of the runway; the M1 motorway access is often very congested. Matters of local planning and airspace capacity are in the balance. Indeed, the CAA is so ambiguous with respect to the implications of the various development options on airspace that one might as well assume all options to be workable if they are given enough warning. To quote (CAA, 1990a, page 39): "... with varying degrees of difficulty, it should be possible to develop airspace and ATC arrangements to accommodate most of the scenarios examined. However, some significant problems would need to be overcome". The report goes on to say that an extra full
runway's capacity at any of the major airports should not impose insuperable design problems, though the requirements for the expansion of airspace could be very serious, particularly if both Luton and Stansted were operating at 40 movements per hour.

The remaining options all involve the development of BAA-owned airports with at least two runways, the latter aspect being clearly beneficial for the air transport system. Concentration of traffic allows hubbing operations and/or interlining and is therefore marketable to airlines, provided that the site is not too far removed from the trip origins of passengers. While a two-runway airport would concentrate the environmental and economic impacts, some alleviation of both may be obtained by the adoption of a relatively short second runway: any likely future operation would only have a minority of the long haul take-offs which require extreme runway length. Airline competition on a head-to-head basis, i.e., at the same airport, would be encouraged. Airport competition, on the other hand, would be limited by the BAA's common ownership of the airports in question.

It could be argued that, to give a more balanced system, it would be preferable to develop single runway airports into two runway airports rather than to throw extra weight onto Heathrow. Apart from the environmental arguments, the overriding difficulty is that both Gatwick and Stansted have had that option removed by legal agreements. Gatwick would be the preferable location from the points of view of minimising disruption to the air transport system and maximising the synergy of the present high level of operations. However, the BAA has signed a 40 year planning agreement with the local authority not to build a second runway. This could be overturned by an Act of Parliament, but only at the expense of creating even greater bitterness and suspicion of the value of any future assurances among those opposed to airport development. Even if the political difficulties could be overcome, neither the CAA's choice of location for the second runway, nor any other location, is practical. There remains, at Gatwick, the complicated alternative of providing a short, remote reliever runway at
Redhill: this could be linked to Gatwick by a dedicated rail service while legitimately claiming not to be a second runway at Gatwick. It is a possibility which should be given further consideration.

A second runway at Stansted may well be preferable to Gatwick on environmental and planning grounds, though the synergistic benefits to operations would only come later. The Government would, however, have to make an even greater U-turn if it were to adopt this solution. As recently as 1985, when making the statement quoted earlier (HMSO, 1985), it required BAA to divest itself of the land it had previously been acquiring in order to safeguard the possibility of further development. This could only have been done as an extra assurance to the parties opposing the development that there was no intention of allowing a second runway in the future.

The final option is to further concentrate the industry by developing more runway capacity at Heathrow. Again the Government is in danger of being inconsistent, in that it encouraged BAA to invest in the early development of Stansted's terminal. Any significant increase in the capacity of either Gatwick or Heathrow would seriously undermine the financial viability of the Stansted investment. Given free choice, the large majority of airlines and their passengers would use Heathrow, despite its unenviable reputation for congestion. This is shown by the market's behaviour. The passengers' preferences are shown by the CAA estimates that Heathrow's expansion would generate fivemppa extra by 2005 compared with the other options. The airlines' preferences are shown by the struggle for peak slots despite BAA's pricing policies: British Midland recently tried to obtain the slots it required to support the new routes it has been granted, but only obtained 30 per cent of them, and only 10 per cent at the requested time (Reid, 1990). BA is keen to have a fifth terminal together with a new rail link to central London, despite the runway capacity problem. Further evidence comes from British Midland in the form of a survey of British business executives in the South East: 45 per cent opted for Heathrow as their preferred airport and 60 per cent believe its capacity must be expanded because of its
location and its contribution to the UK's status (Reid, 1990).

Many schemes have been proposed for increasing Heathrow's runway capacity. These include lifting the night curfew, using the runways in mixed mode rather than the more environmentally acceptable fashion of dedicating one runway to landings and the other to take-offs (Reid, 1990), using the cross-runway for short take-off and landing aircraft (STOL), canting and splitting one of the runways for STOL (Ambrose, 1990), adding a new parallel runway between the A4 and the M4 (CAA, 1990a). As well as the on-site capacity enhancements reviewed above there is also the option of using Northolt in conjunction with Heathrow (Brewitt, 1990). This option requires both military cooperation in releasing control of Northolt and also a much more complicated ground transfer link than would be needed between Gatwick and Redhill. Most of the operational solutions have been deemed by the CAA to be of little or no value in airspace terms: since it both plans and operates the system there seems no easy way of challenging these views. The CAA has also investigated the addition of a third parallel runway and found that a full length runway could be made to work from the airspace point of view (CAA, 1990a): it is, of course, difficult to envisage the Government risking the environmental consequences of such a solution. On the basis of the above arguments, and the Government's history of piecemeal and short-term decisions on South East airport capacity, there seems little hope that the new capacity will be provided at Heathrow, however much that seems to be the preference of the airlines and their passengers. Yet some argue that the concept of hard limits to capacity is erroneous; that airports are "elastic-sided", a phrase coined by the BAA Chief Executive, Sir John Egan (Goldman, 1992). This deserves further investigation.

Despite the well publicised capacity pressures at Heathrow and Gatwick, not only is the demand still strong but the system appears to be coping with it. Table A3 shows that the passenger ATMs have been growing as quickly at the congested airports as at the others in the London system, though at a
TABLE A3: COMPARATIVE UK AIRPORT TRAFFIC GROWTH RATES (PER CENT 1989 ON 1988)

<table>
<thead>
<tr>
<th>Airport</th>
<th>ATM</th>
<th>Passengers</th>
<th>Passengers/ATM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heathrow</td>
<td>4.9</td>
<td>5.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Gatwick</td>
<td>5.0</td>
<td>2.0</td>
<td>-3.0</td>
</tr>
<tr>
<td>Stansted</td>
<td>6.9</td>
<td>26.0</td>
<td>17.9</td>
</tr>
<tr>
<td>Luton</td>
<td>4.1</td>
<td>1.1</td>
<td>-2.8</td>
</tr>
<tr>
<td>Birmingham</td>
<td>18.1</td>
<td>19.6</td>
<td>1.2</td>
</tr>
<tr>
<td>Manchester</td>
<td>9.9</td>
<td>5.8</td>
<td>-3.7</td>
</tr>
</tbody>
</table>

Source: derived from CAA statistics (CAP 566)

lower rate than in the regions. There were even some reductions in passengers per ATM, contrary to the traditional response to capacity problems which has been to increase the average passenger load.

The increase in ATMs has been due largely to increased route competition. The highest frequency routes at Heathrow are among the fastest growing, due to increasing competition. Each airline appears to consider it necessary to offer at least seven frequencies per day on these routes. The main marketing tool in a liberalised system is undoubtedly frequency, and any attempt to improve the marketing of the London hub is likely to be based on it. 1990 schedules indicate that, contrary to the 1989 situation, there was a slight percentage withdrawal of frequencies on the densest routes. The overall increase in ATMs in 1990 was due to some substantial increases in frequency on medium density routes, even though those routes were served only by the two flag carriers. It appears that the airlines have been competing with frequency on the less-liberalised routes, up to the point justified by jet service at the particular route density, currently achieving approximately three frequencies per day each. It is likely that progressive liberalisation will result in further pressure to increase ATM on the medium density routes. Pressure will continue from new entrants for entry on the thick routes.
The crux of the argument about the need for more runway capacity is in many ways the number of passengers per ATM (P/ATM). This depends, as indicated above, on the number of airlines competing and their judgement of the frequency required to dominate the market on each particular route. It also depends on the airlines' own trade-off, when runway slots are limited, between frequency competition on one route and the desire to add frequency on another route. In addition, it depends on the balance of runway to terminal capacity at critical airports and the availability of aircraft of the necessary size to cater for increasing demand while holding frequency constant. The implications of being wrong in this area are huge, yet, compared with forecasts of passenger demand, the effort put into the forecasting of technology, market behaviour and the resulting P/ATM is miniscule. When the subject of London airport capacity was being considered in the early 1960s, it was assumed that the average number of seats per aircraft would rise from a current 80 to 120 in 1970 and then remain constant to the end of the century. The Boeing 747 was already on the drawing board yet the assumption was based on available technology at least as much as on commercial pressures to increase frequency (Watson, 1965). It is of interest to recall also that, despite historic growth rates of 15 per cent per annum, passengers were only predicted to increase by 4.5, 3 and 2 per cent annually during the 1970s, 1980s and 1990s respectively; that the maximum hourly capacity would be 64 ATM at Heathrow and 40 at Gatwick, so requiring a fifth airport by 2000 to handle a total of just 44 million passengers per year in 700,000 ATM. Although a sensitivity analysis was done with aircraft sizes up to 200 seats, it was regarded as "an exercise in arithmetic". In fact, in 1992 Heathrow handled 45 million passengers and 388,000 ATM and the London airports in total handled 70 million passengers and 645,000 ATM, (ie 116 P/ATM at Heathrow and 109 P/ATM overall) and thus very close to the "arithmetic" with the then assumed load factor of 60 per cent. However, the central estimates were 50 per cent low on passengers while being correct on ATM. More importantly, the annual ATM capacity at Heathrow and the central estimates of P/ATM were both some 50 per cent low. It would be prudent to give some
consideration to the possibility that technology will be no more static over the next 30 years than it has proved to be over the preceding 30 years: in which case, Heathrow would still be making new runway sites redundant.

Clearly, there are real and difficult questions of balance between economic, social and environmental issues to be faced if decisions in the best interests of the nation are to be taken. Very little research has been done in some of those areas where the Government rather than the CAA is responsible. It is difficult to see how an intelligent balance can be struck without better knowledge of such issues as: the trade-off between noise impact and benefits to the local economy; the effect of the lack of provision of air service on the national economy; the social and economic consequences of positively encouraging rail for short haul travel. In the absence of this information, actions will always depend on what is politically expedient. The priority must be to improve the input of knowledge to the decision process, starting with the optimum solutions for the industry and its users, together with the cost to them of non-optimum solutions. This is now examined.

Industry influences

Within the sphere of the industry and its users there is a considerable amount of information of relevance to airport policy. The CAA studies, quoted earlier, show clearly enough the penalties borne by passengers when their first preference is not available. To the extent that the industry tends to minimise costs in a competitive environment, much work has also been done which can help in understanding its needs, and this is now reviewed. It is, of course, recognized that neither airlines nor airports behave solely as cost minimisers, but again there has been little work which identifies these other objectives or which models the hubbing and other mechanisms used to achieve them: the CAA chooses not to attempt to internalise airline management tactics in its models.
Airline costs have been subject to a long history of analysis in North America. These studies, their results and their shortcomings, are discussed in Chapter Five, together with a first attempt to model the British airline industry. The results of the latter analysis suggest that the only UK airline which could lower its costs by fragmenting its services to more than one London airport might be BA, but that it would achieve an even better return if it could expand its output by the same amount without significant change in its network. British Airways estimated that expansion at Stansted rather than within Heathrow would require between 19 per cent and 32 per cent more aircraft and between 5 per cent and 8 1/2 per cent increase in annual operating cost (British Airways, 1983). British Midland should definitely attempt to increase its density faster than its scale, while the smaller airlines should be attempting to increase density even at the expense of scale: their opportunity to do this could well be to expand at a secondary London airport rather than attempt to gain access to Heathrow, unless by using Heathrow, they can increase density much faster. The success of these smaller ventures is likely to be rather long term, so there are no apparent arguments based in airline costs for further fragmentation of either London's airport system or of the individual airlines' operations at them.

The other cost-based aspect which needs to be considered is that of the airports themselves. The CAA is charged with ensuring that the BAA airports are not being cross-subsidised. Also, it is CAA and ICAO policy that charges should be cost-related, so the prices paid by airlines to the airports should be influenced only by the airports' costs. The airport cost evidence presented in Chapter 8 suggests that there are returns to scale available at Heathrow and Gatwick of the same order as the returns to density available at Stansted.

In summary, there are opportunities for smaller airlines to concentrate their services at Stansted, and to some extent Gatwick. However, unless there is to be a charging policy which maximises social surplus rather than recovering social
costs, both BA and British Midland would benefit from expansion at Heathrow if there were more capacity, rather than fragmenting their services to Stansted.

Set against the cost and consumer arguments for concentration of services, there are often environmental and marketing reasons for fragmentation of services. Airports often become surrounded by development (eg La Guardia, Sao Paulo Congonhas, Sydney, Athens), while being too valuable in terms of access to markets for them to close. In the past, expansion has been halted by policy rather than pricing. When the closure solution is adopted (eg Munich) in favour of a more distant site, it is because the environment argument is overwhelming. The marketing reasons for fragmentation are usually associated with an airline's desire to retain overall market share in city pair markets in the face of a competitor's exploitation of a new airport pairing within that market. Thus, airlines in the US normally serve at least two of the New York airports at moderate frequency, rather than dominating just one airport market with high frequency (Caves, 1990).

A sample of routes between US hubbing airports in 1988 taken from the ABC World Airways Guide showed an average of 2.8 airlines per route and 6.1 frequencies per day per airline. In contrast, the daily frequency per airline from those hubs into the individual New York airports was only 2.6 at La Guardia and 2.7 at Newark, though the average number of airlines per route remained at 2.8. The services into Kennedy reached only half these levels of frequency or airline participation. In a sample of short haul medium density markets, the frequency per airline into Kennedy was also only half that into Newark or La Guardia, but, in this case, it was due primarily to a greater number of airlines serving each Kennedy route. Newark and La Guardia each had equal shares of the market, with 1.9 airlines per route and 5.0 daily frequencies per airline. In a high density route like Boston, there were 2.5 airlines per route and 12.0 daily frequencies per airline, again equally shared between the two domestic New York airports. If the USA is giving an indication of the eventual state of a liberalised Europe, the
airlines should settle for two or three competitors per route, with five or six daily frequencies per airline on short haul or inter-hub routes; the frequencies per airline would be ten or twelve per day on the densest routes, even into each airport in a hub.

In London, Air France or its subsidiaries chose to serve all London's airports; Aer Lingus and Ryanair serve two airports each. BA, Lufthansa and Air France are now all serving Newark daily without diluting their traffic through New York's Kennedy (Lefer 1990). These marketing moves occur despite the cost arguments and the inevitability of the 'S' curve (de Neufville, 1976) which predicts that a small frequency share in a market will lead to an even smaller market share.

Often, the fragmentation is justified on the grounds of exploiting a genuine new market and becomes a viable expansion when the routes which the service might dilute are already operating at maximum frequency and market share; this is exemplified by the spate of new transatlantic links with twin-engined aircraft. The viability of fragmentation comes earlier if the established service is at a congested airport: not only is there likely to be frequency capping, but the airlines' costs will rise with congestion. The congestion effects are felt by the airlines as increased block times per flight, whether posted as random delays or accepted by opening up the scheduled flight times: the consequence is that more aircraft are required to fly the same network. The only way this effect could be reflected in the UK airline cost study (Ndoh, 1990) is through the 'time' or 'technology' variable. The overall value of this term is remarkably high, implying savings of over 9 per cent per year compared with 1.7 per cent in the Canadian study. Unfortunately, it was only in the last year of the data set that significant congestion began to occur in the London operations, so it is not possible to investigate the part that congestion has played in holding back the 'technology' effect on efficiency. In any case, it would have been very difficult to separate out the effects of congestion at Heathrow from the more general and more serious airspace congestion in the London
Terminal Area and throughout Europe. Fragmentation due to congestion is, of course, an unsatisfactory state of affairs, since it results from a choice between two higher cost alternatives than the cost-preferred option of expansion of service at the original base.

Taken over all the airlines, the remaining possibility for efficient use of a fragmented airport system is in satisfying the desire of new carriers to set up their own hub facility with some degree of autonomy. Experience in the US suggests that not more than two major airlines can hub successfully at a single airport, however large the airport. Since there is relatively little room for expansion at any of the London airports, a new hubbing operation is likely to need a new runway. There are few UK airlines with the financial capacity to launch even the sort of medium-sized hub that could be supported by a single runway: the natural assignment in today's conditions would be BA and British Midland at Heathrow, Air UK at Stansted, Britannia Airways at Luton and the rebirth of Air Europe at Gatwick. However, a delicate post 1992 question is the UK government attitude to any attempt by a non-UK carrier to take advantage of new London runway capacity to create a major hubbing operation in competition with British Airways. This threat already exists now that United Airlines and American Airlines have Heathrow route rights which they can use to connect with their fifth freedom European services, and the latter may soon be augmented as the EEC/US negotiations proceed. The recent move by American Airlines to serve Stansted has been aborted but there is a strong probability that the attractions of achieving a significant presence in London will prove too great for other non-UK major airlines. Either they will take direct advantage of the EC third package or seek control of the indigenous carriers. On these grounds the industry would appear to require new runways at Heathrow and Gatwick immediately, and eventually to support hubbing at Stansted and Luton.

A PARTIAL SOLUTION: A THIRD HEATHROW PARALLEL RUNWAY

The passenger, as the ultimate user, shows a preference for
Heathrow and a desire for low costs. Minimum airport cost implies expansion at Heathrow and Gatwick and full use of Stansted's capacity. Minimum airline cost requires the concentration of each airline's operations at the most appropriate airport, ie at their present bases. Given that marketing reasons for fragmentation within the London system are defensive rather than to exploit new markets, the wider interests of the UK airlines point in the same direction as their cost-minimisation needs, ie to the expansion of Heathrow.

The government's policy objectives internal to the air mode are to promote competition among airlines and among airports and to develop air services from the region as well as to achieve expansion with minimum disruption to airlines and compatible with site and airspace capability.

The broader societal objectives within which the industry and user needs should be met are compatibility with local planning, promotion of the regions and the minimisation of environmental impact.

Unless the government is to overturn the agreements limiting Gatwick and Stansted to one runway, both the user's, the industry's and the wider societal interests point to further expansion at Heathrow, provided that the site and airspace compatibility can be met, that the environmental disturbance is minimised and that airline competition is retained: the threat to competition comes from existing large carriers being able to buy up new slots which would be of value to emergent airlines and thinner routes.

The CAA's recent studies (CAA, 1990a) have apparently rejected an additional STOL runway at Heathrow. They appear to agree that a third full length parallel runway would be adequately compatible with airspace, but it is almost inconceivable that the Department of Transport Working Party will consider it to be compatible with either local planning or the environment. However, a preliminary investigation of the site possibilities from an airport planning viewpoint suggest that a compromise solution may well be available
which could give a valuable addition to Heathrow's runway capacity.

The proposed solution emerged as the result of a directed postgraduate group project in early 1990 (Beliyiannis, et al, 1990). The project showed that sufficient space exists between the A4 and M4 roads to accommodate a remote terminal serving a runway at least 1600 metres long without substantial demolition of property. The site was to have allowed three further runways in the original plans for Heathrow, but a ministerial decision stopped this scheme in 1952 (D'Albiac, 1957). It has however been considered many times since to have potential, not least for the UK-developed V/STOL aircraft proposals of the late 1960s. Indeed, Redhill and Northolt also featured in those studies, and the planning and operational feasibilities were established (Quick, 1971). There could be airside and groundside links to the main Heathrow site for passengers, but aircraft would be confined to the remote site.

It can be seen from Figure A8 that, in the summer of 1989, 95 per cent of European departures had sector lengths less than 1,000 nautical miles (nm). In fact, all domestic and over 60 per cent of European flights had sector lengths less than 500 nm. The total weekly departures were 830 domestic and 1,955 European. Long haul operations accounted for only 15.9 per cent of weekly departures, although they had more pronounced daily peaks. An additional short runway would be able to increase the Air Transport Movement (ATM) capacity very significantly without diminishing the short/long haul synergy. The land take and the potential environmental impact of the new runway would be minimised. The release of slots on the long runway(s) would, of course, encourage heavier ATMs to increase, so increasing the impacts there. However, this would probably occur to some extent wherever the new capacity were to be provided: the most desirable slots will always be at the existing long runways, and the longer haul ATMs will be most able to afford the market price. Any such specialisation of heavy aircraft on the longer runways and lighter aircraft on a short runway could enhance the capacity even further by decreasing the vortex
The study suggested that an 1,199 metre runway would allow access to some routes which are in danger of being priced out of the market, thus allowing even small airlines to compete and complement other services and preserving service to UK regions. This first rough analysis indicated that, by taking advantage of the type of operations licensed at London City Airport, almost no demolition need occur, and no existing residences would suffer even 57 Leq (35 NNI).

A 1,600 metre runway would require the purchase of approximately 50 houses in Sipson and some 400 houses would suffer between 57 Leq and 63 Leq (45 NNI) from 150,000 Stage III ATM on the new runway. No houses would be subject to more than 63 Leq, except those already subjected to that level from the existing operations. A 1,600 metre runway would certainly require the M4 Heathrow spur to be bridged, but the additional expense would undoubtedly be justified by the greater aircraft size and sector length which would then be available. Figure A9 indicates that both the 737-300 and
the 757-200 can land in wet conditions on a 1,600 metre runway at almost maximum landing weight, and can reach destinations of approximately 1,400 nm sector lengths with a full load of passengers and bags on an ISA + 10°C day and zero wind on the runway, even with no additional clearway. This is sufficient range to satisfy 100 per cent of domestic and 98 per cent of European departures, only three of the current European destinations not being within reach.

Even a 1,400 metre runway would allow a 757-200 to reach all domestic destinations and satisfy over 70 per cent of European departures, including virtually all of the dense routes. There are, of course, operational questions which require more detailed investigation, such as Category III operation and the need to allow for cargo. It is also likely that growth in traffic will call for the use of the 767 on some routes. It can be seen from Figure A9 that even the 767 is capable of a 600 nm sector from a 1,600 metre runway, giving the same destination coverage as a 737-300 from a 1,400 metre runway. Needless to say, concentrated operations off critical field lengths require special attention to safety areas at either end of the runway. The general layout of the site for the 1600 metre runway case is given in Figure A10.
FIGURE A10: POSSIBLE 1600m NEW RUNWAY AT HEATHROW

LEGEND:
1 - REMOTE STANDS
2 - PARKING AREA
3 - POWER SUPPLY
4 - SECURITY STAND
5 - MAINTENANCE
6 - FIRE STATION
7 - PEOPLE MOVER (AIRSIDE ROAD (TUNNELED))

1600 metre runway
Scale 1:10,000
In view of these facts, the adoption by the CAA and the elaboration by the BAA in the RUCATSE studies of a full length third runway as one of the options of Heathrow seems to lead to an unnecessary imbalance between the benefits to the industry and the resulting social costs. There are many more issues to be considered in balancing the costs and benefits, but the runway length holds the key to the operational flexibility. A longer runway might offer greater freedom of aircraft choice, but also might result in a much lower environmental limit on movement rates and times. Even a 2,000 metre runway, which would give full unrestricted European operations for a 767-300 even in Cat.III conditions, might be enough to trigger off an adverse balance, as well as giving problems with the eastern Public Safety Zone in Harlington. The environmental consequences of the local ground traffic associated with a free-standing terminal for the new runway might also be too great to be tolerable, compared with a remote satellite linked underground to the probable Terminal Five. The balance might similarly be tipped towards refusal at a public inquiry by the local disruption due to a linking taxiway and the consequent ground noise and emissions impacts between the new runway and the main site, rather than accepting the operational restraints of a remote runway, but integrated passenger, operation. Only a lengthy and complex analysis by the industry could clarify the values they would attach to these choices. Unfortunately, there is no equivalently comprehensive and accurate way of valuing the environmental and economic consequences of the choices prior to the acid test of a public inquiry. Any earlier feedback to the industry of the likely reception of the options could only be obtained from an early and ongoing discussion with environmentalists, planners and decision-makers.

In any such discussions, the industry could help its own case by enhancing the benefits of Reduced Take-off and Landing (RTOL) capability. The advent of high bypass engines has allowed Stage III aircraft not only to have low noise but also to move towards RTOL performance. A natural consequence of RTOL is slower flight, allowing steeper approach paths. It would take few modifications to any Stage III twin-engined
aircraft to allow it to approach at four degrees rather than three degrees, at the weights appropriate for the short fields and short sectors envisaged in the above discussion. This would reduce the Leq footprint areas from a 1,600 metre runway by between 15 and 20 per cent.

It is entirely possible that a combination of improved RTOL with new approach aids could allow steeper approach and climb-out, so offering the type of improvements which are being proposed for Stage III and a half regulations. Perhaps more importantly, the noise of the larger aircraft could be reduced in this manner, so allowing them to meet single event noise limits. Only detailed research can verify these suggestions. These benefits would apply to shorter runway operations at any chosen site, in a similar way to the Heathrow example.

Any other solution to the London runway capacity problem is likely to require a full length runway, with the consequent noise generation associated with fully loaded long haul aircraft. Some of the main Heathrow runway slots released by the new runway would, of course, be taken up by larger and longer haul aircraft, so the overall noise impact needs further study. It is still likely that, in terms of noise dose per new passenger, the Heathrow expansion solution will be preferable to expansion at any other existing sites. The short length of the extra runway should offer some inherent protection for those airlines who use it from competitive bidding by the large carriers, thereby allowing more inter-airline competition and preserving access for thinner routes and regional links, particularly if a separate pricing policy were adopted for the extra runway. This may compensate for the disadvantage of not being able to transfer aircraft between the remote and main runways. A final advantage of the new short runway is that it would help to balance the airside and terminal capacities when Terminal Five is finally constructed, particularly if competition continues to hold down average aircraft size.

A further exercise (Caves and Brooke, 1993), investigated the implication of a long third runway with full terminal
facilities for 40 mppa and taxiways to join the new development to the main Heathrow site. The resulting layout for a 2500 metre runway is shown in Figure A11, retaining the attractive centre of Harmondsworth, its church and graveyard, together with the hotel and industrial activity along the north side of the A4.

It would be necessary to demolish some 3000 houses with a total value (Council Tax Valuation) of £250m. It is therefore likely that £300m would be required for compensation (Chapter 6). The land take would cost a further £120m. If Harmondsworth residents wished to be bought out, a further cost of some £40m would be incurred. In addition, some 17,600 houses would be brought into the three runway 57 Leg contour compared with a two runway layout with 80 mppa. At £2000 per house, insulation would cost £35, though this is likely to be a low value because this noise model (the FAA INM) produced 24 hour Leg rather than the 16 hour Leg used for planning purposes and no industrial compensation is included. However, the major cost is for clearing the site unless the extreme compensation terms agreed at some US airports is presumed. The resulting discounted cost per extra passenger per year amounts to less than £2 at a real 6 per cent discount rate.

A purely market determination would therefore permit a full runway development at Heathrow, since airline experience has shown, that premiums on passenger yields at Heathrow over other airports are much greater than £2. However, this only deals with the purely local matter of land use and quality of life. All the national social, economic and environmental issues associated with the desirable quantity and location of air transport activity would still remain to be determined, together with the local non-aviation implications.
FIGURE A11: POSSIBLE LAYOUT FOR A NEW 2500 METRE RUNWAY AND TERMINAL FOR 40mppa AT HEATHROW
CONCLUSIONS

In retrospect, the development of UK air transport has been a rather classic example of disjointed incrementalism. The piecemeal development of London’s runways was made to seem reasonable by the presumptions that airlines would continue to be regulated and that passengers would not have strong preferences between airports. Development of single runway airports was similarly condoned by taking traffic forecasts only 15 years ahead and neglecting the possible development of 'fortress hubs'. The role of the regional airports was dictated not by the most concerned community as recommended by the Edwards Committee, but by airlines' policies which in turn were shaped by bilateral agreements favouring BA and London. BA's international position has been protected (not very successfully in the latest agreements allowing United and American to gain access to Heathrow) without supporting its position with adequate capacity at its main base.

The apparent lack of understanding of the dynamics of the industry, together with attempts by each element of the system to sub-optimise to its own short term advantage, has led to non-optimism provision of infrastructure.

Market liberalisation has been encouraged, despite the distortions produced by lack of capacity in the infrastructure. Although Edwards' advice to consolidate route licensing, airport development and the management of air traffic services under a single authority was taken precisely to allow coordinated development of services and their infrastructure, air traffic capacity is now well below that required for 'free flow' because the recent strong demand was not predicted. Too often, predictions have been based on assumptions of little change in the capability of aircraft technology, in airline management or in the regulatory environment; while all these factors actually have had a strong influence on the volume of air transport movements and the pattern of service.

The RUCATSE committees are still not internalising most of the more serious system interactions. Little work is being
done on the interactions between supply and demand or between supply and regional economies. Little thought seems to be given to the furthering of airline competition or to the need for peak, rather than annual capacity: the demand distribution model uses shadow costs only to control traffic to annual passenger limits rather than discriminating between those services and passengers who could pay the peak fees and the others. The committees are not open to the public. There is little recognition that the environmental consequences of each site need to be part of the optimisation process for the site prior to its evaluation against other sites, nor that the environmental debate is global as well as local.

The case study indicates that inadequate attention has been paid both to formal systems analysis and also to formal planning methodologies in developing the London airport system. Even within the limited and relatively manageable subsystem of the air transport industry and its users, there has been neither adequate coordination of effort, nor sufficient understanding of the systems costs and dynamics, nor the realisation that top-down assessments need to be balanced by bottom-up feasibility studies, nor any attempt to generate preferred solutions based on clear system objectives and their interpretation. An attempt has been made here to construct such objectives, to interpret them within recognized planning and technological constraints and to generate a feasible solution. A potential solution is a new short parallel runway to the north of the main Heathrow site. Alternatively, it is shown that a market approach to the local issues would justify a full length development which intuition suggests would be unacceptable to earlier public inquiries. It remains to conduct detailed tests of the designs and to evaluate them in relation to other alternatives in a wider societal context.