PLANNING MULTI-AIRPORT SYSTEMS IN METROPOLITAN REGIONS IN THE 1990s

POLICY GUIDE
based upon the
Analysis of Experience
at existing
Multi-Airport Systems

This report is a complete revision and update of
"Multi-Airport Systems in Metropolitan Regions"
R. de Neufville, 1986

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A Policy Guide based upon the Analysis of Experience at Existing Multi-Airport Systems

by Richard de Neufville

EXECUTIVE SUMMARY

This report develops policy guidelines for the development of additional airport capacity at major congested airports, with particular reference to the issue of when this capacity should be placed at the existing major airport or, alternatively, at a second airport.

When thinking about second airports for a metropolitan area, it is necessary to recognize that their performance, specifically their level of traffic and activity, depends on what is happening at the major airport for the region. The fact is that traffic tends to concentrate at dominant airports, just as all types of businesses tend to concentrate in specific locations. Second airports thus cannot be considered in isolation, they must be thought of as part of a multi-airport system.

This report first identifies and describes the performance of multi-airport systems, to provide the basis for defining a sound policy toward their development, if and when appropriate. The report thus features a unique, up-to-date catalogue of multi-airport systems worldwide.

Second, and indeed third, fourth and even fifth airports are a feature of major metropolitan areas throughout the world. The multi-airport systems are mostly located in the United States, since this country has traditionally had the busiest airports. Multi-airport systems are increasingly a feature of other major metropolitan regions worldwide, especially in Europe and the Far East. Airport planners for major cities now need to consider the possibility of multi-airport systems routinely. This report draws the lessons from experience as a guide to future planning.

Five general rules about the way multiple airports function in a metropolitan region can be drawn from the data:

1) Airport traffic for a metropolitan area, both consumer and airline, tends to concentrate at specific airports. The concentration continues until its advantages, due to increased frequency and reliability of service, are no longer worthwhile. Conversely, the old idea that each airport has a distinctive catchment area can be discarded.

2) There is a threshold for the effective commercial viability of a second major airport. This depends primarily upon the number of originating passengers from the metropolitan region as a whole.

3) The threshold for the viability of a second commercial airport increases with the size of the aircraft using the airport. This threshold is now on the order of 10 to 12 million originating passengers a year.

4) Second airports grow around niche markets -- distinct market segments that may be defined functionally, geographically or by some stratification of the customers by fare level or trip purpose.

5) Governments are relatively powerless to influence the distribution of traffic between airports, even under the most favorable circumstances. Market forces impelling concentration almost always prevail decisively.

Three additional rules apply to deregulated and privatized air transport, free of government strictures:

1) The airlines' practice of routing the bulk of their traffic through hub airports tends to reinforce the pattern of concentration of traffic at the dominant airports in a region.

2) To the extent that hubbing operations bring in traffic and trade that would otherwise be elsewhere, metropolitan regions should give priority to providing sufficient capacity at the primary, hub airport to provide for anticipated demands.

3) Governments are unable to use second airports as greenhouses for the establishment of new entrants in a market. thus reducing the possibility that a given airport may become an effective, commercially viable second airport.

The major policy conclusion that results from the analysis of multi-airport systems is that :

> "The development of second airports to serve a metropolitan region must, to be effective, be part of a long-term strategy of dealing with the uncertainties of future aviation traffic, especially as regards hubbing operations. Because of these risks, the most reasonable strategy may be to expand at primary hub airports while simultaneously establishing the option of developing secondary airports to serve some of the traffic originating from the region." (de Neufville, 1991)

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1. INTRODUCTION

1.1 Policy Context of Report

Many major airports are congested and overcrowded. In the United States, Boston/Logan, Chicago/O'Hare, Minneapolis/St.Paul, St. Louis, San Francisco/International and Seattle/Tacoma among others have all chronically been in this situation. Their congestion creates delays and other annoyances for the aircraft, passengers and cargo, and this is generally seen to be a transportation problem.

Moreover, these older airports, established over a generation ago, are each now surrounded by established communities which are adversely affected by the traffic, noise and dirt associated with the airport. Thus the transportation problem is aggravated by an environmental problem.

In the short run, some of the effects of traffic congestion and environmental problems can be mitigated by active management. The worst aspects of traffic congestion may be reduced by a range of pricing strategies and regulations. For example, charging higher prices at peak periods reorients some traffic to different times or other airports, thus reducing the maximum levels of congestion. Alternatively, rationing the number of operations during peak periods by rule or regulation can have a similar effect. Both in the United States and worldwide, there have been a few cases where such measures have been reasonably successful at minimizing the immediate transportation difficulties caused by congestion. For example, Federal Aviation Regulations (US FAA, 1992a) limit peak period traffic at the most congested airports in the United States -- Chicago/O'Hare, New York /Kennedy, New York/LaGuardia and

Washington/National, and the Port Authority of New York and New Jersey applies peak period pricing.

Environmental problems can also likewise be mitigated by various forms of regulation. Sophisticated landing and take-off patterns are used at a number of major airports in the United States to minimize noise effects. Aircraft landing to the South at Washington/National, for example, follow the twists of the Potomac River to avoid flying over the White House and other noise-sensitive residential areas. Similarly, aircraft leaving Boston to the South turn sharply to the left after takeoff, typically being at a right angle to the runway before its end, and thus fly over the harbor channel instead of the South Boston residential areas. Noise effects may also be mitigated by nighttime curfews (as typically applied in Europe), and by directional restrictions on runway use (as proposed for the new runway at Sydney).

Over the longer term, other measures may reduce transportation and environmental problems. Travel needs might be supplied by other modes, for example by high-speed rail in heavily traveled corridors up to about 500 miles. This has been done in Japan with the bullet trains, in France with the TGVs, and in the United States with the conventional Metroliners between New York and Washington. Aircraft noise can be reduced by retrofitting older aircraft with quieter engines and, eventually, by replacing the older, noisier aircraft. In fact, the noisiest transport aircraft now in service in the United States, those classified as Stage 2 aircraft, are slated to be replaced or quieted by the year 2000, in accordance with Part 91 of the Federal Aviation Regulations (US FAA, 1992b).[2]

Additional airport capacity is however the evident, and often the ultimately inevitable, solution to the problems of airport congestion. How additional airport capacity should

be built is a major policy issue for both local and national governments and business interests. The issue has been the focus of extensive controversy in Australia (concerning Sydney), China (Hong Kong/Chek Lap Kok), England (Stansted, the Third London Airport and RUCATSE), Germany (Munich), Japan (Tokyo/Narita and Osaka/Shin Kansai) and on the island of Taiwan. In the United States, similar controversies have been taking place for Boston, Chicago, Minneapolis/St.Paul, St. Louis, San Francisco/International and Seattle/Tacoma.[3]

There are two major questions with regard to additional capacity for major airports. The more obvious is whether the additional airport capacity should be located at the existing major airport or elsewhere, at a second airport for the region. Most studies of capacity expansion at major airports focus primarily on this issue. Specifically, this is the focus of the recurring debates about Boston, St. Louis and Seattle.

The more subtle, but often the crucial question is how traffic will distribute between the existing major airport and a possible second airport. The question is vital because available capacity at second airports often remains unused for long periods. For years, the extensive capacity at New York/Newark and Washington/Dulles went unused while their companion airports in the metropolitan region (New York/LaGuardia and Kennedy, and Washington/National and Baltimore) remained congested (See Section 3.1; de Neufville, 1986, provides numerous detailed case studies). While these facilities are now finally heavily used, the investments in capacity at these locations appear to have been premature. The experience has been similar internationally, notably around London, Milan and Paris. To the extent that capacity at a second airport may not be used for a decade or more, these investments should be as inexpensive as possible.

The point in investing in capacity away from the major congested airport is, in general, to establish a second site as a potential major airport and, thus, to provide the insurance that future capacity for the region can be fully developed as and when needed after the primary airport is fully developed. This is the plan for Sydney, for example: the Australian federal government has deliberately bought a site for the Second Sydney Airport far in anticipation of need, and is to build minimal runways and facilities to establish the use of the site as an airport, but is deferring other major expenses, such as passenger buildings, until there is a clear clientele for these facilities. Meanwhile, it is expanding the capacity of the existing major airport, Sydney/Kingsford Smith (See Australia, 1985; Federal Airports Corp., 1990; and de Neufville, 1991).

The central policy question addressed by this report is: When, and under what circumstances, is it desirable to invest in a second airport in a metropolitan area? To address this issue intelligently, it is necessary to focus on the way traffic divides between primary and secondary airports in a metropolitan region, that is, on the operation of multi-airport systems.

1.2 Objective of Report

This report develops policy guidelines for the development of additional airport capacity at major congested airports, with particular reference to the issue of when this capacity should be placed at the existing major airport or, alternatively, at a second airport.

This report complementarily suggests a strategy for the long-term development of airport capacity for major

metropolitan regions, which involves establishing the option of developing secondary airports, to preserve the flexibility to meet this need if future traffic warrants. In short, this report presents policy guidelines for the development of multi-airport systems for metropolitan regions.

To provide a sound basis for these guidelines, this report presents the conceptual and factual basis for understanding the nature and operation of multi-airport systems in metropolitan regions. It does this by summarizing and bringing up to date the best information available on this topic.

1.3 Organization of Report

The organization of the report reflects its objectives. After this introductory section, Part 2 develops the concept of multi-airport systems in metropolitan areas, so as to present a clear, relevant definition of the system of interest.

Part 3 focuses on the essential phenomenon of traffic concentration at the primary airport facility in the market. Any intelligent discussion of the development of additional capacity at major airports, and of multi-airport systems generally, must start with this understanding that market forces impel this concentration; neither governments nor planners can do much to distribute commercial, customer-oriented traffic in ways they might prefer.

Part 4, finally, develops the basic strategy for how and when second major airports should be developed. In doing so it draws upon extensive worldwide experience.

1.4 Background Work

This report builds upon and extends the previous report to the FAA, entitled "Multi-Airport Systems in Metropolitan Regions" (de Neufville, 1986). The essence of that document has been published in a number of US and foreign professional journals (de Neufville, 1984a, 1984b, 1985a) and two major environmental impact statements (de Neufville, 1985b, 1990).

This report is both an update and a significant extension of the previous document. It presents the current data that document the general conclusions demonstrated earlier. Furthermore, it applies these concepts to describe and explain a number of special, local situations. The result is a comprehensive view of the role of multi-airport systems in the United States and internationally.

The original report established five general rules about the way multiple airports function in a metropolitan region. These were documented in detail through international statistics and case studies of major airports (de Neufville, 1986). In brief, these general rules are:

1) Airport traffic for a metropolitan area, both consumer and airline, tends to concentrate at specific airports. The concentration continues until its advantages, due to increased frequency and reliability of service, are no longer worthwhile. Conversely, the old idea that each airport has a distinctive catchment area can be discarded.

2) There is a threshold for the effective commercial viability of a second major airport. This depends primarily upon the number of originating passengers from the metropolitan region as a whole.

3) The threshold for the viability of a second commercial airport depends on the size of the aircraft using the airport and their frequency. In the mid 1980's, this

threshold was on the order of 10 million originating passengers a year.

4) Second airports grow around niche markets -- distinct market segments that may be defined functionally, geographically or by some stratification of the customers by fare level or trip purpose.

5) Governments are relatively powerless to influence the distribution of traffic between airports, even under the most favorable circumstances. Market forces impelling concentration almost always prevail decisively.

These general rules still hold. They are confirmed by both the developments over the last decade, and the recent data presented in this report. The fact that passengers in a metropolitan area primarily choose their airport according to the frequency of competitive service has particularly been confirmed by a range of empirical studies such as those of Kanafani and Gobrial (1985), Harvey (1987), Ashford and Bencheman (1989), Ozoka and Ashford (1989), Ashford (1989), Alamdari and Black (1992), and Cohas (1993).

1.5 Contribution of Report

This report extends the previous report (de Neufville, 1986) in three important ways:

1) It goes beyond the general rules to describe and explain the range of special situations;

2) Based upon this investigation, it proposes a comprehensive view of the function of multiple airports in metropolitan regions; and

3) It indicates that when additional airport capacity is required in a region, it is most reasonable to site the immediate addition at the primary airport when it serves as a major hub for some airlines; however,

4) Given the unavoidable uncertainty about future traffic, it is generally sensible at least to preserve the possibility to develop a second airport as a reasonable insurance against the risk of need.

This report refines the original analysis in two important details. The scope of the analysis is larger. The report considers virtually all second airports in metropolitan regions, whether these have significant traffic (more than 1 million total passengers a year) or not. It also includes a much wider range of international situations. These extensions reaffirm and strengthen the prior analysis.

Conceptually, the report proposes a new definition for metropolitan regions, one that is both functional and objective. Major airports may now be quite far from traditional city centers, either in time or distance. Consequently, neither the major nor the potential second airports for a region may lie in the jurisdictions defined by custom or administrative rule. It is thus important to be clear about what airports might properly be considered to serve a metropolitan region.

Four new findings concerning multiple airports emerge from the analysis of the industry during the deregulation that has been occurring over the last decade. These are:

1) The threshold for the commercial viability of second airports has risen, in line with the introduction of widebody aircraft into greater use, and the ability to transport more passengers with a given frequency. In the 1990's, the threshold would appear to be between 10 and 12 million originating passengers a year.

2) The airlines' practice of routing the bulk of their traffic through hub airports tends to reinforce the pattern of concentration of traffic at the dominant airports in a region.

3) To the extent that hubbing operations bring in traffic and trade that would otherwise be elsewhere, metropolitan regions should give priority to providing sufficient capacity at the primary, hub airport to provide for anticipated demands.

4) Because of deregulation in the United States, (and privatization of airlines and airports worldwide), second airports may no longer be able to serve as greenhouses for the establishment of new entrants in a market. This reduces the possibility that a given airport may emerge as an effective, commercially viable second airport.

The major policy conclusion that now results from the analysis of multi-airport systems is that (de Neufville, 1991):

> "The development of second airports to serve a metropolitan region must, to be effective, be part of a long-term strategy of dealing with the uncertainties of future aviation traffic, especially as regards hubbing operations. Because of these risks, the most reasonable strategy may be to expand at primary hub airports while simultaneously establishing the option of developing secondary airports to serve some of the traffic originating from the region."

2. CONCEPT OF MULTI-AIRPORT SYSTEMS IN METROPOLITAN REGIONS

2.1 Geographic Definition of System

Generally speaking, a multi-airport system is the set of airports that serve a particular metropolitan area. The multi-airport system for New York City, for example, includes - among others - the major airports associated with the area: New York/Kennedy, New York/LaGuardia and New York/Newark.

In the case of New York, the fact that a single agency, the Port Authority of New York and New Jersey, owns and operates the three major airports reinforces the concept that they are part of an airport system. The Port Authority routinely reports, nationally and internationally, on the performance of these facilities, and consistently creates the image that these airports are part of a system. But does ownership or control by itself usefully define the system for the purpose of transportation planning?

From the perspective of the users, and therefore of the function of the system, the ownership of the airports is almost always irrelevant. The only exceptions to this rule occur when a region is divided by a significant barrier to trade or travel. Until recently, for instance, the several airports around Berlin could not considered to be part of a common system, because a practically impenetrable frontier between the former East and West Germanys separated the airports.

The concept of a multi-airport system, from the perspective of the users, thus properly includes all the airports that effectively serve a region. Thus Oakland Airport - closer to the city of San Francisco than the San

Francisco/International airport - is functionally part of the multi-airport system for San Francisco, even though it is neither in the city nor operated by the same agency. Likewise, because the cities of Baltimore and Washington are so close, the airport next to the city of Baltimore is effectively part of the multi-airport system for Washington - that airport is even called the Baltimore-Washington International Airport.

The fact that airports associated with different cities and jurisdictions can be part of the same multi-airport system needs to be stressed. This concept is a definite shift from the past, when it was understood that the Baltimore airport served Baltimore, the Washington airport served Washington and so on.

The change to a functional, geographic definition of a metropolitan airport system results from the fundamental changes in urban structure in the major cities of the world. The combined effect of enormous growth in the metropolitan areas, and of the spread of rapid modes of urban transport such as expressways and high speed rail systems, has been to spread cities over much wider areas, to merge many cities into each other, and to create metropolitan regions that function effectively as a unit even when the traditional legal boundaries have not changed. Thus as a practical matter Baltimore and Washington merge into a single area, even though their centers are 37 miles apart. Many Washington suburbanites find it easier to get to the Baltimore airport than to either Washington/National or Washington/Dulles.

Where does one draw the line, if one cannot rely on the traditional category of ownership to establish membership in a common multi-airport system? An operational definition seems in order. The most important criteria would seem to

refer to the accessibility of the airports and thus to their potential for participating effectively in the traffic of the metropolitan region.

For this report, airports are considered to be part of a multi-airport system for a metropolitan region if they meet either of two criteria:

1) They are as close as one of the existing major airports, for a significant fraction of the traffic in the metropolitan region, or

2) They are officially designated and operated as part of the multi-airport system by local authorities.

The first criterion is the principal test for membership in the system. In the United States, it translates into including all airports within about an hour of the commercial and residential centers of a metropolitan region, For

Boston, for example, where much of the business and suburbs are located on the ring highway (US Route 128/Interstate 95), this criterion leads to the inclusion of three airports that for many Bostonians are in fact closer in time than the main airport (Boston/Logan) although two of them are in different states. In order of importance, the three airports thus included in Boston's multi-airport system are: Providence, Rhode Island; Manchester, New Hampshire; and Worcester, Massachusetts, each of which is within 50 miles (80 km.) of the ring road around Boston.

Note that this user-oriented criterion for inclusion in a multi-airport system conflicts with established ideas and political pride. The Massachusetts Port Authority (Massport) which operates Boston/Logan, when looking for a site for a second airport for Boston, refused to consider possibilities outside the state. The airport authorities in New Hampshire and Rhode Island likewise do not consider themselves to be dependencies of Boston. These political

attitudes are important and must be recognized in the right context. For analyzing the operation of the system, however, one must take the perspective of the users, for whom these territorial jealousies are of no importance.

Airlines and users make their decisions about airports based upon commercial opportunities and convenience, just as people everywhere do when making other kinds of business and residential decisions. The criterion of accessibility is thus maintained throughout this report.

Note further that the criterion of accessibility applies differently in various situations. For Japan, for example, this criterion translates into hours of travel time since the major metropolitan airports are hard to reach. It routinely takes up to three hours to reach the major international airport Tokyo/Narita from significant parts of the city. At that rate even the airports at Nagoya and Sendai could be considered part of Tokyo's airport system, since they are only (!) 2 hours away from the Tokyo by bullet train. The new Osaka Airport (Shin Kansai) will equally be difficult to reach from parts of the greater Osaka/Kyoto metropolitan area.

The second criterion for being part of the multi-airport system, the designation by local authorities, applies only in special situations. The most obvious one concerns Sao Paulo, Brazil, whose international airport at Viracopos is located some 60 miles (about 100 km.) from the city center, over reportedly difficult roads. Although this airport has little traffic, as passengers prefer to use the convenient Sao Paulo/Garulhos airport and transit to intercontinental flights through Rio de Janeiro/Galeao, it seems necessary to include Viracopos in the Sao Paulo multi-airport system.

2.2 Focus on Commercial Operations

Since the central policy issue addressed by this report is how to add capacity to major airports in metropolitan regions so as to improve air transportation, it is therefore necessary to focus attention on airports that provide air transportation services to the public.

Airports which do not provide commercial air transportation are thus excluded from consideration as part of the multi-airport transportation system for the purposes of this report. In another context, for example that of air traffic control, all airports in a region would have to be considered. But when thinking about where to put airport capacity that will be useful to airlines, passengers and cargo, it is legitimate to exclude non-commercial airports from the discussion.

Military facilities, private airports closed to the public, and general aviation airfields without substantial airline service are thus excluded from consideration in this report. This exclusion now does not mean that some of these facilities might not become part of the multi-airport system for a metropolitan region in the future. A military facility might be opened to commercial services, for example, or a general aviation field such as Boston/Hanscom might receive scheduled commercial services, as that airport once did.

For generality, this report includes all commercial airports that meet the accessibility criterion in the definition of the multi-airport system of a metropolitan region, even if their traffic is low. This approach contrasts with some previous discussions which, for simplicity, excluded airports with less than a certain amount of traffic. The list of airports in multi-airport systems (Tables 1 and 2)

is therefore considerably more extensive than has been usual.

2.3 Multi-Airport Systems Worldwide

Tables 1 and 2 identify the multi-airport systems in metropolitan regions worldwide. The regions are listed by the estimated number of passengers originating in the region, since this parameter is key to the viability of a multi-airport system, as discussed in Section 2.5. The traffic reported includes that of all the airports in the region, not just those traditionally associated with the metropolitan area. Thus the traffic reported for Boston includes the traffic from Providence, Manchester and Worcester.

The numbers of annual passengers are reported only to the nearest million, due to the great variability between data reported in different sections of the world. The number reported as the "Total Traffic" is frequently a compromise between two or three of the sources used. For example, the data of the U.S. Federal Aviation Administration reflects the traffic reported by "Certified Route Air Carriers" -- thus omitting the passengers carried by charter flights, which are especially popular in international trade but that also exist in the United States. These FAA data thus have to be adjusted upwards. The more complete sets of data of the International Civil Aviation Organization are however neither fully consistent with reports of individual airports nor compatible with other comprehensive sources, such as that of the Aeroports de Paris. These discrepancies result from a variety of causes, for example the fact that both Britain and Japan tend to focus on a fiscal year ending March 31 instead of a calendar year. But these differences are not worth arguing over since the number reported for "Total Traffic" may, in any case, be assumed to be accurate

only to within a few percent, that is to about plus or minus half a million.

The number reported in Tables 1 and 2 for the "Estimated Originating Traffic" is estimated from the formula:

Originating Traffic = (Total Traffic - Transfers) / 2

on the reasonable assumption that there is essentially no net migration and the number of travelers originating from a region and arriving in it are equal.

The inaccuracy of the estimates derives from the inescapable vagueness of data on transfer traffic. This is due to the airlines' reluctance to reveal the details of their operations and to different ways of defining which passengers are transfers. (For example, if a traveler spends 8 hours in London between flights, is that person simply suffering an inconvenient connection, or actually visiting London for the day?) Given this uncertainty, estimates of originating traffic are probably accurate to within 10 percent, which is close enough for this discussion.

Tables 1 and 2 list all known multi-airport systems. Table 1 provides information on all the metropolitan regions with the most air traffic, though those with more than either 5 million originating, or 18 million total, passengers a year. This threshold includes regions that have been considering possible major second airports, such as Atlanta, St. Louis and Minneapolis-St. Paul in the United States, and also Sydney and Bangkok. Table 2 gives data on metropolitan regions with fewer passengers a year that feature multi-airport systems.

Table 1: Metropolitan Regions Worldwide Ranked by Millions of Originating Passengers in 1991 (1992 for the United States), for all regions with more than 5 million originating, or 18 million total, passengers a year. (Airports within a region ranked by their total passengers).

Metropolitan Region	Airports in System, by size	Multi-Airport System	Estimated Originating Traffic	Total Traffic
New York	Kennedy; Newark; LaGuardia; *Islip; Stewart; White Plains*	Yes	27	73
London	Heathrow; Gatwick; Luton; Stansted; *London City*	Yes	24	63
Los Angeles	Internatl.; Ontario; Orange Co.; Burbank; *Long Beach*	Yes	23	62
Tokyo	Haneda; Narita	Yes	20	60
Paris	C.de Gaulle; Orly;	Yes	18	45
Chicago	O'Hare; Midway	Yes	15	64
San Francisco	Internatl.; San Jose; Oakland	Yes	15	47
Washington	National; Dulles; Baltimore	Yes	15	43
Miami	Internatl.; Ft Lauderdale; W. Palm Beach	Yes	12	38
Dallas / Fort Worth	Dallas/Fort Worth; Love Field	Yes	11	54

Boston	Logan; Providence; *Manchester; Worcester*	Yes	10	24
Osaka	Itami; Shin Kansai	Opening 1994	10	24
Taipei[4]	Chiang Kai Shek; Shen Shan	Qualified Yes	9	18
Atlanta			8	45
Frankfurt			7	27
Toronto	International; *Island*	Insigni-ficant	7	17
Seoul	Young Jong in construction		7	17
Orlando			7	17
Las Vegas			7	17
Houston / Galveston	Intercont.; Hobby	Qualified Yes	6	27
Denver			6	27
Detroit	Metro; *City*	Insigni-ficant	6	22
Honolulu			6	22
Rome	Fuimicino; *Ciampino*	Insigni-ficant	6	17
Stockholm	Arlanda; *Bromma*	Insigni-ficant	6	13
Rhine-Ruhr Valley	Dusseldorf; Koln/Bonn	Non-Market Yes	6	14
Madrid			6	14
Phoenix			5	22
Hong Kong	Kai Tak; Shenzhen	Non-Market Yes	5	21
St. Louis			5	20
Minneapolis / St.Paul			5	19
Seattle			5	17
Amsterdam			5	16
Singapore			5	15
Bangkok			5	14
Manchester	Internatl; *Leeds/ Bradford Liverpool*	Non-Market Yes	5	13
Sydney			5	13

Sources: ICAO (1993) *Airport Traffic 1991*
ICAO (1993) *Aviation Statistics of the World*

U.S.FAA (1993) *Airport Activity Statistics*
U.K.DoT (1993) *RUCATSE Report*
Mao (1993) *Developing CKS Airport*

For meaning of "Qualified Yes", "Non-Market Yes" and "Insignificant", see the discussion in Section 2.4.

Airports in Italics have less than 1 million total passengers a year.

Table 2: Metropolitan Regions Worldwide With Multi-Airport Systems but less than either 5 million Originating, or 18 million Total, Passengers in 1991 (Airports within a region ranked by their total passengers).

Metropolitan Region	Airports in System, by size	Multi-Airport System	Estimated Originating Traffic	Total Traffic
Milan	Linate; Malpensa	Qualified Yes	5	11
Moscow	Shreremetyevo; Vnukovo; *Domodedovo*	Non-Market Yes	4	9
Oslo	Fornebu; Gardemoen	Yes	4	8
Rio de Janeiro	Galeao; Santos Dumont	Qualified Yes	3	8
Montreal	Dorval; Mirabel	Yes	3	7
Berlin	Tegel; Schonfeld; *Tempelhof*	Non-Market Yes	3	7
Sao Paulo	Garulhos; *Viracopos*	Qualified Yes	3	7
Glasgow/ Edinburgh	Glasgow; Edinburgh; *Prestwick*	Non-Market Yes	3	7
Buenos Aires	Aeroparque Ezeiza	Qualified Yes	3	6

Sources: ICAO (1993) *Airport Traffic 1991*
ICAO (1991) *Civil Aviation Statistics of the World*
BAA (1992) *1991 Annual Review*

For meaning of "Qualified Yes", "Non-Market Yes" and "Insignificant", see the discussion in Section 2.4.

Airports in Italics have less than 1 million total passengers a year.

2.4 Special Situations

Tables 1 and 2 qualify multi-airport systems in three ways: "Qualified Yes", "Non-Market Yes" and "Insignificant". As described in detail below, these qualifications mean either that planners did not have any real choice in the matter, or that the second airport in the system has so little traffic that it does not justify the cost of major capital investment. Either way, the qualifications imply that these multi-airport systems are not appropriate examples on which to base future policy about major capacity additions.

"Qualified Yes": means that because the primary airport was unable to handle intercontinental aircraft, a second airport with long runways was developed as an operational necessity. This was certainly the case for Buenos Aires, Houston, Milan, Rio de Janeiro, Sao Paulo and Taipei. In the case of Buenos Aires, Milan and Sao Paulo, the older airport has proved to be more convenient for travelers (much as more passengers use Washington/National than Washington/Dulles), and has remained the dominant airport. At Rio de Janeiro and Taipei the downtown airport operates close to its capacity.

"Non-Market Yes": means that the multi-airport system came into existence through historical reasons rather than by design. This is the case for the airports in the Rhine-Ruhr Valley, in Scotland, and around Manchester (England), Hong Kong, Moscow and Berlin.

The situation in Berlin is obviously a result of the division of the city between East and West Germany. Each country then needed to maintain a major airport on its side of the frontier. Now that Germany is reunited, planners are trying to develop a more rational future for the airports. Already Berlin/Tempelhof is virtually closed.

The airports around Moscow were apparently developed primarily for military and security purposes. Now that these motives no longer seem to drive planning decisions, it may be expected that the role and use of these airports will shift to some more rational transportation arrangement.

The future of the Hong Kong airports is subject to an intense political contest. The commercial interests oriented toward Britain favor replacing the existing crowded airport (Hong Kong/Kai Tak) by constructing a new airport at Chek Lap Kok, as an extension to one of the Hong Kong islands. Although this project is estimated to cost no less than US$ 15 billion (!), it would have the advantage of keeping business near the existing city. The mainland Chinese on the other hand favor developing the new airport at Shenzhen, outside the Hong Kong territory, but plausibly as accessible to the city as Chek Lap Kok -- and certainly much closer to the booming industrial zone being built in Shenzhen. Ironically, much of the crowding at the existing airport is due to transfer traffic between Taiwan and Mainland China, which may be expected virtually to vanish when normal relations and direct flights are established between those two jurisdictions. In short, the existence of these two airport projects reflect a struggle over the future of the city rather than a transportation necessity.

The airports in the Rhine-Ruhr Valley, in Scotland for Glasgow and Edinburgh and in England around Manchester, developed around nearby cities, much as the Washington/National and Baltimore airports developed to serve their cities. In Germany, development of the secondary Koln/Bonn airport was almost a political necessity since it was nearest to the capital of West Germany. It will be interesting to see how the Koln/Bonn airport fares as the German capital reverts to Berlin.

"Insignificant": Means that the second airport is virtually not a factor in the air transportation for a metropolitan region, because it has little traffic (less than 1 million total passengers a year) and serves a trivial fraction of the traffic for the region. This is the situation for the second airports around Detroit in the United States and around Toronto, Rome, Stockholm, Manchester and Sao Paulo, as Tables 3 and 4 show. This level of traffic does not justify major investments in new airport capacity, and these situations should not be taken as good examples of multi-airport systems for future transportation planning.

A number of smaller airports in the larger multi-airport systems also have insignificant levels of traffic, and can in general terms be disregarded as major airports. These exist around New York, London, Los Angeles, Boston and Detroit, as Table 4 shows.

Table 3: Second Airports outside the United States with Insignificant Levels of Traffic (less than 1 million Total Annual Passengers a Year in 1991) ranked by the traffic in the multi-airport system.

Metropolitan Region	Second Airport	Total Passengers Millions/yr.	Market Share, %
London	London City		~ 1
Toronto	Island		~ 1
Rome	Ciampino	0.52	3.2
Stockholm	Bromma		~ 1
Manchester	Leeds Bradford	0.70	5.0
	Liverpool	0,1?	~ 1
Sao Paulo	Viracopos	0.16	1.4
Glasgow	Prestwick	0.07	1.0

Source: ICAO (1993) *Airport Traffic 1991*
BAA (1992) *1991 Annual Review*
U.K.(1993) *RUCATSE Report*

Table 4: Secondary Airports in the United States with Insignificant Levels of Traffic (less than 1 million Total Annual Passengers a Year in 1992), ranked by traffic in the multi-airport system.

Metropolitan Region	Second Airport	Traffic, Millions/yr.	Market Share, %
New York	Islip	0.75	1.1
	Stewart	0.65	0.8
	White Plains	0.40	0.6
Los Angeles	Long Beach	0.80	1.3
Boston	Manchester	0.56	2.4
	Worcester	0.14	0.6
Detroit	City	0.56	2.4

Source: U.S.FAA (1993) *Airport Activity Statistics*

2.5 Threshold of Viability of Second Airport

Table 1 illustrates a simple and most important proposition:

> Above a certain level of originating traffic from a metropolitan region, a second airport (and thus a multi-airport system) is viable. Below this level it is not.

All the metropolitan regions with the greatest number of originating passengers have active second airports, well known to be commercially viable and to fill a significant role in the regional air transportation system.

The rule for regions with lesser amounts of traffic is that they only have second airports because of operational or political necessity.

The only exceptions to this rule are Oslo, where charters have been directly away from the downtown airport; and Montreal, which is widely interpreted to have been a mistake, both as a transportation and a financial decision.

The threshold for the viability of second airports -- in terms of having a significant amount of traffic, that is of over 1 million total passengers a year -- appears now to be between 10 and 12 million originating passengers a year. This threshold is not likely to be reached until the total traffic of the region exceeds 25 million total passengers a year or much more if the primary airport is a transfer hub at which many passengers arrive by air merely to change aircraft for a final destination elsewhere.

The threshold has risen along with the size of aircraft, as larger aircraft carry more passengers at a comparable frequency of service. It appears to have risen from about 8

million originating passengers a year of a decade ago. This trend is likely to continue.

3. DISTRIBUTION OF TRAFFIC

3.1 Natural Concentration of Traffic

There is always a dominant or primary airport in a multi-airport system. The secondary airports generally have significantly less traffic than the dominant airport.

This natural tendency of traffic to concentrate at primary airports is demonstrated in Table 5. As can be seen, the traffic at the largest secondary airports is typically 50% or less than the traffic at the primary airport. Traffic at the third, fourth and fifth airports in a multi-airport system is correspondingly even lower.

This tendency exists even though many of the secondary airports are more convenient to a large fraction of the passengers, and even though governments, airport authorities and city planners have tried to spread the traffic around to the secondary airports. In the San Francisco region for example, San Francisco/Oakland is the airport closest to about 40% of the region's passengers but only has about 17% of the market, despite the airport's continuing desire to attract traffic. The situation is much the same for New York/Newark.

Table 5: Traffic at Secondary Airport is Generally Significantly Less than at the Dominant Airport (Rank of Second Airports as in Tables 1 and 2).

Metropolitan Region	Traffic at Secondary Airports as a Percent of Traffic at Primary Airport			
	Second	Third	Fourth	Fifth
New York	84	75	3	2
London	46	5	4	1
Los Angeles	13	12	8	2
Tokyo	44			
Paris	93			
Chicago	7			
San Francisco	18	17		
Miami	26	18		
Washington	48	43		
Dallas/Fort Worth	12			
Boston	9	2	1	
Taipei	38			
Houston/Galveston	42			
Hong Kong	10			
Rhine-Ruhr Valley	27			
Montreal	50			
Manchester	5	1		
Oslo	26			
Glasgow	57	2		
Buenos Aires	80			
Average percent	37	20	4	2
Average times less than first airport	2.7	5	25	50
Range	1.1 - 20	1.3 - 100	12 - 100	25 - 100

Sources: ICAO (1993) *Airport Statistics 1991*
U.S.FAA (1993) *Airport Activity Statistics*
U.K.DoT (1993) *RUCATSE Report*
Mao (1993) *Developing CKS Airport...*

3.2 Reasons for Concentration

Market forces drive the concentration of traffic: Customers flock to where the service is best; Providers install themselves preferentially where there are the most customers. Competition reinforces the tendency of traffic to concentrate. Providers recognize that customers will go preferentially to the site with the widest, the best array of services, and thus strive to match the level of services provided by their competitors. They thus are reluctant to provide services to secondary sites.

Geographic concentration of services is a pervasive phenomenon. It occurs in virtually all markets, and has done so throughout recorded history. In any city, various services are predominantly found in particular areas: the financial center, the entertainment district, the jewelers' streets, etc. Regionally or nationally, particular types of services concentrate in specific metropolitan areas: in the United States for example, financial services center in New York, the movie industry focuses on Los Angeles, automobile production dominates around Detroit, and high tech industries are salient in Silicon Valley.

The concentration of airline traffic at primary airports is a natural expression of competitive markets. The phenomenon will be present wherever there are market economies. The fact has been extensively documented for airports systems (Gelerman and de Neufville, 1973; de Neufville, 1976, 1984b, 1985b and 1986; Cohas, 1993).

The interesting question is not the fact of concentration, which is clear, but its extent. How much concentration will exist? It obvious that secondary sites do develop: suburban malls complement downtown shopping areas, for example. What

factors encourage the development of secondary sites, of second airports in particular?

Congestion at the primary site is a principal factor counteracting the tendency toward concentration. It intrinsically increases delays and thus the costs of doing business: people and machines are forced to wait unproductively. Customers and businesses naturally try to avoid these aggravations and are impelled to consider less busy -- that is, secondary -- sites.

A useful way to think about the tendency to concentrate is that, as Figure 1 suggests, it consists of two main elements:

1) the *positive* reinforcement of better services (bigger => more services => more attractive => even bigger), and

2) the *negative* counteraction of congestion (bigger => congestion => higher costs => less attractive => smaller).

The degree of concentration established in a multi-airport system depends on the equilibrium between the positive and negative feedback loops. That equilibrium is of course specific to the context of the system, as defined by at least four elements: the size of the aircraft being used; the degree of hubbing operations; the competitive environment between the airlines; and the comparative accessibility of the primary airport.

The size of the aircraft affects the level of congestion at the primary airport. In general terms, when larger aircraft are used to service any given number of passengers, there is less congestion. Larger aircraft may be introduced into service in two ways: either because they become available, as with the introduction of the wide-body aircraft in the

late 1980's, or because of airline decisions about their fleets. Since larger aircraft become available because airlines decide to buy them, the long-term tendency is to have larger aircraft, to reduce the congestion associated with a given number of passengers per year, and thus to raise the threshold for the viability of secondary airports. This phenomenon is reflected in the trend of the last 20 years.

The degree of hubbing, of transfer operations, that occurs at a primary airport clearly influences the relative allocation of passengers in a multi-airport system, as Section 3.3 discusses in detail. Passengers transferring between aircraft do not switch airports, and should be excluded from consideration when thinking about the traffic that promotes a multi-airport system, as discussed in Section 2.3. The degree of hubbing can change relatively quickly in a deregulated environment, simply as a result of airline decisions.

The competitive environment is clearly an important factor: the phenomenon of concentration is a direct result of market forces. The greater the competition, the stronger the tendency to concentrate. Conversely, monopolistic situations favor the development of secondary airports. An important reason why the two Paris airports share traffic fairly evenly (see Table 5) is that the French government generally prefers to dampen competition.[5] Similarly, the development of secondary airports is thus often stimulated by airlines that have a unique, niche market, as Section 3.4 indicates.

The accessibility of an airport, compared to other airports in the system, influences its share of the market. Secondary airports will have a comparative advantage in terms of being close to their immediate region, and will normally draw most

of their traffic from a local catchment area. In effect, they have a geographically defined niche market.

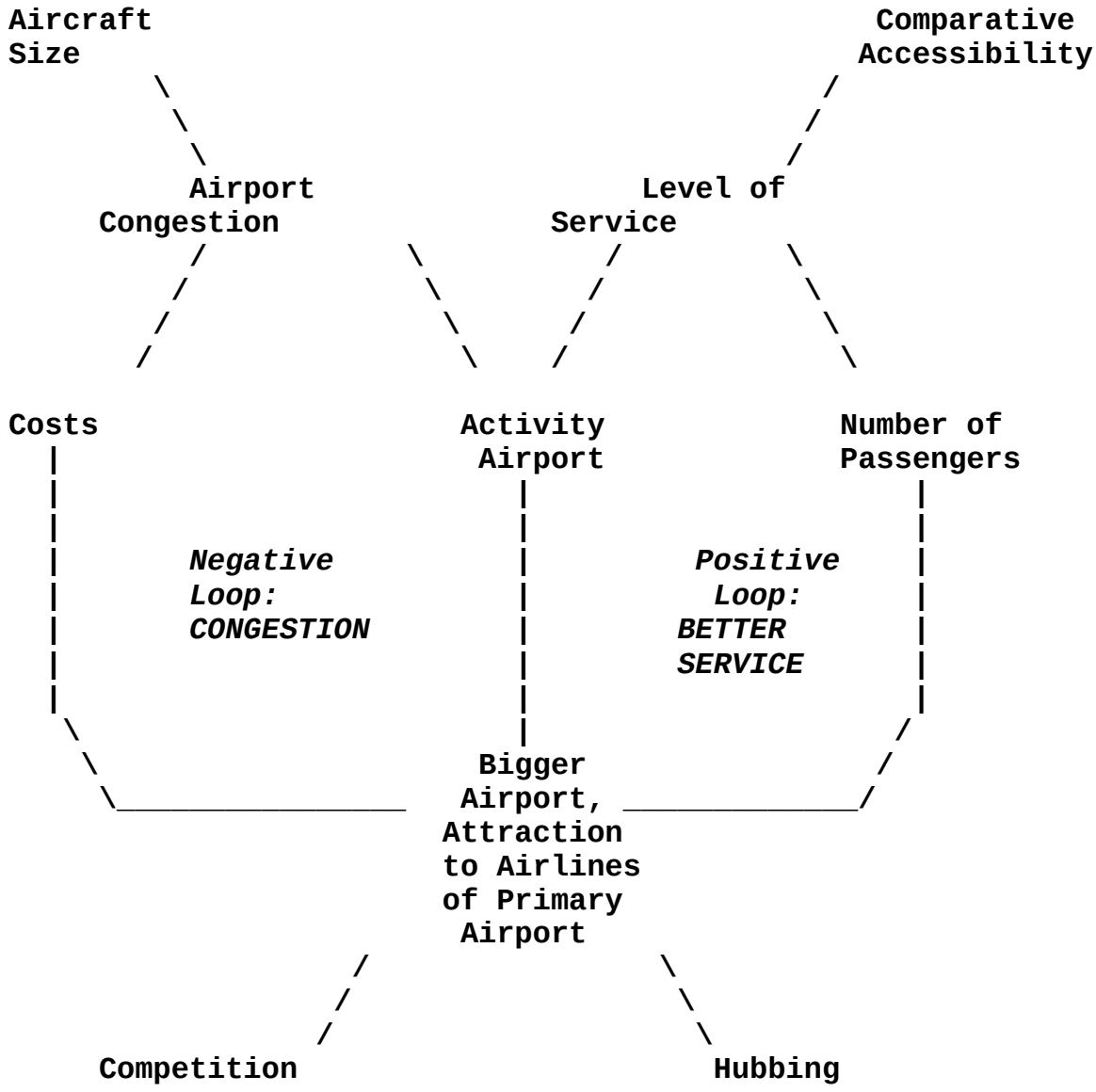

Figure 1: Model of Forces Promoting Congestion at Primary Airport in a Multi-Airport System.

3.3 Transfer Hubs Reinforce Concentration

The development of transfer hubs is a major obvious result of the economic deregulation of the airline industry. They are now a solid feature of air transportation in North America, and are now emerging in Europe as the Common Market liberalizes its airline industry. As the trend toward free trade in air transport expands worldwide, airport planners must consider the effects of transfer hubs.

Airlines promote transfer hubs because they lead to less expensive service with higher frequencies, two factors of great importance to most travelers. The essence of the idea is simple: instead of providing direct service between dozens of cities (which implies hundreds of separate routes, each with relatively few passengers), the airlines funnel passengers from and to these cities through a common central place, using far fewer distinct routes. Each of these routes thus has many more passengers and justifies larger aircraft (which have economies of scale), or more frequent service, or both. Properly configured, these arrangements lead to much more attractive services for passengers, despite the disadvantages of changing aircraft and of circuitous routing. These arrangements also reduce the levels of extra crews and parts that airline must position around their network.

The essence of the hubbing system is that passengers must be able to connect rapidly from the aircraft on which they arrived to a broad range of possible destinations. They can only do so at a single airport.

The advantages of hubbing operations are thus a further reason why an airlines and its passengers will concentrate at a single airport in a metropolitan region. The passengers who take advantage of the hubbing system cannot use the

services that might be provided at other airports in the region.
For example, the market share of San Jose airport in the multi-airport system around San Francisco depends on the extent to which American Airlines maintains hub operations at San Jose. Likewise, the much of the current traffic through Washington/Dulles is due to the fact that United Airlines established a hub there and attracted connecting traffic from all over the eastern United States: before this happened, the traffic at Washington/Dulles was far less than the other two airports in the metropolitan region, Washington/National and Washington/Baltimore.

For cities in which the primary airport is a major transfer hub for an airline, such as Minneapolis/St.Paul (Northwest) or St.Louis (TWA), it is unlikely that of this hub traffic will be split away to an alternative airport.

It should be noted in this context that the new airline practice of hubbing brings a lot of traffic and airline and airport jobs to the hub airport. The frequent services available at a hub airport also make the hub city especially attractive for a variety of business. Hub cities such as Dallas/Fort Worth, Pittsburgh, Charlotte and Raleigh-Durham have thus benefited substantially from this phenomenon. This has proven to be a strong argument in favor of reinforcing the primary airport, by locating additional runways and capacity at the primary airport rather than at some secondary site.

3.4 Traffic Specialization

Monopolistic situations favor the development of secondary airports. A secondary airport will be stronger to the extent that it serves an exclusive market that it does not have to

share with the dominant airport. Such exclusive markets can occur through government regulation, historical precedents and geography, and airline strategy.

As an example of the effect of government regulation, the growth of London/Gatwick in the 1970's and 1980's was enhanced by the fact that the second British Airline, British Caledonian, both was restricted to London/Gatwick and had exclusive rights to a broad array of destinations from London.[6] Likewise, the growth of Tokyo/Narita was promoted by the decision of the Japanese government to make it the exclusive international airport for the metropolis.[7] And the international traffic at Montreal/Mirabel only exists because the Canadian Federal Government does not permit it to go to the more convenient downtown airport at Montreal/Dorval.

For historical and geographic reasons, the traffic at Paris/Orly (which is on the South side of Paris) is mostly oriented towards Africa, the Antilles and Latin America, and thus also to holiday traffic. Its traffic is furthermore enhanced by the fact that it is closer to the homes of most of the travelers from Paris. Paris/Orly thus maintains a significant role in the Parisian region, despite the desire of the government to make Paris/de Gaulle the major platform for the region.

The development of San Francisco/Oakland and Los Angeles/Ontario are likewise favored by the concentration of the small package courier services, UPS and Federal Express, who do not compete with the passenger services focused on San Francisco/International. The future development of Koln/Bonn should similarly be enhanced to the extent that it remains a hub for UPS services to continental Europe.

3.5 Limitations on Government Interference[8]

Attempts by governments to force significant amounts of traffic to move to less convenient or less desirable second airports have repeatedly failed, wherever airlines and passengers have been free to exercise their choice. It has always been possible to have some operators to displace their traffic, but attempts to force major traffic segments to move to a second airport have not succeeded when the primary airport could have met their needs.

The successful development of a second airport as a major facility -- with traffic commensurate with its facilities -- has occurred only when either the volume of traffic at the primary airport significantly exceeded its practical capacity or the runways at the primary airport could not accommodate large, intercontinental aircraft. This is illustrated by Houston: its second airport (Intercontinental) was developed to cater to the long-distance aircraft that its original airport (Hobby) could not handle. The story for Chicago is similar: O'Hare provides for the long-range aircraft that the old airport (Midway) could not handle. Internationally, the fact is illustrated by Tokyo: its second airport (Narita) was opened when its primary airport (Haneda) had about 20 million total passengers a year.

It is important to note that the successful development of a second major airport does not mean that the primary airport closes down, or even that it loses traffic. Tokyo/Haneda is the domestic hub and is still Tokyo's primary airport, now catering for about 40 million total passengers a year, about double its traffic when the second, international airport opened at Tokyo/Narita. In the same vein, Houston/Hobby is only capable of limited operations and was slated to be closed to airline traffic when Houston/Intercontinental

opened: it now serves approximately 8 million total passengers a year. Similarly, Dallas/Love Field now serves nearly 6 million total passengers a year.

The development of the Washington/Dulles International Airport demonstrates the difficulty of moving a significant amount of traffic when a primary airport is available. When the US Government[9] opened Washington/Dulles as the international airport for the capital, it firmly intended that Washington/Dulles should supplant the downtown airport, Washington/National. After all, Washington/National only serves narrow-bodied aircraft and exposes nearby residential and business areas to high levels of noise: for example, a normal straight-in flight path would pass about 1 kilometer from the White House. To implement the policy of developing Washington/Dulles, the Government established rules for Washington/National limiting both the frequency of flights and destinations, to those within a radius of about 1000 statute miles (about 1600 km.).(US FAA, 1992c).

Despite the rules favoring Washington/Dulles, its traffic has grown very slowly. Twenty years after opening, its traffic is still considerably less than that of Washington/National. This is because airlines and passengers find many ways to circumvent the rules. For example, airlines arranged to serve airports about 3000 miles (5000 km.) away from Washington/National, such as Los Angeles or San Francisco, by scheduling intermediate stops at some airport within the allowable radius. As another example, fifteen years after Washington/Dulles was inaugurated as the capital's international airport, more international flights to both London and Tokyo were scheduled through Washington/National than through Washington/Dulles. The airlines accomplished this by selling through tickets requiring a change of aircraft at an intermediate point such as Boston or Chicago. The passengers endorsed these

maneuvers by using these flights from the more convenient downtown airport. Thus the airlines and the passengers together frustrated the government's desire to have the second airport supplant the primary airport.

Even when governments have the most extensive powers, they are unable to counteract the market's natural tendency toward concentration at the primary airport. The experience of the French government with the Paris airports demonstrates this fact. The French government[10] opened the Paris/de Gaulle in 1976, intent on making it the premier airport for the capital, supplanting the Paris/Orly airport. The French government had extensive powers to help carry out this policy: as owner of the national airline, Air France, it could simply decree that the airline move; as the owner of the railroads, it could spend hundreds of millions of dollars on regional and national high speed rail connections to Paris/de Gaulle[11]; as a national government, it also had deep pockets to pay for extra costs involved, incurred either by the airline, the airport authority or the railroads. Furthermore, the site was favorable: Paris/de Gaulle is as close and as accessible to the center of the city as Paris/Orly. Despite 15 years of these efforts and advantages, the second airport of Paris/de Gaulle had less traffic than Paris/Orly until 1991.

Governments internationally are furthermore now losing their limited powers to influence the development of second airports. Through both the deregulation of the airlines, and the privatization of the airlines and airports, governments have less and less ability to direct traffic to particular airports. This ability while it lasted was key to the development of London/Gatwick and of Paris/de Gaulle, since the airlines could both direct airlines to serve these markets and provide sheltered greenhouses to permit new carriers to develop services free from significant

competition. In the case of London/Gatwick for example, the British Caledonian airline had exclusive British rights to serve Latin America and could only do so from London/Gatwick, for example, and this promoted both the airline and the airport.

Local governments of course have much less power than national governments, are correspondingly even less successful in moving traffic to second airports. The Port of Authority of New York and New Jersey, for example, tried unsuccessfully throughout the 1970s to get airlines to provide significantly more service to New York/Newark, an airport convenient for a large fraction of the region. During most of that decade, its other two airports, New York/Kennedy and New York/LaGuardia, were operating at capacity while New York/Newark had very low traffic -- one of its three brand-new terminals was literally boarded up and not used! Traffic at New York/Newark only finally grew substantially when some carriers developed new, specialized services.[12]

When a local government has to compete with other local authorities to attract traffic, its efforts are marginal, at best. Around San Francisco for example, the Oakland airport has tried for years to attract traffic from the primary airport, San Francisco/International, capitalizing on the fact that it is not congested and closer to the business district and many travelers (see de Neufville, 1976). Yet its market share is virtually unchanged in 20 years.

For metropolitan regions whose originating traffic is below the threshold for a viable multi-airport system, efforts to force traffic are effectively doomed. This has been the case for Montreal. Around 20 years ago the Canadian federal government opened the huge second airport at Montreal/Mirabel and closed the much more convenient

downtown airport, Montreal/Dorval, to international traffic (except cross border traffic to the United States).[13] This move did not force substantial quantities of traffic to the second airport however: overseas travelers by and large prefer to use the more frequent international services from Toronto or even US airports, via a short flight from the primary Montreal /Dorval airport. Airlines, unwilling to fly aircraft with many empty seats, schedule flights to accommodate the passengers and thus avoid Montreal/Mirabel.

3.6 Traffic Volatility at Second Airports

Traffic at second airports is especially volatile, especially variable compared to traffic at major metropolitan airports. It tends to fluctuate by large percentages over the short term. This phenomenon complicates both the physical and financial planning for second airports.

The natural variations in traffic are amplified at secondary airports, because their traffic is small and specialized. A shift of traffic from one airport to another obviously has a relatively much larger effect on the smaller facility: what is comparatively small for the big airport is ten times as significant for an airport with only a tenth of the region's traffic -- as typical of many second airports (see Section 3.1). Because traffic at second airports is specialized (see Section 3.4), they are more vulnerable to changes in their market niche than airports with a more diverse clientele.

The recent experience at Chicago/Midway illustrates the problem, see Table 6. In 1990 and 1991 its total annual traffic was both small (around 6 million total passengers that is, 3 million emplanements, or about 10% of the Chicago

traffic) and specialized, since Midway Airlines accounted for about two-thirds of the passenger traffic. When Midway Airlines ceased operations in November 1991, the effect on Chicago/Midway was tremendous: the airport lost not about one-third of its traffic but also around $700,000 a month in concession revenues (Cohas, 1993). Meanwhile, any impact on the traffic at Chicago/O'Hare was barely perceptible. Since 1992, traffic seems to have been returning to Chicago/Midway, along with the growth of Southwest Airlines in the market -- another rapid change in the level of traffic.

The volatility of traffic at an airport is usefully defined as a percentage change around the long term trend. Specifically, a practical formula is:

Volatility = [(Actual Traffic - Trend Traffic)/Trend] 100

The higher volatility of traffic at second airports was demonstrated analytically by Cohas (1993). He examined three multi-airport systems, those of New York, San Francisco and Washington, using quarterly data over the eleven-year period of 1980 through 1990, and found that the volatility of traffic at the individual airports was clearly higher. Table 7 gives the details.

Traffic in a deregulated environment is, furthermore, much higher than under strict regulation which prevents airlines from rapidly changing their routes, fares or frequency of service (de Neufville and Barber, 1991). For regions experiencing deregulation, such as the European Common Market in the 1990's, it can be expected that the traffic at secondary airports will be doubly volatile -- once because of the airlines' new freedom to move operations, and again because of the greater vulnerability of secondary airports.

Traffic at the secondary airports with less than 1 million total passengers (that is, less than 500 thousand emplanements) can be expected to be most highly variable. The statistics in Table 8 illustrate the possibilities.

Table 6 : Rapid fluctuations in Traffic at Secondary Airport of Chicago/Midway

Airport / Airline	Emplanements in thousands,by year; Percent					
	1987	**1988**	**1989**	**1990**	**1991**	**1992**
Chicago/Midway	2541	3174	3410	3547	2937	1972
Midway Airline, %	65	65	65	71	69	0

Source: U.S.FAA (1993) *Airport Activity Statistics*

Table 7 : Increased Volatility of Traffic at Individual Airports in Multi-Airport Systems

Multi-Airport System	Higher Traffic Volatility at Individual Airports (%)
New York	+ 10
San Francisco	+ 86
Washington / Baltimore	+ 127

Source: (Cohas, 1993)

Table 8 : Rapid fluctuations in Traffic at Secondary Airports with less than 500 thousand Annual Emplanements

Airport	Emplanements in thousands, by year					
	1987	**1988**	**1989**	**1990**	**1991**	**1992**
Detroit City	0	130	345	363	321	284
Islip	495	513	427	422	415	375
Long Beach	605	579	662	693	650	400[14]
Manchester	112	169	229	268	293	282
Stewart	0	0	0	183	357	325
White Plains	174	117[15]	145	160	178	203
Worcester	92	142	129	105	74	68

Sources: U.S.FAA (1998 to 1993) *Airport Activity Statistics*

4 PLANNING MULTI-AIRPORT SYSTEMS

4.1 Context of Risk

The essential fact to remember in airport planning is that:

"the forecast is 'always' wrong".

Despite the very best efforts over many years, neither transportation planners nor economists have been able to predict future levels and types of traffic accurately.

This reality has been demonstrated by numerous retrospective studies over many years, as summarized by, among others, the U.S. Office of Technology Assessment (19.) and de Neufville (1976, Chap.3; and 1991). Forecasting errors, that is, differences between the forecast and the actual traffic that occurs. of plus or minus 20% or more after only 5 years are common. Errors normally increase for longer term forecasts (Maldonado, 1990). Errors also are greater for components of a forecast, such as the proportion of international or transfer traffic in the total for an airport.

When planning for major new facilities that will be in service 10 or more years hence, forecast errors of plus or minus 50% are routine. For example, planners for the New Denver International Airport anticipated that the traffic would increase from about 17 million emplaned passengers in 1987, to about 22 million in 1985 (Peat, Marwick, 1989); as of 1993 the traffic had in fact decreased to about 13 million. On the other hand, traffic at Bangkok and Kuala Lumpur has grown about 10% a year recently, surging beyond what were recently considered to be optimistic forecasts.

The inability to forecast aviation traffic accurately reflects the fact that aviation traffic does not follow a stable, long-term trend -- as population does, for example. Aviation traffic is highly variable for two reasons:

1) It is sensitive to a broad range of unpredictable innovations that alter the cost and thus the attractiveness of the product (these may be technological -- new aircraft; industrial -- innovative work rules, marketing or mergers; or political -- such as the fall of the iron curtain and the opening of Russian airspace to international commercial traffic); and

2) It is a good whose demand is derived from, and thus is especially sensitive to, changing economic conditions, either in the short run through business cycles, or in the longer run as developing nations such as China begin to use air transport extensively.

The inability to forecast aviation traffic accurately is a fundamental phenomenon from which there is no likely escape. All airport planning is therefore subject to the risk that a project will either be premature or unavailable when and where needed.

4.2 Dynamic Strategic Planning

Dynamic strategic planning is the approach to take when the future cannot be forecast accurately. The approach is:

1) Strategic, in that it takes the long term view; and

2) Dynamic, in that it recognizes and thus anticipates the need to adjust plans to meet the actual circumstances that eventually prevail.

Doing dynamic strategic planning is comparable to playing chess well: one plans many moves ahead, but commits to only one move at a time -- moreover one chooses this move to provide flexible response to future challenges, either to protect against threats or to exploit opportunities.

In practical terms for planning multi-airport systems, dynamic strategic planning leads to:

1) Building up incrementally the capabilities of the primary airport in a system -- to give the region the accessibility to compete effectively with other regions for business, industrial and touristic activity; while

2) Safeguarding, the possibility of developing major additions to capacity in the future, such as new runways or second airports in the system .

This is the approach successfully taken for the development of the multi-airport system for Sydney, Australia (See de Neufville, 1991). In that case, the Federal Government recognized both the desirability of developing more airport capacity where it would do the most good immediately (at the existing primary airport of Sydney/Kingsford Smith) and to provide for future capacity for the region, when and if it would needed, by reserving a sufficient site for at major second airport (at Badgery's Creek).

In planning a multi-airport system, the first question that must be asked is whether it is likely that the region will realistically ever make good use of a second major airport. The threshold for the viability of second airports must be considered (refer to Sections 2.3 through 2.5).

4.3 Threshold of Viability

The threshold for the viability of a second commercial airport for a metropolitan region is over 10 million originating passengers or at least 25 million total passengers a year. The only exceptions to this rule occur when the primary airport is somehow constrained, for example by runways which are too short to permit trans- or

intercontinental flights (as has been the case for Taipei/Shen Shan and Buenos Aires/Aeroparque).

Considering that the traffic at airports routinely doubles every 10 to 15 years (implying an average rate of growth between 5 to 7% a year) and that this period is about the length of time it takes to plan, get approval for and implement major projects, it is reasonable to anticipate the possible eventual need for a second airport for a metropolitan region when its traffic is about 5 million originating or at least 12 million total passengers a year. In fact, most of the metropolitan areas with that level of traffic (as listed in Table 1) have actively considered the possibility of a second airport.

If an airport is constrained by having only one full-length runway, then the threshold for the possibility of a second airport is defined by the capacity of the one runway. This situation rather uniquely occurs in Britain, for example at London/Gatwick and at Manchester. The capacity of such situations depends on the mix of traffic and the hours of operation, but is roughly around 20 million total passengers a year, as has been achieved at London/Gatwick. This is in fact close to the level at which second airports would normally begin to be viable.

At either level of threshold traffic for a second airport, 20 to 25 million total passengers a year, the second airports just begin to reach commercially significant levels of traffic. As can be seen from Table 4, second airports for the smaller metropolitan areas -- can hope for a market share of only a few percent, maybe about as much as 1 million total passengers a year, but probably less. Furthermore, the traffic at the second airport is likely to be especially volatile, as indicated in Section 3.6.

The prospect of low and uncertain levels of traffic at a second airport is not a good basis for large investment in this facility. However important this site may eventually be, only minimum investments can be justified in the development of the site at the beginning.

4.4 Dynamics of Development

In deregulated, market economies, second airports will develop in a region only to the extent that they fulfill a role in the air transport business. The possibilities for influencing their development significantly are very limited. Despite years of effort, Oakland Airport has not grown relative to the primary airport of the region, San Francisco International; it has only a fraction of the market share of what might be considered its catchment area. Likewise, despite the extreme congestion at London/Heathrow, the secondary airport of London/Gatwick has been losing traffic and London/Stansted has only about 3% of the traffic of the London region. As a general rule the development of second airports cannot be forced; their progress can only be nurtured.

Yet second airports can fulfill a vital role in metropolitan regions with substantial traffic, in excess of 25 million total passengers a year for example. Planning authorities for large metropolitan regions should prepare for their development. Insofar as airport traffic can be expected to double every 10 to 15 years (representing a growth of 5 to 7% a year, which is a rough average), and insofar as the time between planning and implementation of major projects is also about a decade or more, this means that regions which currently have 10 to 15 million total passengers a year should anticipate and plan for the possibility of some kind of second airport.

Anticipation and planning does not entail substantial commitment and development. Second airports develop slowly. Unless the existing airport is limited by inadequate runways, the traffic at second airports will be relatively small, only a fraction of that at the primary airport. Furthermore, their potential is further reduced if the primary airport is a major transfer hub. The development of second airports should thus proceed cautiously.

Good planning will secure or maintain the possibility of developing second airports, but at the least reasonable commitment of resources. For example, airport authorities should:

1) identify possible future sites for active second airports, such as existing airfields, military bases or empty spaces;

2) establish the possibility of using at least one site, as by acquisition (as was done by the Australian Federal Airports Authority for Sydney), or by supporting the local authorities -- this is their insurance option against the risk of future need;

3) maintain the possibility of using the site, as by keeping the future second airport active (for example by using its runways for training flights) -- this is keeping the insurance policy in force; and

4) encourage and promote the use of the second facility in line with the natural growth of passenger and freight traffic at the second airport -- this will be through relatively small incremental investments that can be justified through the traffic; but

5) develop the primary airport, which is naturally the most desirable focus of air transport for both the passengers and the airlines, along its natural trends until the traffic there reaches the point where the value of extra frequency of service is so little, and the cost of

congestion so large, that the customers naturally gravitate to the alternative, second airport.

The major policy conclusion that thus results from the analysis of multi-airport systems is that:

> "The development of second airports to serve a metropolitan region must, to be effective, be part of a long-term strategy of dealing with the uncertainties of future aviation traffic, especially as regards hubbing operations. Because of these risks, the most reasonable strategy may be to expand at primary hub airports while simultaneously establishing the option of developing secondary airports to serve some of the traffic originating from the region" (de Neufville, 1991).

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NOTES

[1] Prof. de Neufville has been active in Airport Systems Planning for over twenty years, and has been studying and working on the issue of second airport since the major strategic study for Mexico City. In addition to over 50 research papers and reports, over 130 theses and dissertations and his book on "Airport Systems Planning," he has participated in major airport projects worldwide. Since 1976, Prof. de Neufville has also served as Founding Chairman on the MIT Technology and Policy Program, a graduate program designed to educate young men and women for leadership on policies for technological systems.

[2] The published rule is: "Except as provided in 91.853, after Dec.31, 1999 no person shall operate to or from any airport in the

United States any airplane subject to 91.801c of this subpart, unless that airplane has been shown to comply with Stage 3 noise levels." The aircraft subject to this regulation are: "any *civil subsonic turbojet* airplane with a maximum certificated weight *more than 75,000 pounds* operating to or from any airport *in the contiguous United States and the District of Columbia*".

[3] Complete, objective documentation for any one of the long-term controversies is difficult to obtain. It in the nature of these arguments that reports are typically one-sided and tendentious. For additional reading, the following references may be useful to consult:

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Sydney: Australia, Department of Aviation (1985), and Federal Airports Corp. (1990).

Taiwan: Mao (1993) and Republic of China (1992)

Boston: Massachusetts Port Authority (1989)

Minneapolis/St.Paul: Minnesota (1990)

St. Louis: St.Louis (1992)

Seattle/Tacoma: Port of Seattle (1991)

[4] The data are for 1992.

[5] As of 1994, for example, the French government owns both the virtually monopolistic domestic airline, Air Inter, and the national flag carrier, Air France. With the active support of the Government, Air France has consistently participated in a broad range of agreements with foreign airlines to fix prices and split markets under so-called "pooling" agreements. These agreements have now been restricted by the rules of the European Common Market.

[6] Broadly speaking, British Caledonian had the British rights to South America and West Africa. It has since merged with British Airlines.

[7] As ever, a few exceptions to this rule occur. For example, some flights to China used to go through Tokyo/Haneda for diplomatic reasons.

[8] This Section draws heavily on and paraphrases de Neufville (1990).

[9] At that time, the United States Federal Aviation Administration operated both Washington/Dulles and Washington/National. It was only much later, as a result of the "Metropolitan Washington Airports Act of 1986", that control of these facilities was passed to the Metropolitan Washington Airports Authority.

[10] The Aeroports de Paris has been wholly controlled and financed by the French national government. This may change in the future, but has not as of this writing.

[11] The high-speed regional commuter systems, the RER, was connected to Paris/de Gaulle since around 1980; the very high speed national rail system, the TGV, will have a station with long distance connections at within the Air France passenger buildings at the airport as of 1985.

[12] After the deregulation of the airlines in 1978, Peoples Express started up cheap fare, "no frills" services out of New York/Newark. They eventually failed and were replaced by Continental Airlines, which now uses the passenger building that was formerly boarded up.

[13] The Montreal airports are, as of 1992, under the control of a local airport authority, the Aeroports de Montreal.

[14] Between 1991 and 1992 American Airlines, which had 227 thousand emplanements at Long Beach in 1991, dropped its service, causing a drop of about 40% in emplanements at Long Beach.

[15] Between 1987 and 1988 Continental Airlines, which had 68 thousand emplanements at White Plains in 1987, dropped its service, causing a drop of about 40% in emplanements at White Plains.

[16] These regulations have been continuously updated over the years, in particular by the provisions starting in 1986 for transferring slot allocations. See the sections 93-13 and -15 (1969), -19 and -20 (1970), -22 (1971), -25 (1972), -27 (1973), -46 (1984). -49 (1986), -57 and -59 (1989), -61 and -62 (1991), -65 and -66(1992), -68 (1993).

[17] The original rule 93-37 (1981) has been amended many times, for example: -38, -41, -41, -42, -43, -44 (1981); -54 (1986).