MANAGEMENT OF MULTI-AIRPORT SYSTEMS:
A DEVELOPMENT STRATEGY

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This paper proposes a dynamic strategy for developing the multi-airport systems for needed for large metropolitan regions. It is based upon two fundamental factors:
(1) the pattern of concentration of airline traffic at specific airports, impelled by the dynamics of the competition amongst airlines and airports, that sets limits on second airports; and (2) the uncertainty of future traffic in this competitive environment, that implies financial risks for capital intensive airport projects. Development plans should thus be strategic, making investments that insure the future; incremental, phasing modest investments according to proven opportunities; and flexible, providing the insurance to adjust easily to future situations.

Keywords: Multi-Airport Systems; Dynamic, Strategic, Planning; Competition, Airlines, Traffic Concentration

The Issue

The proper management and development of multi-airport systems are a major concern of airport managers worldwide. All metropolitan regions generating more than 10 million originating passengers a year have several airports serving commercial carriers. Some thirty cities already have or are planning for second airports. Major second airports:

* have recently opened at London and Osaka;
* are under development at Bangkok, Hong Kong, Kuala Lumpur, Oslo, Seoul, and Sydney; and
* are in various stages of consideration for Atlanta, Berlin, Boston, Minneapolis/St.Paul, St.Louis, and Seattle.

Yet the experience in managing multi-airport systems is poor. It is routinely marked by expensive mistakes. Planners fail to anticipate the patterns of traffic distribution between airports, and managers consequently over invest in second airports, over building facilities for a traffic that is unlikely to be there. Some examples illustrate the point:

* Edmonton: The International airport has been emptied as passengers flock to the more convenient downtown Municipal Airport (Edmonton Airports, 1992, 1994);
* London: Despite long-term predictions that a Third London Airport was urgently needed, the magnificent passenger buildings at London/Stansted are virtually deserted (BAA, 1992);
* Montreal: Montreal/Mirabel, the International airport, receives about less than 3 million passengers a year, in facilities built 20 years ago for 6 to 10 million passengers (Carr, 1994);
* Osaka: Planners for the new Osaka/Kansai airport failed to anticipate that the convenient Osaka/Itami airport would remain open and thus over built facilities for the opening;
* Washington: The major international airport at Washington/Dulles remained largely underutilized for about two decades, despite strenuous regulations designed to force airlines to use the facility (de Neufville, 1986, 1994).

How can airport managers avoid over investing in second airports? The answer is first to understand how traffic develops at second airports, and then to adopt a management process that suits this reality.

Theory and the analysis of practice indicate that the pattern of traffic distribution among multiple airports in a region is determined by the dynamics of competition among the airlines and airports. Their competitive behaviour leads to:

* concentration of traffic at primary airports, and
* volatility of traffic at second airports.

This reality means that investments in second airports, while clearly desirable in the long run for large metropolitan regions, are risky in the short run. As always in dealing with risky investments, prudent management minimises exposure and hedges risk.

Dynamic strategic planning seems to be the best approach to managing the development of second airports (de Neufville, 1991). As indicated below, it is <u>strategic</u>, making investments that insure the future; <u>incremental</u>, phasing modest investments according to proven opportunities; and <u>flexible</u>, providing the insurance -- physical, financial or organisational -- to adjust easily to future situations.

Concept of Multi-Airport Systems

A multi-airport system is the set of airports that serve the airline traffic of a metropolitan area. The multi-airport system for London, for example, includes -- among others -- its major airports: London/Heathrow, London/Gatwick and London/Stansted. The fact that a single organisation, the BAA, owns and operates these airports reinforces the idea that they are part of a system. Yet unity of ownership or control does not define the system for transport planning and management -- the independently owned London/Luton airport is certainly part of the London multi-airport system.

From the perspective of the users, a multi-airport system properly includes all the airports that effectively serve the region. For example, the Baltimore airport is effectively part of the multi-airport system serving the Baltimore- Washington region, even though it is in a different state and under different ownership than Washington/National and Washington/Dulles airports. It 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 past thinking, when airport planners generally assumed that airports served "catchment areas", that the Baltimore airport only served Baltimore, the Washington airports only served Washington, and so on.

The change to a functional, geographic definition of a metropolitan airport system results from worldwide changes in urban structure. The combined effect of population growth and the spread of rapid modes of transport such as expressways and high speed rail systems, has been to extend cities over much wider areas, merge cities into each other, and create metropolitan regions that function as a unit despite traditional boundaries. Thus as a practical matter Baltimore and Washington merge as a market for air transport, even though their centers are 60km. apart. Many Washington suburbanites find it more attractive to use the Baltimore airport than either Washington/National or Washington/Dulles.

Airline airports can be considered part of a multi-airport system if they are either:

* as close as one of the existing major airports for a significant fraction of the metropolitan region, in particular the suburban centers of traffic, or
* officially so designated by local authorities.

The criterion of accessibility applies according to the context. Around Tokyo, where urban travel is comparably difficult, it includes airports within about 2 to 3 hours. In the United States it includes all airports within about an hour of the suburban centers of a region, which are often located some distance from the traditional city center. For Boston, for example, the multi-airport system properly includes three airports (Providence, Rhode Island; Manchester, New Hampshire; and Worcester, Massachusetts) that are closer in time to Bostonians along the ring road than the main airport (Boston/Logan), although two of these airports serve the capitals of different states.

The second criterion applies only in special situations. The most obvious case is that of Sao Paulo/Viracopos, the international airport located some 100 km. from the city center over difficult roads.

Military facilities, general aviation airfields without substantial airline service and private airports closed to the public are not part of multi-airport systems for air transport. They must be considered in the context of air traffic control. They can be excluded, however, when considering how to develop airport capacity to serve airlines, passengers and cargo.

Impetus for Successful Multi-Airport Systems

In the context of serving passengers and cargo, a multi-airport system is successful to the extent that airlines and passengers use the several airports to some significant degree. If the secondary airport is underutilized compared to its cost, it is a failure as a transport investment, regardless of its technical features and architectural beauty. London/Stansted -- over built for its prospective traffic -- might now be an example of such a failure.

Successful multi-airport systems must be more likely to exist in metropolitan areas with a high level of airline and passenger traffic: the greater the traffic, the more likely that there will be enough to justify a second airport and a multi-airport system. Yet a high level of passenger traffic is clearly not sufficient: Atlanta and Frankfurt are among the busiest airports on their continents, but neither is part of a multi-airport system.

A second airport will be a transport success if it is sufficiently attractive, in comparison with the alternative primary airport, to draw a sizable clientele. To develop successful second airports, it is necessary to understand the factors that make them attractive.

The attractiveness of an airport is always defined in comparison to its competition. Passengers and airlines will not use a second airport when they can get better service elsewhere. To develop second airports, it is necessary to understand this competition.

The passengers' perspective

For passengers and shippers, a second airport is attractive when it provides convenient access to desired air services. In thinking about this, it is necessary to distinguish between originating and transfer traffic. Originating traffic consists of the passengers who either live in the metropolitan area or who have been there for some time. Transfer traffic on the other hand consists of the passengers who arrive at the airport by plane for the purpose of changing to another aircraft to continue their journey. Transfers require easy connections. They do not want to change between airports and, rather than do so, prefer to connect through some other hub. Transfers thus do not constitute a sizable market for second airports. The focus needs to be on the passengers that originate in a region.

Originating passengers seeking access to air services consider two factors: the geographic accessibility of an airport and the frequency of departures. Passengers consider the time it takes both to get to the airport and to wait for a flight. Airports with minimal air services are unattractive. Passengers routinely by-pass close airports to use more distant airports that provide better service. Frequency of flights to any destination is a key aspect of the value of the service to passengers. Airlines recognize this and respond accordingly.

The Airlines' perspective

Airlines generally have considerable choice about which airport they serve, and choose according to their commercial advantage. Sometimes they have to use a second airport for technical reasons. This is the case when the runways at the primary airport are too short for long-range aircraft, as they are for example at Milan/Linate, Taipei/Shen Shan, and Washington/National. These exceptional cases modify the general rules.

A second airport is commercially attractive to airlines if it provides a good market. That is obvious. The subtlety comes in understanding how airlines decide when the market at a second airport is worthwhile.

Airlines continually try to optimise the use of their major assets, that is their aircraft. Specifically, the airlines allocate flights to routes, by means of large-scale optimisation programmes. These procedures have the great virtue of being able to account not only for the value of individual flights but, most importantly, for the multiplier effect of concentrating flights in a market. Understanding this multiplier effect is the key to appreciating the distribution of traffic to secondary airports.

Theory and experience indicate that the market share achieved by an airline is disproportionate to its "frequency share", the fraction of the total flights it offers in a market (Fruhan, 1972; de Neufville, 1976; Cohas, 1993). An airline that offers 60% of the flights in a market may, for example, get 75% of the passengers. Airlines that dominate a market will achieve higher yields and greater profits. Airlines thus try to concentrate their flights to dominate markets, or at least prevent competitive airlines from doing so. This is the competitive dynamic that leads airlines to match flights on specific routes.

Because of this multiplier effect, the profitability of allocating any flight to a route is not determined merely by its own loads. An additional flight in a major market reinforces the value of the other flights in that market. When airlines consider the possibility of allocating flights to secondary airports, they thus have to consider not only whether they can achieve competitive load factors in the secondary market, but whether there is sufficient additional traffic that will compensate for the loss in the airline's market share in the major market. This is a subtlety that analysts all too often ignore.

This competitive dynamic that leads airlines to match flights on routes also leads them to allocate flights to the primary airports rather than provide service to second airports. This is a stable result of the competitive game between airlines (Gelerman and de Neufville, 1973).

When airlines have the choice, they tend to allocate flights to secondary airports either when their primary airport either is heavily congested or has so much frequency that there is little penalty to allocating a flight elsewhere, which occurs only when the primary airport has very high levels of traffic. In short, airlines voluntarily use second airports only when the metropolitan traffic is substantial.

Pattern of Concentration

The dynamics of the competition between airlines thus establish a pattern of concentration of traffic among the airports in multi-airport systems. The evidence demonstrates this quite clearly. As Table 1 indicates, the second busiest airport in a multi-airport system now typically has 3 times less traffic than the busiest airport.

[Table 1 about here]

As a rule, second airports only have more than 50% of the traffic of the busiest airport if there are overwhelming political or technical constraints to the concentration of traffic. At Tokyo, Washington, Osaka and Montreal for instance, the government mandated international flights to use more distant airports. In Paris, the French government directed its national carrier, Air France, to serve Paris/de Gaulle. The more accessible airports in Washington, Taipei, Houston/Galveston and Buenos Aires have technical restrictions that force flights to use second airports.

Second airports will also have traffic comparable to the primary airport when the traffic to the metropolitan region is so large that is saturates several major airports. This situation only exists in the busiest centers of air transport, currently New York and London. Note that the traffic to these regions still concentrates noticeably, as indicated by the relatively low levels of traffic at their third, fourth and fifth airports.

The pattern of concentration of traffic is so important that it extends to the type of traffic that locates at secondary airports. The traffic at the several airports in a multi-airport system differ not only in size but in character. Each airport tends to concentrate on its own market. Secondary airports, being smaller, tend to serve niche markets. The traffic that does develop at second airports is not just a random spill-over of traffic that does not get served at the principal airport in the system. The traffic at secondary airports is normally a concentrated block of specialised traffic, often represented by just one dominant airline, as Table 2 indicates.

[Table 2 about here]

This pattern of concentration of air transport is an example of a larger phenomenon. It is a commonplace of location theory and urban planning that services concentrate. Cities thus have financial districts, theatre districts and so on.

The concentration of traffic at specific airports in a multi-airport system is inevitable. It has withstood many governmental attempts to alter it, in London and Washington in particular (see de Neufville, 1986 and 1994 for detailed examples). Traffic concentration is a persistent phenomenon that airport managers must deal with realistically.

Threshold of Viability

Combination of the passengers' perspective that leads to a focus on originating passengers, with the airlines' perspective that emphasizes concentration of flights at the primary airport, implies that multi-airport systems will be most successful only when the level of originating traffic is quite high. The evidence validates this conclusion.

The worldwide data on all the metropolitan regions with the most traffic (Table 3) illustrates a simple and most important proposition:

> Above a threshold level of originating traffic from a metropolitan region, the multi-airport system will be successful. Below this level it is only successful if the primary airport is limited technically or if special political circumstances apply.

The threshold for successful multi-airport systems is now around 10 million originating passengers a year. It has been rising over time, along with the introduction of wide-body aircraft, the improvements in air traffic control and peak spreading -- all of which permit more frequent operations from existing runways. A decade ago this threshold was about 8 million originating passengers a year (de Neufville, 1984a, 1984b, 1985a, 1985b). If the trend continues, the threshold may reach 12 million originating passengers a year sometime before the year 2010.

[Table 3 about here]

Table 4 completes the inventory of multi-airport systems worldwide. As can be seen, multi-airport systems for regions with less than 10 million originating passengers a year exist almost exclusively from technical necessity or overwhelming political reasons. The situation for Oslo is unclear as the development at Gardemoen seems uncertain. Glasgow and Edinburgh perhaps ought not to be considered part of a multi-airport system, these cities are about 80km. apart which may appear considerable although it is not in other contexts. The lack of any salient examples of multi-airport systems that are successful for commercial reasons validates the concept of the threshold for success.

[Table 4 about here]

Traffic Volatility

Traffic at second airports is especially volatile and 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 the financial planning for second airports.

The natural uncertainties in traffic (see de Neufville, 1976 for example) are amplified at secondary airports, because their traffic is small. 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.

The volatility of traffic at secondary airports is further increased because these are often dominated by specialised carriers. When the activities of these smaller airlines shift, as they frequently do, the traffic at the secondary airport can change radically both in level and in character.

The recent experience at Chicago/Midway illustrates the problem, see Table 5. 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 only 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.

[Table 5 about here]

The volatility of traffic at an airport is usefully defined as a percentage change around the long term trend (de Neufville and Barber, 1991). Specifically, a practical formula is:

$$\text{Volatility} = [(\text{Actual Traffic} - \text{Trend Traffic})/\text{Trend}]\ 100$$

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 secondary airports was clearly higher than at the primary airports. Table 6 gives the details.

[Table 6 about here]

Traffic is, furthermore, much more volatile in a deregulated environment than under strict regulation that 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 annual passengers (that is, less than 500 thousand emplanements) can be expected to be most highly variable. The statistics in Table 7 illustrate some possibilities.

[Table 7 about here]

Planning Issues

The appraisal of how and why multi-airport systems develop brings three issues to the fore. First, managers of larger airports need to develop a vision, a strategy of how and where they will develop the multi-airport system they already or may soon have. Second, they should develop relatively modest programs of investment at second airports, suitable to the relatively low levels of traffic at these platforms. Third, they should insist that these plans be flexible, and can easily be adapted to various levels and types of traffic.

A Strategic Vision

Since multi-airport systems seem inevitable for large metropolitan areas, airport managers in those regions ought to plan actively for their intelligent development. Specifically, they need to determine and acquire sites for prospective second airports. If airport planners do not secure a site early, the natural growth of the built-up areas of the city will tend to preclude the most accessible, desirable sites.

All regions with 10 to 15 million passengers a year probably should develop a vision of how they will develop their multi-airport system. These regions may have 30 to 40 million passengers a year in about 15 years, and thus be beyond the threshold for a successful multi-airport system. (This assumes that the compound rate of growth of air traffic is in the plausible range of between 5 to 7 percent annually.) Experience shows that it may easily take 10 to 15 years to select, acquire and develop a site for a second airport.

Securing a site for a second airport insures that future developments will be possible. As it is impossible to determine what kind of airport will be needed so far in advance, no major investments in facilities are appropriate until needs are demonstrated. However, if a site is truly to represent an option for future development, it must actually be an airport. If the site looks like a nature preserve, as does the land set aside for the one-time putative Toronto/Pickering airport, its later transformation into an airport may be politically impossible.

To secure a site as an option for future development, it seems necessary to lay down some kind of runway and establish some pattern of use. This is what the developers of the Fort Worth/Alliance airport did.

Managers in regions that already have several active airports should likewise define how they will develop these facilities. They need to make sure that their investments will accord with the patterns of relatively low, specialised traffic that are characteristic of second airports. In short, they ought to avoid the kind of financially wasteful investments apparently typified by the expensive, and virtually unused passenger buildings at London/Stansted.

Incremental Investments

When future demands are certain, it makes sense to build large facilities, achieve economies of scale and thus reduce the present value cost of providing for some level of need. There is a trade-off between the economies of scale that accrue to a design and the cost of the money required to build in advance of need. The determination of the optimum level of construction in advance of need is quite straightforward (see de Neufville, 1990b, for a textbook presentation).

When future demands are quite uncertain, as they have been for second airports, it is wasteful to build far in advance of need. This is because an over built facility can become a white elephant if anticipated demands do not materialise. This is what happened at Montreal/Mirabel, London/Stansted and at New York/Newark, where the owners literally boarded up a major terminal for more than a decade, and at Washington/Dulles, which was under utilised for nearly 20 years.

When there are risks, prudent managers buy insurance. In the case of constructed facilities, the obvious insurance against having white elephants is to build facilities only incrementally, according to demonstrated need. The cost of this insurance is the loss of economies of scale and the resulting higher costs per unit of capacity. The value of this insurance is, of course, the potential savings that result from not having to pay for capacity that turns out to be unneeded.

The optimum level of insurance to buy as a hedge against uncertain future levels of traffic is easy to calculate by decision analysis. The idea is to maximise expected value by weighting the consequences of possible futures by their estimated probability (see de Neufville, 1990b, for a textbook presentation). This method is at the heart of the dynamic strategic planning procedure discussed in the next session.

Uncertainty in the traffic at second airports concerns more than the level of traffic. The type of traffic at secondary facilities is also quite changeable. A decade ago, no designer anticipated that Washington/Dulles would develop as a transfer hub for United Airlines, or that Los Angeles/Ontario would become a major cargo center for UPS, which still is primarily a trucking company.

Flexible Plans

Because the type of traffic is variable at second airports, the configuration and the nature of the facilities ought also to be flexible. For example, the planners should design passenger buildings that can easily be reconfigured to accommodate different proportions of domestic and international traffic, or of transfer and terminating traffic. In this context it is well known that some designs (such as gate-arrival or unit terminals) are quite inflexible (see de Neufville, 1973).

When investing in risky projects such as second airports, managers should consider using the payback criterion to evaluate alternatives -- along with the traditional rate of return methods. The payback analysis disregards all benefits that occur beyond the payback period, which is normally only a few years. When these later consequences are so uncertain, it may be just as well to set them aside and focus on immediate consequences that are quite certain, as to sully the evaluation with quite speculative benefits. The managers of the Toronto airport have used this approach successfully (McCoomb. 1994).

Dynamic Strategic Plan

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

This approach consists of three elements (Clark et al, 1994):

1) Recognition of the risk;

2) Analysis of the consequences of different choices at different periods, using what is known as "decision analysis" in operational research; and

3) Choosing a strategy of development that commits only to immediate decisions and that buys flexibility to respond to future developments.

A most practical way to recognise the risk of investing in second airports is to collect data on similar facilities, in similar contexts, over the previous 10 to 20 years. This exercise will demonstrate that forecasters do not manage to anticipate correctly what the traffic will be a decade hence, which is a minimal period for major construction. The exercise will also provide a reasonable approximation of the range of variation in the forecasts and the probability of specific deviations from the most likely forecast. As a result, managers should have a fair assessment of the real risks they face.

With the estimates of risk, managers can estimate the consequences of alternative investments using decision analysis. Since the future is uncertain, these outcomes are assessed as expected values (see de Neufville, 1990b, for a textbook explanation of the method). The analysts will associate these results, together with the possible range of outcomes, with each of the scenarios for phasing investments over time that are under consideration. With the recent development of computer programmes to do this on personal computers, this seemingly arduous task is quite easy. Once these results are available, it is relatively simple to choose the best strategy to initiate.

Choosing an initial strategy of development only commits to a first phase, of course. Because the future is uncertain, good planning will respond to whatever events unfold. Good managers will therefore choose their investments in later phases according to how the market and traffic have developed. To insure that they can do this, they will have chosen designs that are flexible -- these are the ones that will emerge as preferable from the decision analysis.

Doing dynamic strategic planning is comparable to playing chess well: the planner considers many moves ahead, but commits to only one move at a time -- moreover the decision-maker 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 the desirability of both developing more airport capacity where it would do the most good immediately (at the existing primary airport of Sydney/Kingsford Smith) and providing future capacity for the region, when and if it would be needed, by reserving a sufficient site for at major second airport (at Badgery's Creek, now named Sydney/West).

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Table 1: Traffic at Secondary Airport is Generally Significantly Less than at the Dominant Airport (Metropolitan Regions Ranked by Millions of Originating Passengers, Second Airports by level of traffic).

Metropolitan Region	Special Factors	Traffic at Secondary Airports a Percent of Traffic at Primary Ai		
		Second	Third	Fourth
New York		87	70	3
London		44	5	4
Los Angeles		13	12	8
Tokyo		44		

Paris		99		
Chicago		7		
San Francisco		18	17	
Washington / Baltimore	Technical	48	43	
Miami		26	18	
Dallas / Fort Worth		12		
Boston		9	2	1
Osaka		NA		
Taipei	Technical	38		
Houston / Galveston	Technical	42		
Manchester, UK		5	1	
Rhine-Ruhr Valley	Political	27		
Hong Kong	Political	10		
Milan	Technical	25		
Moscow	Political	NA		
Oslo		11		
Rio de Janeiro	Technical	NA		
Montreal		53		
Berlin	Political	NA		
Glasgow		57	2	
Buenos Aires	Technical	80		
Edmonton		65		
ent		27		
s less		~ 4		

Sources:
ICAO (1993) *Airport Statistics 1991*
ICAO (1994) *Aviation Statistics of the World, 1993* ;
U.S.FAA (1993) *Airport Activity Statistics*
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Notes :

"Technical" means that the second airport was necessary to handle intercontinental aircraft.

"Political" for the Rhine-Ruhr Valley because of Germany's need to establish an airport for its then capital city; for Berlin because of the division of the city into two countries for nearly 45 years; for Moscow because the the use of the airports was dictated by military reasons; for Hong Kong because strained relations between Taiwan and the China mainland direct a lot of traffic to this neutral city, and political realities require China to have its own airport outside of this city;

Table 2: Role of Second Airports in Metropolitan Regions

Metropolitan Region	Second Airports	Special Roles
New York	Newark	Hub for Continental/SAS
	LaGuardia	Short-range
London	Gatwick	Non-British Airways
	Luton	Summer tour
	Stansted	???
Los Angeles	Ontario	Hub for UPS
	Orange Co.	Short-Range
	Burbank	Short-Range
Tokyo	Narita	International
Paris	de Gaulle	Intercontinental
	Orly	Domestic and African
Chicago	Midway	Hub for Midway
San Francisco	San Jose	Hub for American
	Oakland	Local Traffic
Washington /	Dulles	International; Hub for UAL
Baltimore	Baltimore	Local Traffic
Miami	Ft.Lauderdale	Local Traffic
	West Palm Beach	Local Traffic
Dallas / Fort Worth	Love Field	Short Range
Boston	Providence	Local Traffic
Osaka	Kansai	International
Taipei	Shen Shan	Domestic
Houston / Galveston	Hobby	Local Traffic
Manchester, UK		
Rhine-Ruhr Valley	Koln/Bonn	Capital Traffic
Hong Kong	Shenzhen	Mainland China
Milan	Malpensa	International
Moscow	Vnukovo	
Oslo	Gardemoen	Summer tours

Rio de Janeiro	Santos Dumont	Local Traffic
Montreal	Mirabel	International
Berlin	Schonfeld	Local Traffic
Glasgow	Edinburgh	Local Traffic
Buenos Aires	Ezeiza	Local Traffic
Edmonton	Municipal	Local Traffic

Table 3: Metropolitan Regions Worldwide Ranked by Millions of Originating Passengers in 1993 (1992 for the United States and Taiwan), 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 Origin. Traffic	Total Traffic
New York	Kennedy; Newark; LaGuardia; *Islip; Stewart; White Plains*	Yes	27	73
London	Heathrow; Gatwick; Luton; Stansted; *London City*	Yes	25	67
Los Angeles	Internatl.; Ontario; Orange Co.; Burbank; *Long Beach*	Yes	23	63
Tokyo	Haneda; Narita; *Fukushima*	Yes	21	62
Paris	C.de Gaulle; Orly;	Yes	20	50
Chicago	O'Hare; Midway	Yes	17	69
San Francisco	Internatl.; San Jose; Oakland	Yes	15	47
Washington / Baltimore	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	58

Boston	Logan; Providence; *Manchester,NH* *Worcester*	Yes	10	25
Osaka	Itami; Kansai	Yes	10	24
Taipei	Chiang Kai Shek; Shen Shan	Technical	9	18
Atlanta			8	45
Frankfurt			8	30
Toronto	International; *Island;* *Hamilton*	Insigni-ficant	7	19
Seoul	Kimpo; Young Jong in construction		8	21
Orlando			7	17
Las Vegas			7	17
Rome	Fuimicino; *Ciampino*	Insigni-ficant	7	19
Madrid			7	18
Houston / Galveston	Intercont.; Hobby	Technical	6	27
Denver			6	27
Detroit	Metro; *City*	Insigni-ficant	6	23
Honolulu			6	21
Amsterdam			6	19
Singapore			6	17
Bangkok	Don Muang; Second Bangkok in development		6	15
Manchester	Internatl; *Leeds/ Bradford* *Liverpool*	Insigni-ficant	6	15
Sydney	Kingsford Smith; Sydney West in development		6	14
Madrid			6	14
Rhine-Ruhr Valley	Dusseldorf; Koln/Bonn	Political	6	14
Stockholm	Arlanda; *Bromma*	Insigni-ficant	6	13

Phoenix			5	22
Hong Kong	Kai Tak; Shenzhen; Chep Lak Kok under const.	Political	5	23
St. Louis			5	20
Minneapolis / St.Paul			5	19
Seattle			5	18

Sources:
ICAO (1993) *Airport Traffic 1991* ;
ICAO (1994) *Aviation Statistics of the World, 1993* ;
U.S.FAA (1993) *Airport Activity Statistics* ;
U.K.DoT (1993) *RUCATSE Report* ;
Mao (1993) *Developing CKS Airport*

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

Notes :
"Technical" means that the second airport was necessary to handle intercontinental aircraft.
"Political" for the Rhine-Ruhr Valley because of Germany's need to establish an airport for its then capital city; for Hong Kong because strained relations between Taiwan and the China mainland direct a lot of traffic to this neutral city, and political realities require China to have its own airport outside of this city;
"Insignificant" means that the second airport serves less than 1 million total passengers a year and a trivial fraction of the traffic for the region, so that a multi-airport system is embryonic.

Table 4: Metropolitan Regions Worldwide With Multi-Airport Systems but less than either 5 million Originating, or 18 million Total, Passengers in 1993 (Airports within a region ranked by their total passengers).

Metropolitan Region	Airports in System, by size	Multi-Airport System	Estimated Originat'g Traffic	Total Traffic
Milan	Linate; Malpensa	Technical	5	12
Moscow	Shreremetyevo; Vnukovo; *Domodedovo*	Political	4	9
Oslo	Fornebu; Gardemoen	Yes	3	7
Rio de Janeiro	Galeao; Santos Dumont	Technical	3	7
Montreal	Dorval; Mirabel	Yes	3	7
Berlin	Tegel; Schonfeld; *Tempelhof*	Political	3	7
Sao Paulo	Garulhos; *Viracopos*	Technical	3	7
Glasgow/ Edinburgh	Glasgow; Edinburgh; *Prestwick*	Maybe	3	7
Buenos Aires	Aeroparque Ezeiza	Technical	3	7
Edmonton	International Municipal	Technical	1	3

Sources:
ICAO (1993) *Airport Traffic 1991*
ICAO (1994) *Civil Aviation Statistics of the World, 1993*
BAA (1992) *1991 Annual Review*
Edmonton Airports (1994) *Aviation Statistics*

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

Notes :

"Technical" means that the second airport was necessary to handle intercontinental aircraft.

"Political" for Berlin because of the division of the city into two countries for nearly 45 years; for Moscow because the the use of the airports was dictated by military reasons;
"Insignificant" means that the second airport serves less than 1 million total passengers a year and a trivial fraction of the traffic for the region, so that a multi-airport system is embryonic.

Table 5 : 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 6 : 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 7 : Rapid fluctuations in Traffic at North American Secondary Airports with less than 0.5 Million Annual Emplanements

	Emplanements in thousands, by year					
Airport	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**
Detroit City	0	130	345	363	321	284
Hamilton	9	48	75	56	39	25
Island	200	168	141	135	72	78
Islip	495	513	427	422	415	375
Long Beach	605	579	662	693	650	400*
Manchester, NH	112	169	229	268	293	282
Stewart	0	0	0	183	357	325
White Plains	174	117#	145	160	178	203
Worcester	92	142	129	105	74	68

Sources:
U.S.FAA (1998 to 1993) *Airport Activity Statistics*
Transport Canada (1993) *Official Forecasts*

* 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.

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.

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

Metropolitan Region	Second Airport	Total Passengers Millions/yr.	Market Share, %
London	London City		~ 1
Tokyo	Fukushima		~ 1
Toronto	Island	0.14	0.7
	Hamilton	0.07	0.4
Rome	Ciampino	0.52	3.2
Stockholm	Bromma		~ 1
Manchester, UK	Leeds Bradford	0.70	5.0
	Liverpool	0,1?	~ 1
Sao Paulo	Viracopos	0.06	~ 1
Glasgow	Prestwick	0.07	1.0

Sources:
ICAO (1994) *Civil Aviation Statistics of the World, 1993*
ICAO (1993) *Airport Traffic 1991* ;
BAA (1992) *1991 Annual Review* ;
U.K.(1993) *RUCATSE Report*

Table XX: 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,NH	0.56	2.4
	Worcester	0.14	0.6
Detroit	City	0.56	2.4

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

[1] 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).

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