Airport Operations

Second Edition

Norman Ashford
H. P. Martin Stanton
Clifton A. Moore

McGraw-Hill, Inc.
New York San Francisco Washington, D.C. Auckland Bogotá
Caracas Lisbon London Madrid Mexico City Milan
Montreal New Delhi San Juan Singapore
Sydney Tokyo Toronto

Library of Contress Cataloging-in-Publication Data

Ashford, Norman.
Airport operations / Norman Ashford, H.P. Martin Stanton, Clifton A. Moore. — 2nd ed.
p. cm.
Includes bibliographical references.
ISBN 0-07-003077-4 (alk. paper)
1. Airports—Management. I. Stanton, H.P. Martin. II. Moore. Clifton A. III. Title.
IN PROCESS
387.7'36'068—dc21 96-48398
CIP

McGraw-Hill

A Division of The McGraw-Hill Companies

2 3 4 5 6 7 8 9 0 DOC/DOC 9 0 1 0 9 8

ISBN 0-07-003077-4

The sponsoring editor for this book was Shelley IC. Chevalier, the technical editor was Charles Spence, and the production supervisor was Don Schmidt. This book was set in ITC Century Light. It was composed by Wanda Ditch through the services of Barry E. Brown (Broker—Editing, Design, and Production).

Printed and bound by R.R. Donnelley & Sons Company.

This book is printed on acid-free paper.

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Chapter

1

The Airport as an Operational System

1.1 The Airport as a System

The airport forms an essential part of the air transport system, because it is the physical site at which a modal transfer is made from the air mode to land modes. Therefore, it is the point of interaction of the three major components of the air transport system:

- The airport, including for these discussion purposes the airways control system
- The airline
- The user

The planning and operation of airports must, if they are to be successful, take into account the interaction of these three major components, or system actors. For the system to operate well, each of the actors must reach some form of equilibrium with the other two. Failure to do so will result in suboptimal conditions, exemplified by a number of undesirable phenomena that are indicators of inadequate operation. Each can, in a state of unrestrained competition, lead to an eventual decline in scale of operation at the airport facility, as traffic is attracted elsewhere, and in the absence of a competitive option, to depressed demand levels. Such conditions become manifest in a variety of ways:

- Deficit operations by the airport
- Deficit operations by the airline at the airport

- Unsatisfactory working conditions for airline and airport employees
- Inadequate passenger accommodation
- Insufficient flight supply
- Unsafe operations
- High operational costs to users
- Inadequate support facilities for airlines
- High delay levels for airline and passenger
- Inadequate access facilities
- Sluggish passenger demand levels

Figure 1.1 displays a simplified hierarchical system diagram of the primary interactions between the airport, the airline, and the user (Ashford and Boothby 1979). The diagram attempts to show how these interactions produce the prime parameters of operational scale, passenger demand, airport capacity, and flight capacity. Although a simplified diagram helps the conceptualization of the main factors of airport operation, large airports are in fact very complex organizational structures. This is not surprising since a large airport might well be one of the largest generators of employment in a metropolitan region. The very largest hub airports, such as Chicago O'Hare, Los Angeles, London Heathrow, and Atlanta all have total site employment levels of more than 50,000. To place this in some context of scale, the number of persons could well be the total central business district employment of a city of a quarter- to half-million population. Large systems such as this are necessarily more complex than the simple trichotomy expressed in Figure 1.1. A more complete listing of involvement for a large airport is contained in Table 1.1. This now includes an important fourth actor, the nonuser, who can have an important impact on airport operation and who is also greatly affected by large-scale operations.

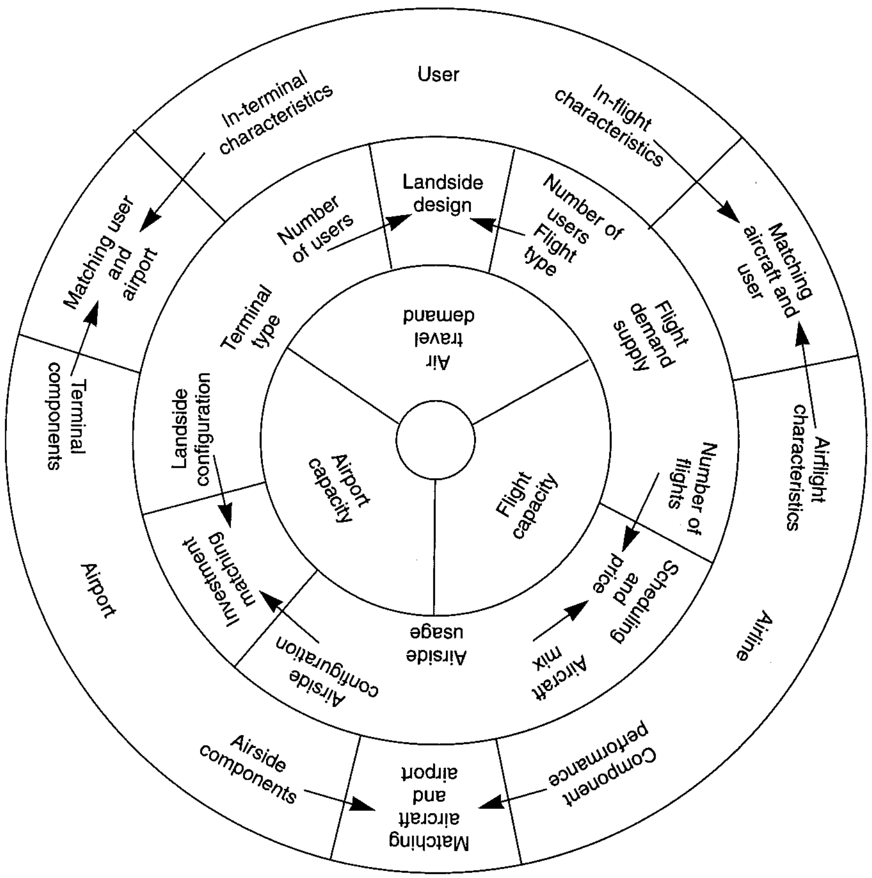


Figure 1.1 A hierarchical system diagram of airport relationships.

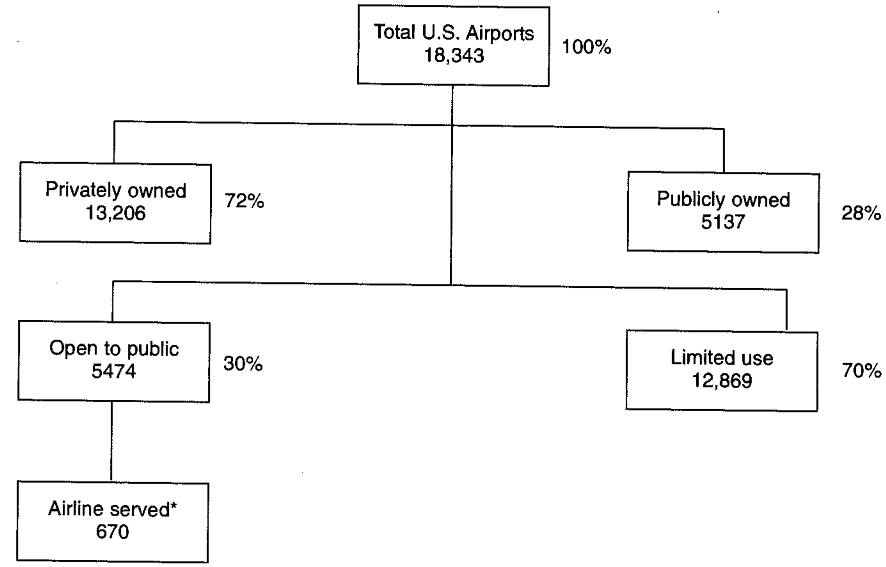
TABLE 1.1 Organizations Affected by the Operation of a Large Airport

Principal actor	Associated organizations
Airport operator	Local authorities and municipalities Central government Concessionaires Suppliers Utilities Police Fire service Ambulance and medical services Air traffic control Meteorology
Airline	Fuel supplies Engineering Catering/duty free Sanitary services Other airlines and operators
Users	Visitors Meeters and senders
Non-users	Airport neighbor organizations Local community groups Local chambers of commerce Anti-noise groups Environmental activists Neighborhood residents

1.2 National Airport System

Modern airports, with their long runways and taxiways, extensive apron and passenger terminal areas, and expensive ground handling and flight navigation equipment, constitute substantial infrastructure investments. All over the world, they are now seen as facilities requiring public investment. As such, they are frequently part of a national airport system designed and financed to produce maximum benefit from public investment. Each country with its own particular geography, economic structure, and political philosophy will develop a national airport system peculiar to its own needs. This system is important to the operation of the individual airport in that national constraints will determine the nature of current and future traffic handled at the facility in terms of such parameters as volume, aircraft type, international/domestic split, number of airlines served, and growth rates. Two different national systems will be discussed briefly, those of the United States and the United Kingdom. They serve to illustrate how systems vary to suit different national needs.

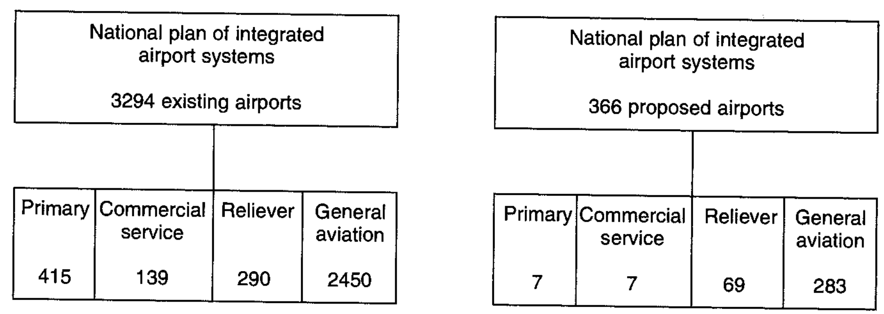
The United States is a very large industrialized nation with more than 18,000 airports (including heliports, STOLports, seaplane bases, and joint-use civil-military airports), of which approximately 12,800 are closed to the public or of limited public use (Figure 1.2a). Of the remainder, approximately 670 provide commercial service through passenger transport aircraft. Some of the more than 5000 airports in the U.S. not served by air carriers have more flight operations than do a number of the airports served by major or commuter airlines. General aviation airports like Van Nuys in California and Fort Lauderdale in Florida have in excess of 200,000 itinerant operations annually. Van Nuys is the ninth busiest airport in the U.S. Publicly owned airports in the National Plan of Integrated Airport Systems (NPIAS) are eligible for federal aid in the construction of most facilities required at the airport, other than those related to commercial activities. Ownership of the large and medium sized airport is almost entirely in the hands of local communities. The two Washington, DC, medium sized airports were formerly operated by the federal government, but these are now under the operation of the Metropolitan Washington Airports Authority. Privately owned commercial transport airports now are few in number and are not significant to the national system, although by the mid-1990s there is significant pressure for some of the largest facilities to be privatized. The scale of monies derived by each publicly owned airport from the Airport and Airway Trust fund is largely related to the functional role of the facility. The system also consists of geographically widely separated hub, regional, and municipal airports that have the opportunity to expand as traffic increases. As a consequence, the functional classification system of the U.S. National Airport System plan (Figure 1.2b) is a relatively free structure related to passenger throughput and aviation activity. Airports are free to



*Regional airline association reports 758 airports served by commuter/regional airlines

(a)

Figure 1.2a A classification of the U.S. airport system, number of airports by ownership and public or limited use, including heliports, STOLports, seaplane bases, and joint-use civil-military airports as of December 31, 1994. *(FAA)*



(b)

Figure 1.2b The U.S. National Plan of Integrated Airports System, NPIAS report, 1993 to 1997. *(FAA)* move their classification, which is a de facto demand classification (NPIAS 1987).

An entirely different national airport system exists in the United Kingdom, which has, in addition to a few major airports, a large number of small regional facilities spread over a small area. Economic appraisal of the performance of the British airport system indicated that most of this system was comprised of loss-making facilities that were unlikely to be able to recoup past investments made in the hope of attracting traffic (Doganis and Thompson 1973; Doganis and Pearson 1977). To encourage the development of a national airport system in which a few major hubs would cater to international traffic and the rest of the airports would assume a support role, the British government in 1978 developed an airports policy to guide central government investment into the airport system. The policy recognized four distinct categories of airports and indicated that governmental approval in the form of finance and permission to develop facilities would be based on this categorization. These were: Gateway International Airports, which supplied a wide range of international and intercontinental services; Regional Airports, which provided short-haul international and domestic services; Local Airports providing third level services, (scheduled passenger services with aircraft having fewer than 25 seats); and General Aviation Airports.

For a number of reasons both political and economic, in 1987 all publicly owned airports with an annual revenue in excess of $1 million were privatized. This meant that the British Airports Authority, which owned seven airports including the two largest, London Heathrow and London Gatwick, was floated on the London share market in a public flotation in that year (Ashford and Moore 1993). All other airports at that time remained as private companies but with all shares entirely owned by local governmental authorities. Since the general privatization occurred in 1987, several other airports have been brought into private hands: e.g., Prestwick, Liverpool, East Midlands, Belfast, and Southampton. The major elements of the British airport system are shown in Table 1.2, although de facto deregulation since privatization has considerably blurred the distinctions between the categories. Five major airports can still be considered to have "gateway" status: the three London airports (Heathrow, Gatwick, and Stansted), Glasgow, and Manchester. Some long-range intercontinental services are available from airports such as Birmingham, which might otherwise be classified as Regional airports. By the mid-1990s, the neat classifications of 1978 had been allowed to blur into a laissez faire system where airport capacity and ability to generate traffic were the prime determinants of function. For example, a number of airports that would otherwise fall into the Regional airport category provided scheduled intercontinental service particularly on transatlantic routes. The development of traffic and the change of status of the airports to a privatized status have reduced the number of airports that are overall loss makers.

TABLE 1.2 The British National Airport System (as of 1978)

Gateway International Airports
Airports supplying a wide range and frequency of international services, including intercontinental services and a full range of domestic services.
Regional Airports
Airports catering to the main air traffic demand of individual regions. They are concerned with the provision of a network of short-haul international services (mainly to Scandinavia and other parts of Europe), a range of charter services and domestic services, including links with gateway airports.
Local Airports
Airports providing third-level services, (scheduled passenger services operated by aircraft with fewer than 25 seats), catering privately for local needs, concentrating on general aviation with some feeder services and some charter flights.
General Aviation Airports
Airports concerned primarily with the provision of general aviation facilities.

1.3 The Function of the Airport

An airport is either an intermediate or terminal point of an aircraft on the air portion of a trip. In simple functional terms, the facility must be designed to enable an aircraft to land and take off. In between these two operations, it might, if required, unload and load payload and crew and be serviced. It is customary to divide the airport's operation between the *airside* and *landside* functions shown in the simplified system diagram in Figure 1.3. More detailed system diagrams are provided for passenger and cargo processing in Figures 8.1 and 10.7. The overall system diagram indicates that after approach an aircraft uses the runway, taxiway, and apron prior to docking at a gate position, where its payload is processed through the terminal to the access/egress system. Departing passengers make their way through the landside operation to the departing gates.

The airport passenger and freight terminal is itself a facility that has three distinct functions (Ashford and Wright 1992).

1. *Change of mode.* To provide a physical linkage between the air vehicle and the surface vehicle designed to accommodate the operating characteristics of the vehicles on airside and landside, respectively.
2. *Processing.* To provide the necessary facilities for ticketing, documentation, and control of passengers and freight.
3. *Change of movement type.* To convert continuous arrivals of freight by trucks and of departing passengers by car, bus, and train into aircraft-sized batches that generally depart according to a preplanned schedule: to reverse this process for arriving aircraft.

Many small airports that provide little more than a simple passenger terminal for low-volume passenger operations, provide very little more than a

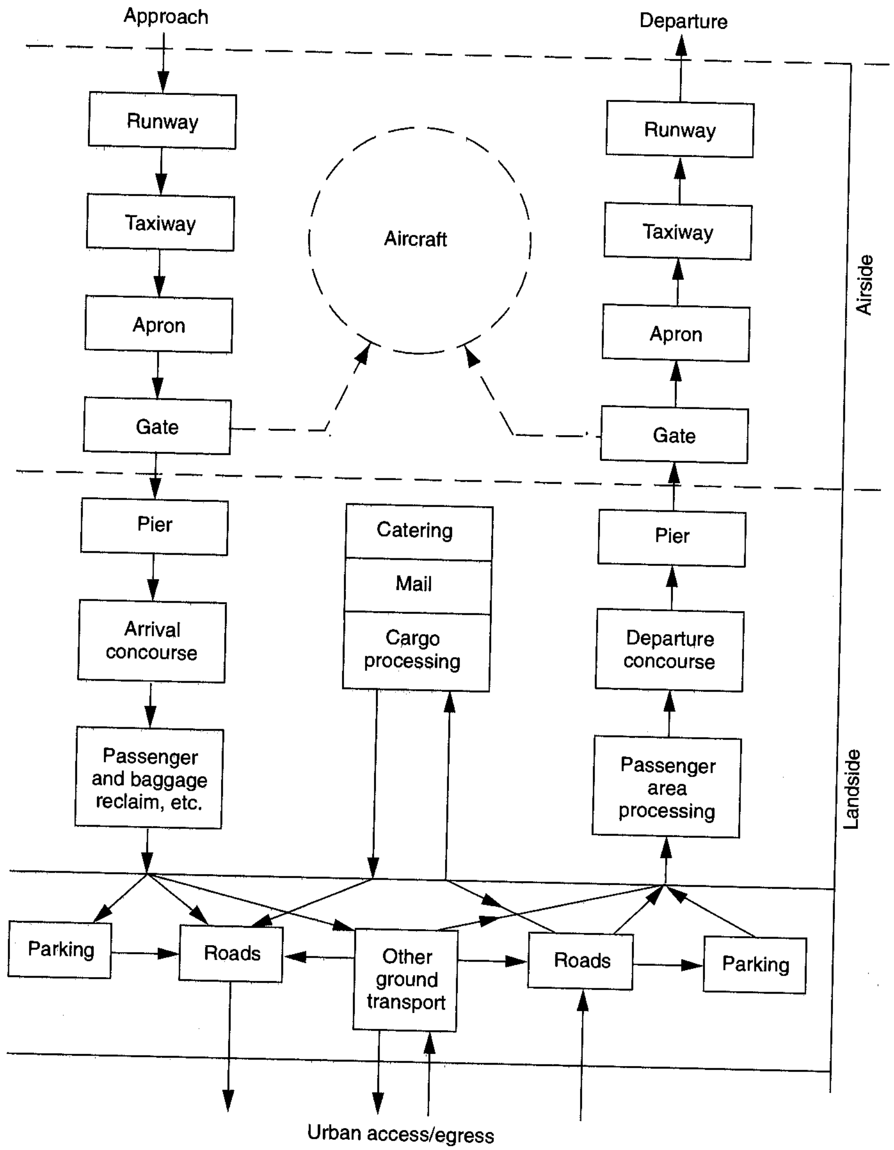


Figure 1.3 The airport system.

passenger terminal facility. The operation of the airport is not significantly more complex than that of a railroad station or an interurban bus station. The medium- or large-scale airport is, however, very much more complex and requires an organization that can cope with such complexity. Airports

of a significant size must have an organization that can either supply or administer the following facilities:

- Handling of passengers
- Servicing, maintenance, and engineering of aircraft
- Airline operations including aircrew, cabin attendants, ground crew, terminal and office staffs
- Businesses necessary for the economic stability of the airport (concessions, leasing companies, etc.)
- Aviation support facilities (air traffic control, meteorology, etc.)
- Government functions—agricultural inspection, customs, immigration, health

Large international hubs are complex entities that have all the problems of any large organization with many employees. In some cases, the airport itself is a large employer (e.g., Frankfurt, with a throughput of 30 million and an airport authority staff of 12,000). In other cases the authority acts more as a broker of services, resulting in a low level of direct authority employment (e.g., Los Angeles, with 51 million passengers and 1335 staff in 1994). Regardless of the chosen modus operandi, overall staffing levels at major airports will be high, and there will be complex interactions between the various employing organizations. Inefficient operations and operational failures in such large systems, whether through incompetence, disorganization, or industrial action, involve huge expenses in terms of additional wages, lost passenger time, and delayed freight costs.

1.4 Centralized and Decentralized Terminal Systems

The way in which an airport is operated and the administrative structure of the operating authority are affected by the physical design of the airport itself. It is convenient to classify airports into two broad and very different operational classes: *centralized* and *decentralized*. Most older airport terminals were designed using the centralized concept, where processing was carried out in the main terminal building and access to the aircraft gates was attained by piers and satellites or by apron transporters. Many airports still operate quite satisfactorily using centralized facilities (e.g., Tampa and Brussels). Other airports started as centralized facilities but became decentralized when additional terminals were added to cope with increased traffic (e.g., London Heathrow, Paris Orly, Madrid, and Johannesburg). Other airports were designed ab initio as decentralized facilities operating with a number of unit terminals each with a complete set of facilities (e.g., Dallas-Fort Worth, Paris Charles de Gaulle, Kansas City, Toronto, and New

York JFK). Another form of decentralization occurs with extensive remote pier developments (e.g., Atlanta) and remote satellites (e.g., Pittsburgh). Figures 1.4a and 1.4b show examples of a centralized and decentralized layout, respectively.

Up to the early 1960s, passenger traffic through even the world's largest airports was so small that centralized operation was commonplace. There are economies of scale on the use of fixed equipment such as baggage systems and check-in desks and with movable apron equipment. Similar economies are found with airport authority, airline, and airport tenants' staff requirements. Subsequently it has been found that fewer security personnel are required in centralized designs.

As traffic grew at the major hubs, the physical size of the centralized facilities grew with additions until they became extraordinarily large in scale. For example, in the 1980s, before the redevelopment of Chicago O'Hare within a single terminal building, the distance between extreme gates was just under 1 mile (1.5 km). Parking facilities also grew in scale. Therefore, travelers could face very long walks, either interlining or leaving the terminal at the end of a trip.

In order to overcome the problem of unsatisfactory walking distances, decentralized designs were developed to keep walking distances down to the region of 984 feet (300 m) as recommended by International Air Transport Association (IATA), with a maximum distance between curbside and the furthest check-in counter set at 328 feet (100 m). Decentralization was carried as far as the gate arrival concept of Dallas-Fort Worth and Kansas City, where total walking distances from car to aircraft are approximately 328 feet (100 m). The advantages of decentralization are significant. Terminals are kept on a human scale, passenger volumes never become uncomfortably high, and walking distances are kept low (Ashford and Moore 1993). Parking lots are small, keeping walking distances reasonable. Therefore, the lots are easier to supervise and thus safer from a crime viewpoint, and curbside drop-off areas are simple to design. Operationally, however, decentralization can lead to higher airport staff requirements, since the same functions, such as administration and security, must be carried out separately in each terminal. Because the scale of such facilities is very large, each unit requires a full range of passenger and staff facilities. It is possible, therefore, to have poor economy of scale in terms of the fixed facilities, such as baggage rooms, baggage claims, and check-in areas, and the mobile facilities, such as apron handling equipment.

(a)

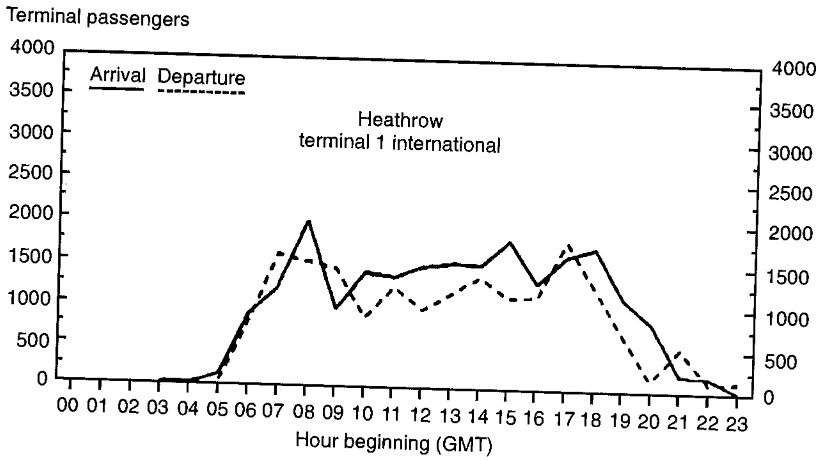
Figure 1.4a Schiphol Airport, Amsterdam—a centralized terminal layout. *(Schiphol Amsterdam Airport)*

(b)

Figure 1.4b JFK Airport, New York

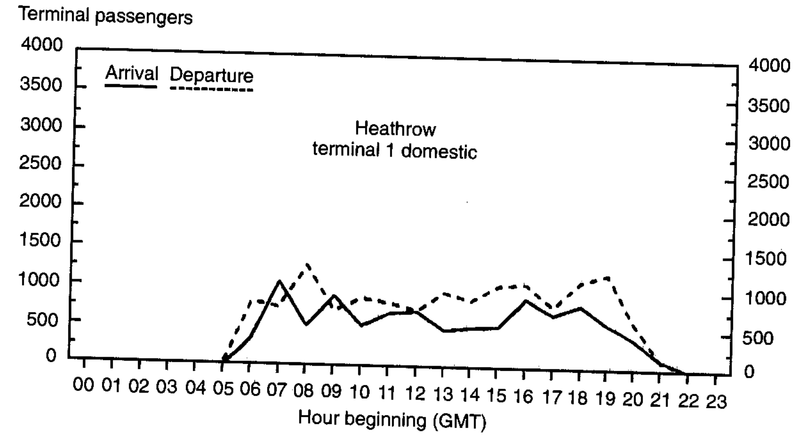
For a large airport, the scale of separation between units can be very large. For example, if the 14-unit terminals at Dallas-Fort Worth (DFW) were to be constructed according to the original master plan the distance between the two most distant units would be 3 miles (4.5 km). Completely decentralized designs mean that interlining passengers must have some form of transit system to permit interterminal movement. At DFW, this is achieved by an automatic transit vehicle; at older terminals, such as New York JFK and London Heathrow, and newer airports such as Charles de Gaulle, this is achieved by a simple bus service. Neither method is particularly convenient.

An often ignored operational difficulty arising from decentralization is the loss of daily capacity that occurs when a given terminal area is broken down into a number of subareas. Capacity is determined by peak hour operation, and demand peaks are more easily smoothed for one large terminal than three smaller terminals Figures 1.5a through 1.5e show total passenger flows at Terminals 1, 2, 3, and 4 at London Heathrow. These would be smoothed to the much less peaky pattern shown in Figure 1.5f if all operations were in one terminal.



(a)

Figures 1.5a to 1.5e Passenger flows through terminals 1, 2, 3, and 4 at London Heathrow. *(a)* arrival/departure Terminal 1 International; *(b)* arrival/departure Terminal 1 domestic; *(c)*arrival/departure Terminal 2; *(d)* arrival/departure Terminal 3; *(e)* arrival/departure Terminal 4. **Figure1.5f** Effect of multiple terminal operations: Heathrow peak month departure and arrival demands for individual terminals and totals.



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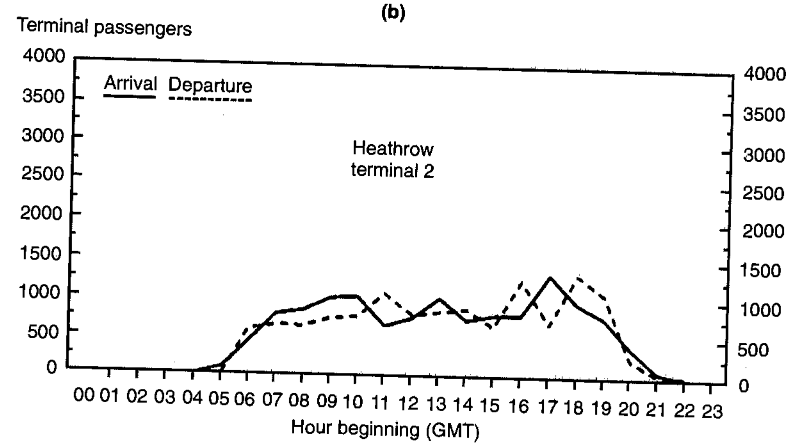

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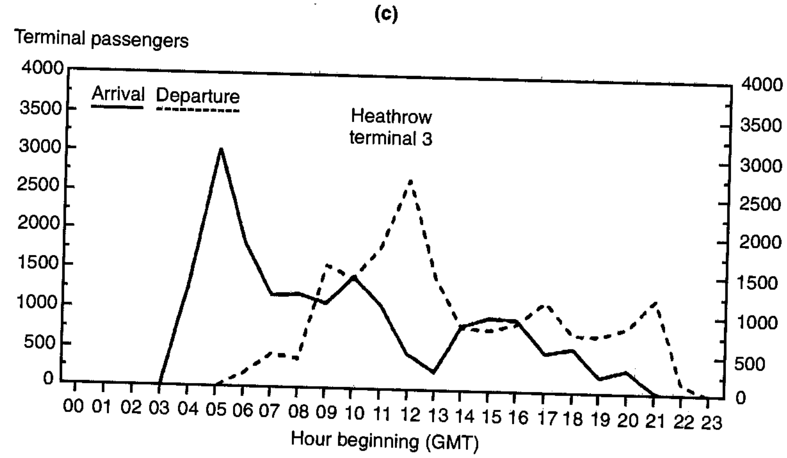

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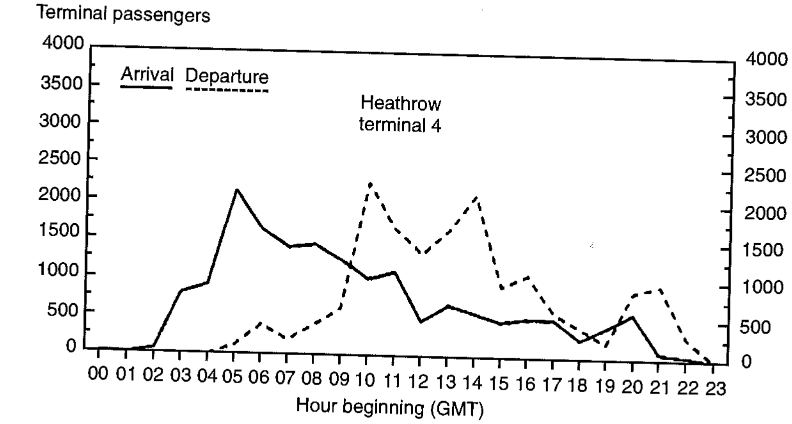

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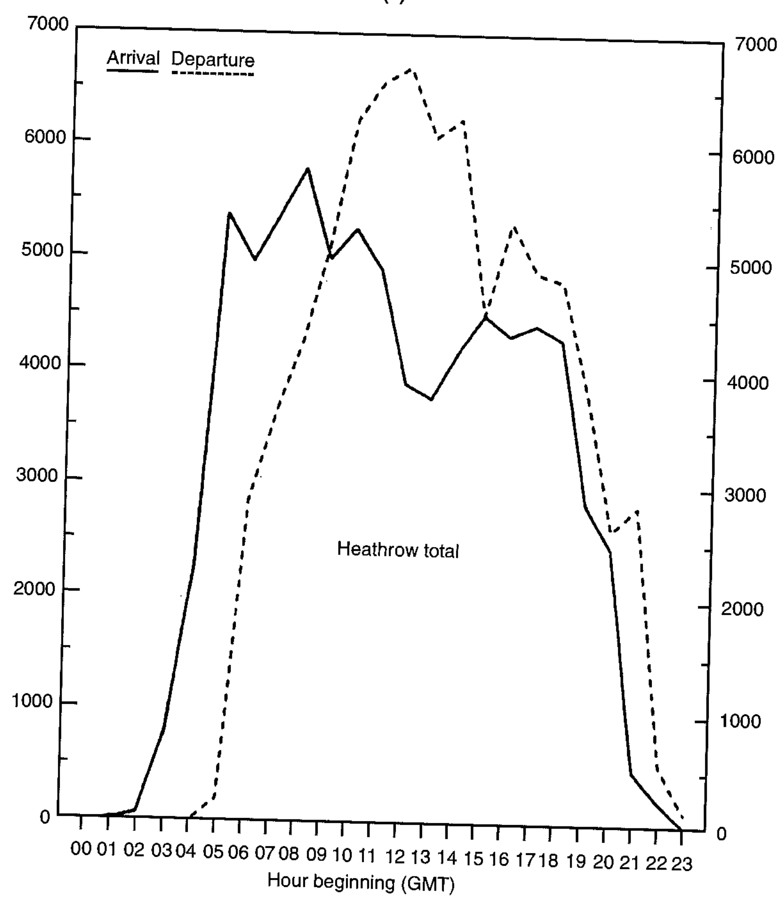


(f)

Figures 1.5 Continued.

1.5 The Complexity of Airport Operation

Airports are complex businesses with functions that extend substantially beyond the airfield or "traffic" side of operations. As airports increase in size in terms of passenger throughput, the nonaviation revenues become increasingly important (Ashford and Moore 1993). It is also clear that in most countries, airports maintain economic viability by developing a broadly based revenue capability. In general, the organizational structure of the operating authority changes to reflect the increasing importance of commercial revenues with increasing passenger throughput. As the relative and absolute size of the non-traffic element of an airport's revenue increase, much more attention must be paid to developing a commercial expertise. Many airport authorities around the world have developed a considerable expertise in maximizing this kind of revenue.

1.6 Management and Operational Structures

There is no unique form of administrative structure that is ideal for every airport. Airports differ in their type and scale of throughput, vary in their interrelationship with other governmental and quasi-governmental bodies, and also fit within differing matrices of allied and associated organizations at central and local governmental levels. Organizational structures must also be recognized as being evolutionary in nature, depending on the previously existing structure and on the pressures for change, not the least of which are those that relate to the personalities and abilities of individuals with directional responsibilities within the organization.

Organizational structure will undergo radical reform should an airport become privatized. Structure also depends on the role the airport authority assumes, varying from a brokering function with minimal operational involvement in many on-airport activities (the U.S. model) to direct operational involvement in many of the airport's functions (the European model). It must also be borne in mind that in common with other commercial and governmental organizations that operate facilities, the management structure of airports may be divided into staff and line functions. The way these functions are accommodated also varies between airports. Staff departments are those that provide direct managerial support to the administrator. Often relatively small in size in terms of personnel, they are engaged in decision making that has a major impact on the whole organization. Line departments, on the other hand, are those portions of the organization engaged in the day-to-day operation of the facility. In comparison with the staff departments, they usually require heavy staffing. The manner in which staff and line departments report to the airport director differs greatly between airports. Figure 1.6 shows three different formalized structures that cover the range of what might occur at any particular airport.

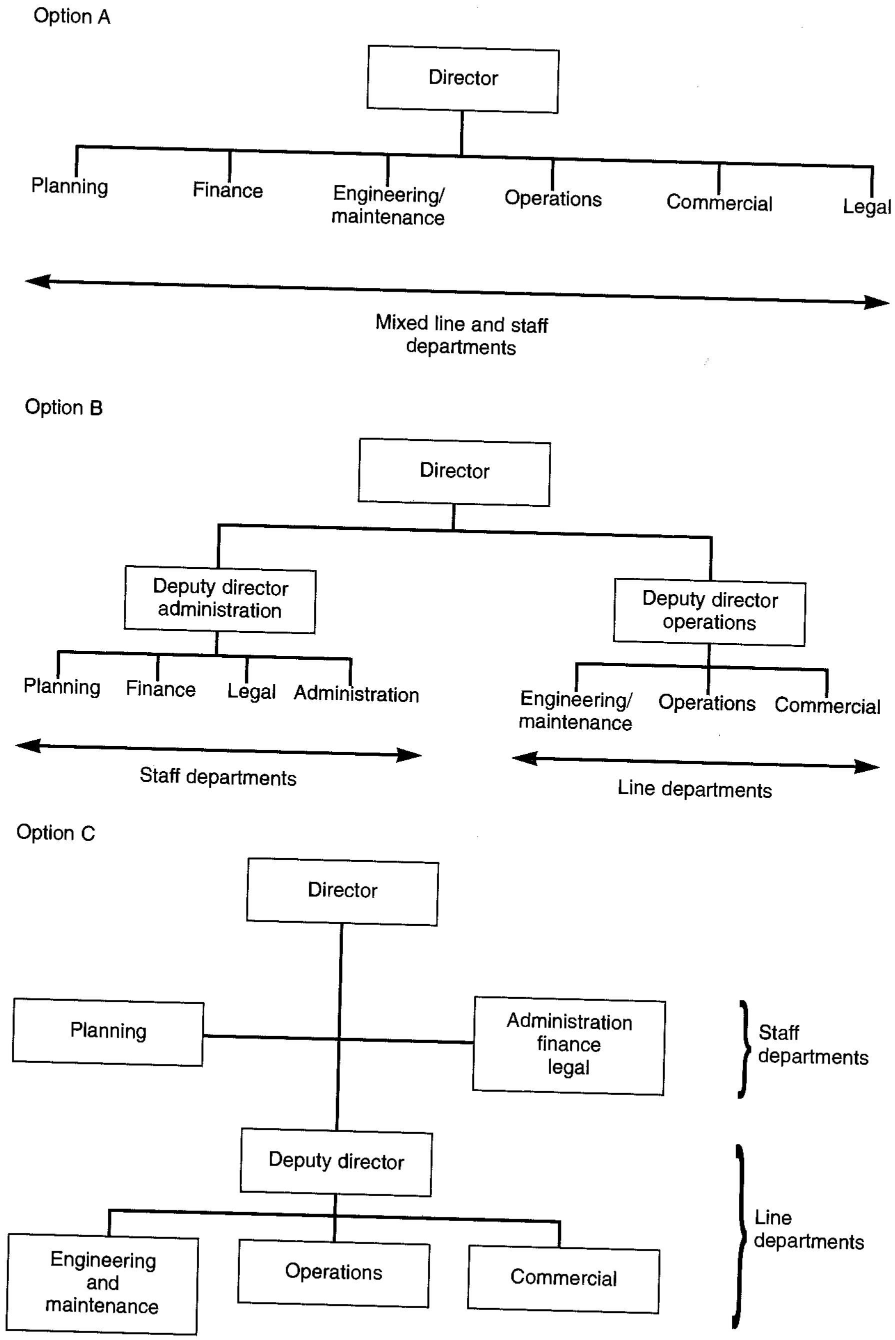


Figure 1.6 Schematic positions of line and staff departments in the structure of airport administrations.

Option A is the structure where staff and line departments all report directly to the airport director. This is the normal situation at a small airport where the staff functions are not excessive and the airport director, as a matter of course, is closely involved with day-to-day operations. Option B is likely to occur at larger airports. The increasing busy line departments report through a deputy director while the staff departments are in a close supportive role to the director. At large airports, Option C is likely to occur, with line and staff departments reporting through two separate deputy directors. Examples with minor variants are shown later in this chapter.

Figures 1.7 and 1.8 show the organizational structures of two autonomous West European airports. Both structures reflect the fact that the organization is involved with the operation of a single airport on the European model and that much of the ground handling of passengers and of aircraft is carried out by airport authority employees. The Munich structure is somewhat conventional in its categorization of activities into operations, technical, and

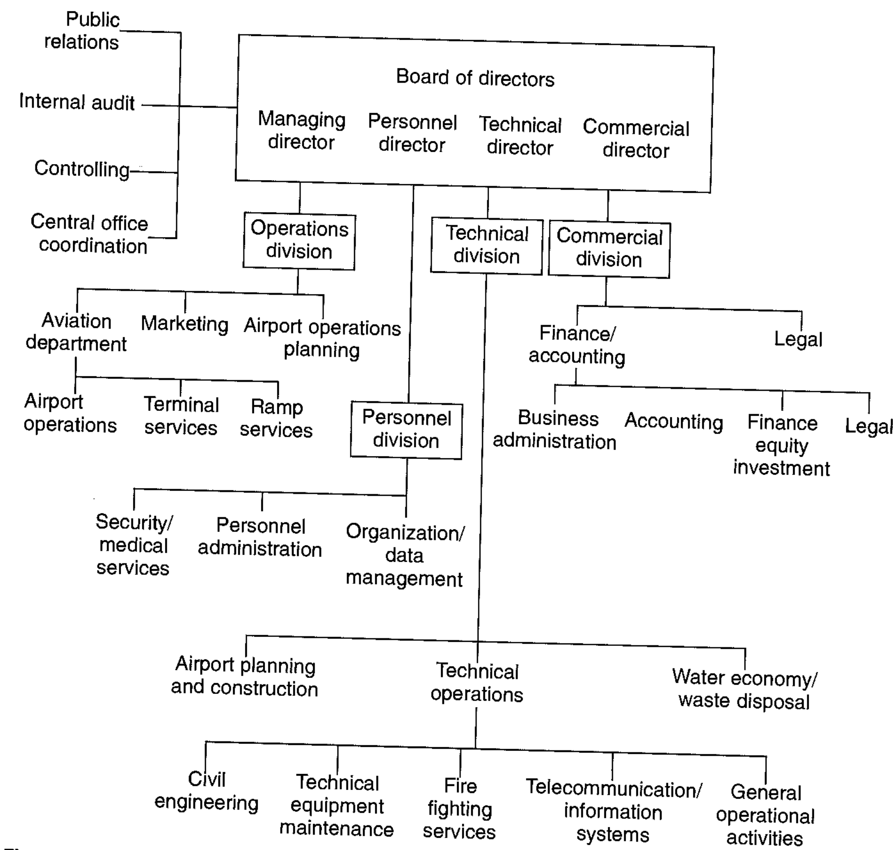


Figure 1.7 Administrative and staff structure, Munich Airport, 1995. Total staff 2700.

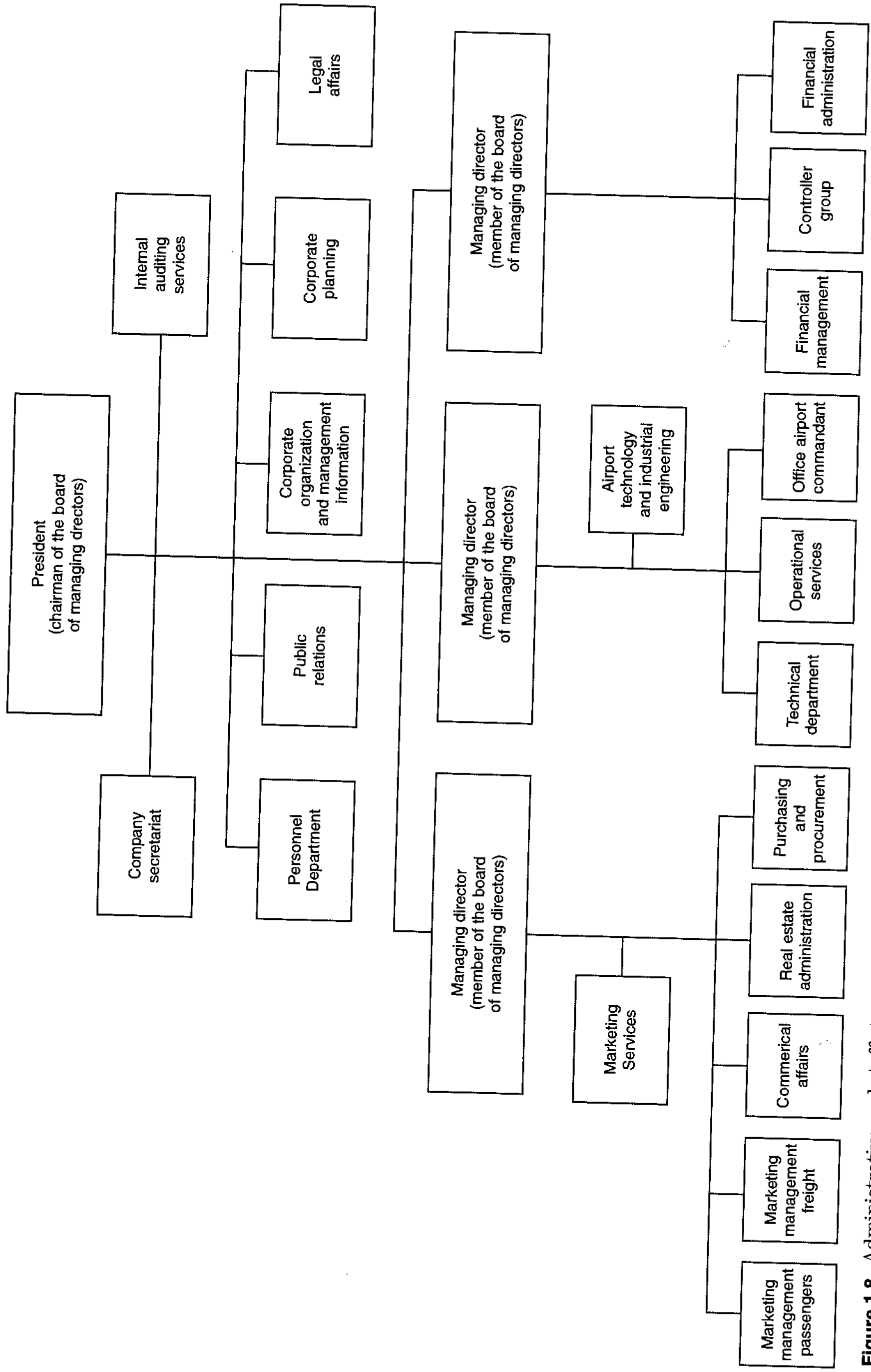


Figure 1.8 Administrative and staff structure, Schiphol Amsterdam Airport, 1995.

commercial divisions. Less usual is the arrangement whereby each division reports to an individual director who serves as an individual member on the board of directors. With an annual passenger throughput of more than 14 million, the number of annual passengers per airport authority employee is approximately 3500. This reflects the high level of airport authority activity on the operational side, with approximately 50 percent of the airport staff being employed in the operations division.

The total number of persons employed on the Schiphol Airport site in 1995 was 41,900, making it the second largest employer in the Amsterdam region, the municipality being the largest. Of these, close to 1550 persons were airport authority employees, giving a relationship of approximately 15,160 annual passengers per authority employee, indicating a much lower level of operational involvement in the airport. It is interesting to note that the Schiphol structure reflects the airport's reputation for aggressively pursuing the commercial and marketing aspects of passenger traffic. Of the eight divisions, two are concerned with external relations and commercial exploitation. Partly as a result of the commercial policy of the airport, 80 percent of all passengers passing through Schiphol take advantage of the shopping facilities.[1]

A very different form of functional arrangement exists at Los Angeles International Airport (Figure 1.9), where the throughput of annual passengers was 51 million in 1994, and the airport authority employs directly a staff of only 1335 giving a ratio of 38,239 annual passengers per airport authority employee. This high ratio does not necessarily imply a greater efficiency or productivity at the U.S. airports; it reflects instead the philosophy that in the United States the airlines are required to provide and staff more of their own facilities and equipment at airports and that more areas are designated to the uses of particular airlines, with fewer common areas and common facilities staffed by airport authority personnel. The implications of airport authority staffing are shown in Figure 1.9, where the line relationships indicate how much operational activity is delegated by the U.S. airport authorities.

Sacramento is a smaller metropolitan airport in northern California. With an airport authority staff of only slightly more than 250 in the mid 1990s, a very simple organization structure was feasible (Figure 1.10). This structure is frequently used at smaller airports around the world. Where the airport director is routinely involved in the day-to-day decisions of running the airport and the technical complexities of the various departments are not of a nature that require extensive range of skilled staff, a structure with essentially two operational divisions (planning/development and operations/

[1]The commercial possibilities at large airports are substantial. It is of interest to note that the commercial areas at Heathrow generate a greater turnover per square meter than the world's most successful department stores.

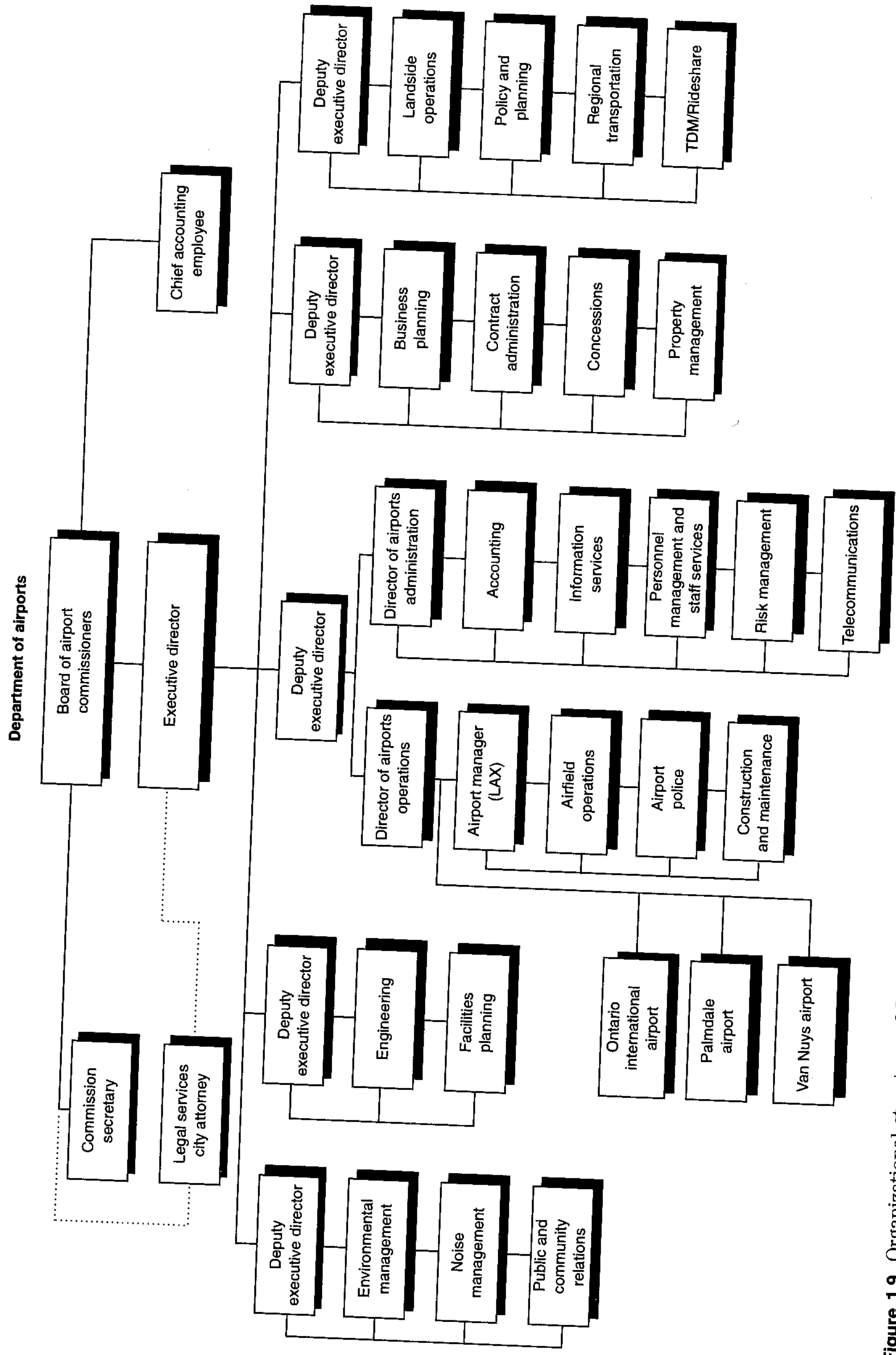


Figure 1.9 Organizational structure of Los Angeles International Airport. Note: *For simplicity, the administrative structure of Van Nuys and Ontario International Airports are omitted from this chart.*

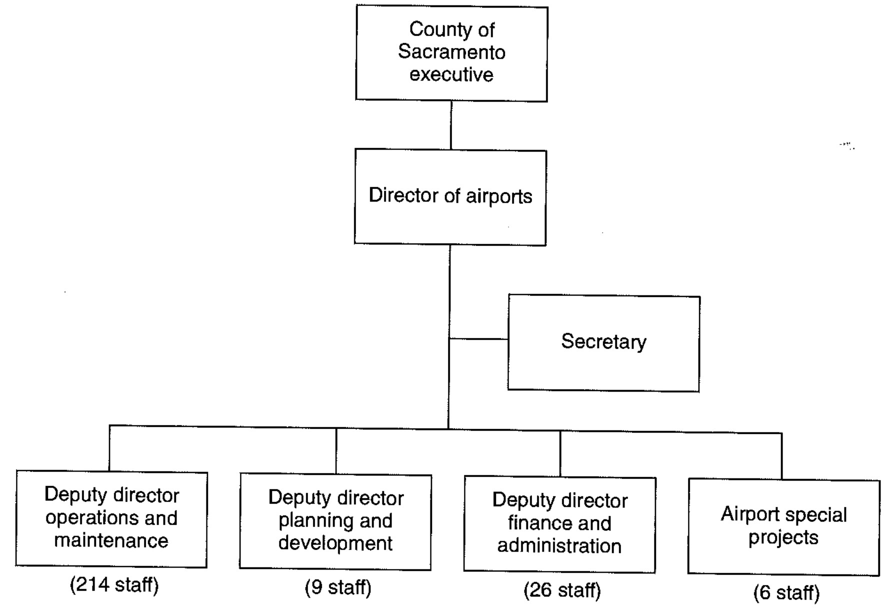


Figure 1.10 Organizational structure of Sacramento Airport.

maintenance) and one staff division (finance and administration) works well. As the complexity of the airport operation increases with size, a structure of this nature often breaks down because the individual divisions usually become too large, and the division directors are overloaded with day-to-day details. This is not always the case, as can be seen from the administrative structure of San Francisco International Airport, where divisional responsibility accrues to only three divisional directors who in conjunction with five heads of bureaus report to the Director (Figure 1.11).

In many countries, governmental or quasi-governmental authorities are charged with the operation of a number of airports (e.g., the Port Authority of New York and New Jersey [PANYNJ], Aeroport de Paris, and Aeroportos e Navegacao Aerea [ANA] in Portugal). The organizational structure of such multiairport authorities is usually designed for achieving systemwide objectives. Therefore, policies are directed by an overall executive to whom the usual system staff functions give support. Individual airports become operational elements in the overall structure. Wiley (Wiley 1981) has developed a typical pro forma organization for a three-airport authority that is shown in Figure 1.12. Practical examples of structure are shown in Figures 1.13a and 1.13b, which show the actual organizational structures of The Port Authority of New York (1995), and the Civil Aviation Authority of Portugal (1995). In each case, the organization permits the development of systemwide policies affecting a number of airports; this is a requirement that is

Chapter

2

Airport Peaks and Airline Rescheduling

2.1 The Problem

Airport operators usually speak enthusiastically of the business of the airport in terms of the throughput of passengers and cargo as represented by the annual number of passengers processed or the annual turnover of tons of air freight. This is entirely understandable, since annual income is to a large degree determined by these parameters; moreover, the numbers are impressively large. However, it is important when considering annual figures to bear in mind that whereas annual flows are the prime determinant of revenue, it is the peak flows that to a large degree determine the physical and operational costs involved in running a facility. Staffing and physical facilities are naturally keyed much more closely to hourly and daily requirements than to annual throughput.

In common with other transportation facilities, airports display very large variations in demand levels with time. These variations can be described in terms of:

- Annual variation over time
- Monthly peaks within a particular year
- Daily peaks within a particular month or week
- Hourly peaks within a particular day

The first of these is extremely important from the viewpoint of the planning and provision of facilities. Air transportation is still the fastest-growing mode, and there is little indication that this situation is likely to change. Consequently, operators of airport facilities often are faced with growing volumes that approach or exceed capacity. During the period 1970 to 1995, the average worldwide rate of air passenger growth was close to 7 percent (ICAO 1995). Even during the difficult period of oil price increases in the 1970s and early 1980s the average world growth rate was also approximately 7 percent. Air transport passenger travel is expected to continue to grow at over 5 percent up to the year 2005 and air cargo to grow at 6.5 percent during the same period (World Traffic 1994). Although the operator must be closely involved in the long-term planning of the airport, it is not the function of this text to deal with planning aspects that are covered elsewhere (Ashford and Wright 1992). Emphasis here will be on the short-term considerations of day-to-day operation. Therefore, the discussion will concentrate on monthly, daily, and hourly variations of flows. In the operational context, this is natural because many of the marginal costs associated with the day-to-day provision of staffing and rapidly amortized equipment are not really related to long-term variations of traffic, but rather to variations within a 12-month span.

At most, if not all, air transport airports, the major consideration must be passenger flow. At many of the larger airports, cargo operations are becoming increasingly important, partially because cargo transport continues to outstrip passenger traffic in terms of growth rate. In the planning and operation of air cargo facilities, however, it must be noted that the peaks for air cargo operations do not coincide with those for air passenger transport. The two submodes can usually be physically separated to the necessary degree, even though proximity of the freight and passenger aprons is desirable because most freight is carried in the bellies of passenger transport aircraft. The particular problems of cargo operations will be discussed in Chapter 10.

When considering the characteristics of the peaking of passenger flows, it is always important to bear in mind that the "passenger" is not a homogeneous entity. Passenger traffic is built up from the individual journey demands of many passengers. These passengers are traveling under different conditions, they have different needs and consequently place different overall demands on the system. Not surprisingly, this is reflected in different peaking characteristics, depending, for example, on whether the passenger is domestic or international, scheduled or charter, leisure or business, full fare or special fare.

Complicating the whole matter of peaking is the fact that, unlike the situation in most other modes of transportation where the passenger is dealing with only one operator, in air transport there is the complex interrelationship of the passenger, the airport, and often several airlines. In the matter of peaking, the aims of the airline and the airport operator do not necessarily coincide. The airport operator would like to spread demand more evenly over the operating day in order to decrease the need for the supply of facilities governed by the peak. The airline, on the other hand, is looking to maximize fleet utilization and to improve load factors by offering services in the most attractive time slots. There is, therefore, a potential conflict between the airline satisfying its customer, the passenger, and the airport attempting to influence the demands of its customer, the airline.

2.2 Methods of Describing Peaking

Even the busiest airport operates over a wide range of traffic flows. Many of the world's largest air transport terminals are virtually deserted for many hours of the year; these same facilities only a few hours later might be operating at flows that strain or surpass capacities. Few facilities are designed to cope with the very highest flow volume that occurs in the design year of operation. Most are designed such that for a few hours of the year there will be an acceptable level of capacity overload. Different airport and aviation authorities approach this problem in different ways. Figure 2.1 shows one of the characteristics of traffic peaking for a typical airport, that is, the curve of passenger traffic volumes in ranked order of magnitude. It can be seen that for a few hours per year there are very high peaked volumes of traffic. Operational practice tends to accept that for a few hours of each year facilities must be operated at some level of overload (i.e., volumes that exceed physical and operational capacity) with resultant delays and inconvenience. To do otherwise and to attempt to provide capacity for all volumes would result in uneconomical and wasteful operation.

The Standard Busy Rate (SBR)

The *Standard Busy Rate* measure or a variation of it is a design standard used in the United Kingdom and elsewhere in Europe, most notably by the

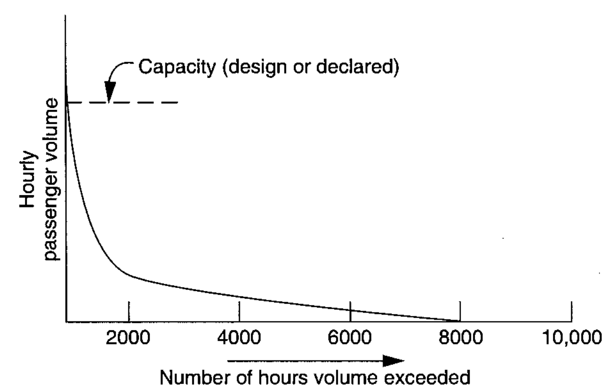


Figure 2.1 Typical distribution of hourly passenger traffic volumes at an air transport airport throughout the year.

former British Airports Authority. It is frequently defined as the 30th highest hour of passenger flow, or that rate of flow that is surpassed by only 29 hours of operation at higher flows. The concept of the 30th highest hour is one that is well rooted in civil engineering practice in that this form of design criteria has been used for many years to determine design volumes of highways. Design for the SBR ensures that facilities will not operate at or beyond capacity for more than 30 hours per year in the design year, which was felt to be a reasonable number of hours of overload. The method does not, however, take explicit note of the relationship of the SBR to the actual observed annual peak volume. Although in practice this relationship is likely to be on the order of

$$\text{absolute peak hour volume} = 1.2 \times \text{standard busy rate} \qquad (2.1)$$

there is no guarantee that this will be so.

Table 2.1 shows that in terms of aircraft movements the ratio of the SBR to the absolute peak increases with increasing annual volume. This reflects the fact that as the traffic of an airport develops, extreme peakness of flows tends to disappear.

The table indicates that use of the SBR method in low-volume airports could result in high (peak/SBR) ratios that in turn could lead to severe overcrowding for a few hours per year. The location of the standard busy hour is shown in Figure 2.2.

Busy Hour Rate (BHR)

A modification of the SBR, which has been used for some time is the *Busy Hour Rate* or the 5 percent busy hour. This is the hourly rate above which 5 percent of the traffic at the airport is handled. This measure was introduced to overcome some of the problems involved with using the SBR, where the implied level of congestion was not common between airports. The BHR is easily computed by ranking the operational volumes in order of

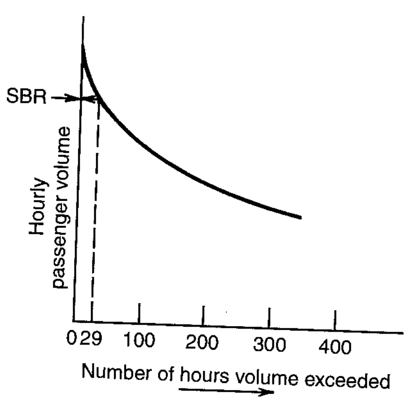


Figure 2.2 Location of the standard busy rate.

Annual movements	Peak day: to average day ratio	Peak day: number	Peak hour: to peak day ratio	Peak hour: number	SBR: to peak hour ratio	SBR: number
10,000	2.666	73	0.1125	8	0.688	6
20,000	2.255	124	0.1051	13	0.732	10
30,000	2.045	168	0.1011	17	0.759	13
40,000	1.907	209	0.0983	21	0.779	16
50,000	1.807	248	0.0961	24	0.794	19
60,000	1.729	284	0.0944	27	0.807	22
70,000	1.666	320	0.0930	30	0.819	24
80,000	1.613	354	0.0918	32	0.828	27
90,000	1.568	387	0.0908	35	0.837	29
100,000	1.529	419	0.0898	38	0.845	32
110,000	1.494	450	0.0890	40	0.852	34
120,000	1.463	481	0.0883	42	0.859	36
130,000	1.435	511	0.0876	45	0.865	39
140,000	1.409	541	0.0869	47	0.871	41
150,000	1.386	570	0.0863	49	0.876	43
160,000	1.365	598	0.0858	51	0.881	45
170,000	1.345	626	0.0853	53	0.886	47
180,000	1.326	654	0.0848	55	0.891	49
190,000	1.309	681	0.0844	57	0.895	51
200,000	1.293	708	0.0840	59	0.899	53
210,000	1.278	735	0.0836	61	0.903	55
220,000	1.264	762	0.0832	63	0.907	57
230,000	1.250	788	0.0828	65	0.910	59
240,000	1.237	814	0.0825	67	0.914	61
250,000	1.225	839	0.0821	69	0.917	63
260,000	1.214	864	0.0818	71	0.920	65
270,000	1.203	890	0.0815	73	0.924	67
280,000	1.192	914	0.0812	74	0.927	69
290,000	1.182	939	0.0810	76	0.929	71
300,000	1.172	964	0.0807	78	0.932	72
310,000	1.163	988	0.0804	79	0.935	74
320,000	1.154	1012	0.0802	81	0.938	76
330,000	1.146	1036	0.0799	83	0.940	78
340,000	1.137	1060	0.0797	84	0.943	80
350,000	1.130	1083	0.0795	86	0.945	81
360,000	1.122	1106	0.0793	88	0.948	83
370,000	1.114	1130	0.0791	89	0.950	85
380,000	1.107	1153	0.0788	91	0.952	87
390,000	1.100	1176	0.0786	92	0.954	88
400,000	1.094	1199	0.0785	94	0.957	90
410,000	1.087	1221	0.0783	96	0.959	92
420,000	1.081	1244	0.0781	97	0.961	93
430,000	1.075	1266	0.0779	99	0.963	95
440,000	1.069	1288	0.0777	100	0.965	97
450,000	1.063	1311	0.0776	102	0.967	98
460,000	1.057	1333	0.0774	103	0.969	100
470,000	1.052	1354	0.0772	105	0.971	102
480,000	1.047	1376	0.0771	106	0.972	103
490,000	1.041	1398	0.0769	108	0.974	105
500,000	1.036	1420	0.0768	109	0.976	106

SOURCE: UK Civil Aviation Authority.

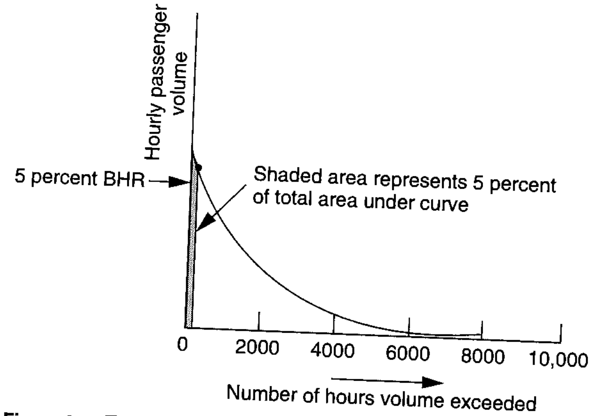


Figure 2.3 Five percent busy hour rate.

magnitude and computing the cumulative sum of volumes that amount to 5 percent of the annual volume. The next ranked volume is the busy hour rate. This is shown graphically in Figure 2.3. One great disadvantage of the BHR method is that so many data must be collected and analyzed that this method might be beyond the resources of a small airport.

Typical Peak Hour Passengers (TPHP)

The Federal Aviation Administration (FAA) uses a peak measure called *Typical Peak Hour Passengers* that is defined as the peak hour of the average peak day of the peak month. In absolute terms this approximates very closely with the SBR. To compute the TPHP from annual flows, the FAA recommends the relationships shown in Table 2.2. Stated in this form it is apparent that the peak is more pronounced with respect to annual flows at small airports. As airports grow larger the peaks flatten and the troughs between peaks become less pronounced.

TABLE 2.2 FAA Recommended Relationships for TPHP Computations from Annual Figures

Total annual passengers	TPHP as a percentage of annual flows
30 million and over	0.035
20,000,000 to 29,999,999	0.040
10,000,000 to 19,999,999	0.045
1,000,000 to 9,999,999	0.050
500,000 to 999,999	0.080
100,000 to 499,999	0.130
Under 100,000	0.200

Busiest Timetable Hour (BTH)

This simple method is applicable to small airports with limited data bases. Using average load factors and existing or projected timetables, the *Busiest Timetable Hour* (BTH) can be calculated. The method is subject to errors in forecasting, the rescheduling and reequipping vagaries of the airlines and variations in average load factors.

Peak Profile Hour

Sometimes called the average daily peak, the *Peak Profile Hour* method is fairly straightforward to understand. First the peak month is selected. Then for each hour, the average hourly volume is computed across the month, using the month (i.e., 28, 30, or 31 days as applicable). This gives an average hourly volume for an "average peak day". The peak profile hour is the largest hourly value in the average peak day. Experience has shown that for many airports the peak profile hour is close to the standard busy rate.

Other methods

Although many outside the United States use some form of the SBR method to define the peak, there is little uniformity in method. In West Germany, for example, most airport authorities use the 30th highest hour. Prior to the introduction of the BHR, the British Airports Authority used the 20th highest hour, while most other British airports used the 30th highest hour. In France, the Aeroport de Paris bases its design on a 3 percent overload standard. (In Paris, studies have shown that the 30th busy hour tends to occur on the 15th busiest day.) Dutch airports use the 6th busiest hour, which is approximated by the average of the 20 highest hours.

Airport differences

The shape of the volume curve shown in Figure 2.1 differs between airports. The nature of these differences can be seen by examining the form of the curves for three airports with widely differing functions, as shown in Figure 2.4.

Airport A — A high-volume airport with a large amount of short-haul domestic traffic (typical U.S. or European hub).

Airport B — A medium-volume airport with balanced international/domestic traffic and balanced short-haul/long-haul operations (typical North European metropolitan).

Airport C — A medium-volume airport with high proportion of international traffic concentrated in a vacation season (typical Mediterranean airport serving resort areas).

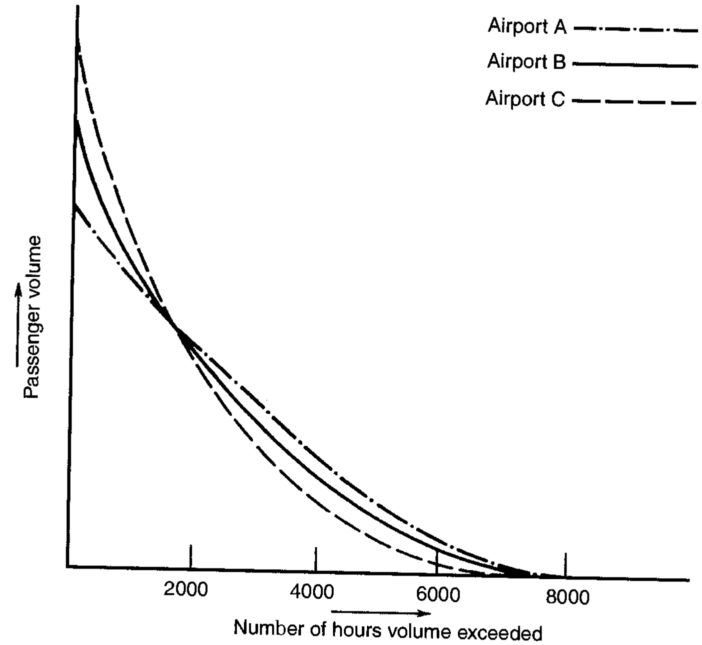


Figure 2.4 Variation of passenger volume distribution curves for airports of different traffic characters.

Airport C will carry a higher proportion of its traffic during peak periods, and there is therefore a leftward skew to the graph in comparison with Airport B. A typical U.S. or European hub, on the other hand, with larger amounts of domestic short-haul traffic carries more even volumes of passengers across the period 0700 to 1900 hours, decreasing the leftward skew of the graph.

Nature of peaks

Airport traffic displays peaking characteristics by the month of the year, by the day of the week, and by the hour of the day. The form and time of the peaks is very much dependent on the nature of the airport traffic and the nature of the hinterland served.

The following factors are among the most important affecting peaking characteristics:

1. *Domestic/international ratio.* Domestic flights will tend to operate in a manner that reflects the working day pattern because of the large proportion of business travelers using domestic flights.
2. *Charter/scheduled ratio.* Charter flights are timetabled for maximum aircraft usage and are not necessarily operated at the peak periods found most commercially competitive by scheduled airlines.
3. *Long-haul/short-haul.* Short-haul flights are frequently scheduled to maximize the usefulness of the day either after or prior to the flight. Therefore, they peak in early morning (0700 to 0900) and late afternoon (1630 to 1830). Long-haul flights are scheduled mainly for a convenient arrival time, allowing for reasonable rest periods for the travelers and crew and to avoid night curfews.
4. *Geographical location.* Schedules are set to allow passengers to arrive at a time when transportation and hotels are operating and can be conveniently used. For example, the six to eight hour eastward transatlantic crossing is most conveniently scheduled for early morning arrivals at the Western European airports avoiding curfews. Allowing for the time differences between North America and Europe, this means an evening departure from the Eastern Seaboard.
5. *Nature of catchment area.* The nature of the region served has a strong influence on the nature of traffic peaking throughout the year. Areas serving heterogeneous industrial-commercial metropolitan areas such as Chicago, Los Angeles, London, and Paris show steady flows throughout the year with surges at the Christmas, Easter, and summer holiday periods reflecting increased leisure travel. Airports in the vicinity of highly seasonal vacation areas, such as the Mediterranean, display very significant peaks in the vacation months.

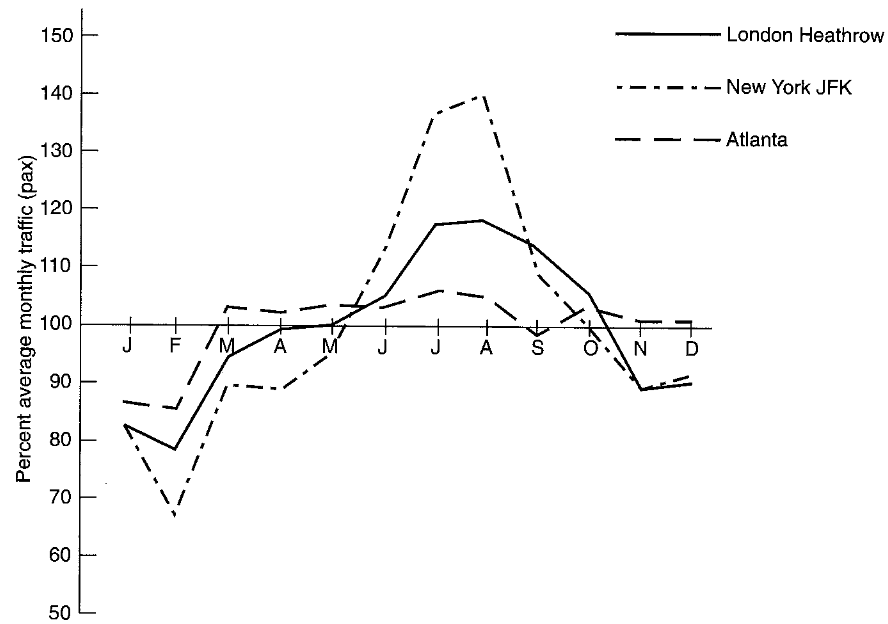


Figure 2.5 Monthly variations of passenger traffic for various airports. *(BAA plc and Los Angeles Department of Airports.)*

Figure 2.5 shows the monthly variations in traffic at several airports serving widely different geographical areas. Daily variations in the peak week are shown in Figure 2.6. The analysis is carried further by Figures 2.7 and 2.8, which show hourly passenger movements and arrival/departures, respectively. It is clear from the last two figures that hourly peaks are significant and differ substantially between airport terminals depending on the airport's function.

In spite of the difference between peaks caused by the many factors that affect peaking, there is in some aspects, in fact, great overall similarity between airports. It is therefore possible to deduce general relationships between peak and annual flows at airports, largely because no airport is entirely unifunctional, just as no town is entirely industrial, governmental, educational, or leisure-structured in its makeup.

Figure 2.9 shows the relationship between peak flows as represented by SBR and annual flows for a number of rather diversely selected airports. Also shown on this graph are the FAA peak/annual recommended ratios, as embodied in the typical peak-hour passengers (TPHP) concept. The great similarity of the two approaches becomes apparent when they are presented graphically.

2.3 Implications of Variations in Volumes

It can easily be demonstrated that the demand for peak-hour schedules affects the amount of infrastructure that must be supplied by the airport.

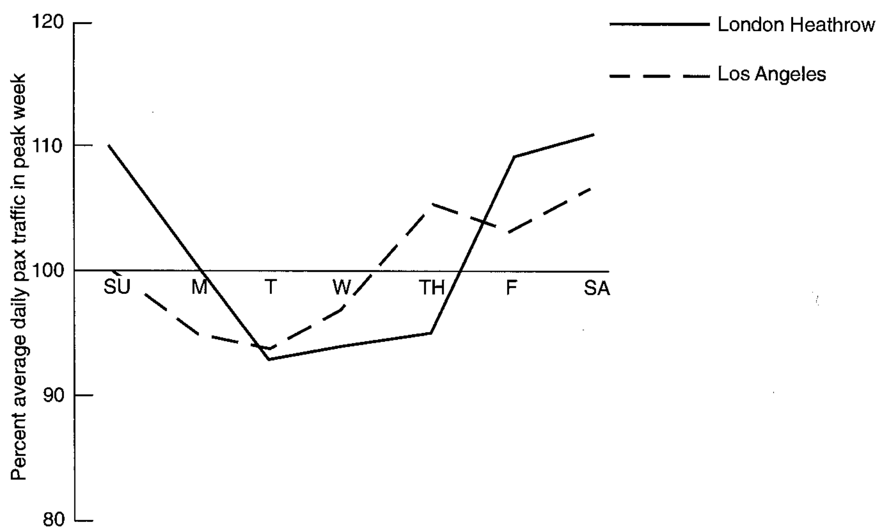


Figure 2.6 Daily variations of passenger traffic in peak week. *(BAA plc and Los Angeles Department of Airports.)*

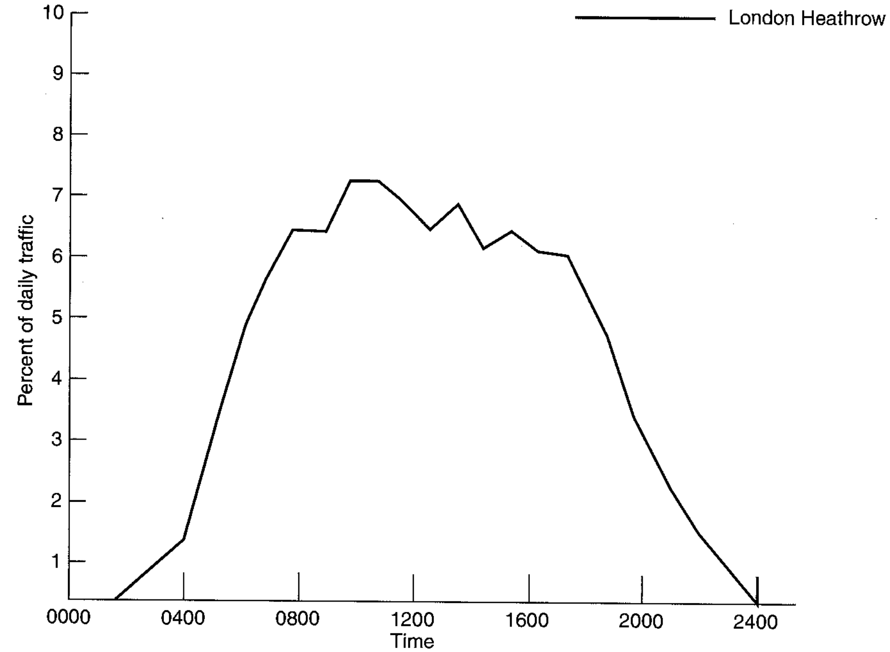


Figure 2.7 Hourly variations of passenger traffic in a typical day in peak season. *(BAA plc.)*

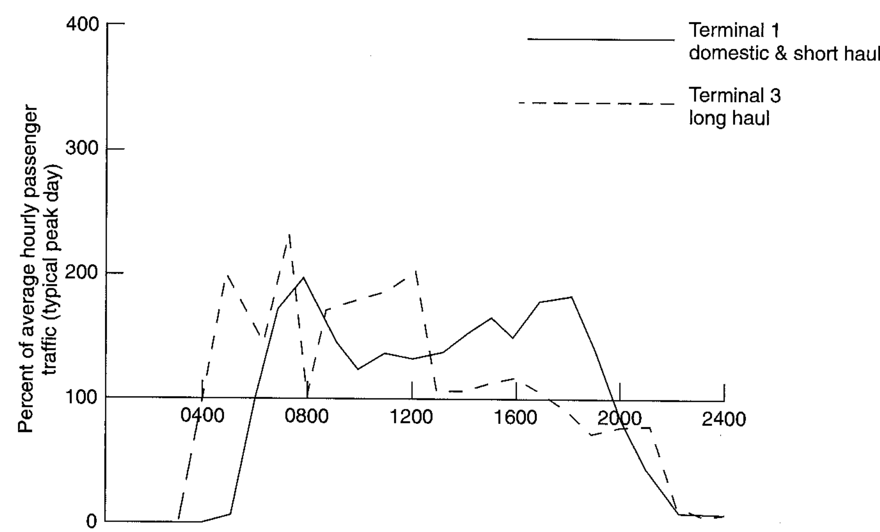


Figure 2.8 Hourly variations of arriving and departing passengers at London Heathrow for long- and short-haul terminals. *(BAA plc.)*

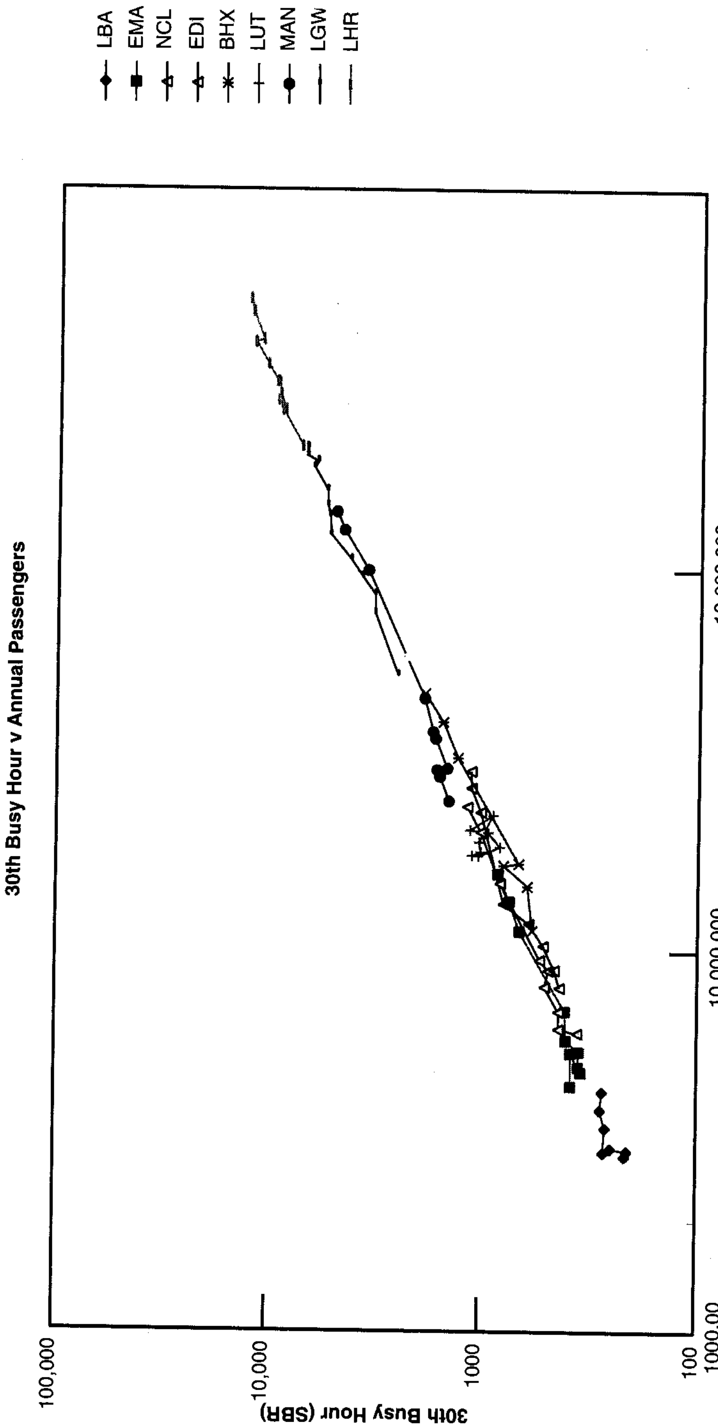
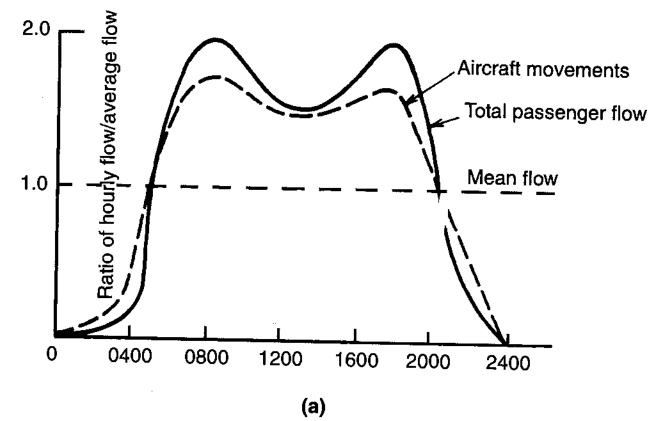


Figure 2.9 Relationship between standard busy rate, *typical peak hour passenger* volume, and annual passenger volume for selected airports. LHR = Heathrow; LGW = Gatwick; MAN = Manchester; LUT = Luton; BHX = Birmingham; NCL = Newcastle; EMA = East Midlands; LBA = Leeds Bradford. *(Civil Aviation Authority.)*

Whereas the need to implement service in an off-peak period will not necessarily involve the airport in significant marginal costs, at a crowded airport the decision to take another service in the peak hour might well add significant marginal costs. There are, however, economies of scale that result from peak hour operations.

Figure 2.10a shows the relationship between passenger flows and air carrier aircraft operations. It can be seen that whereas passenger volumes vary significantly between peak and nonpeak hours, the same scale of variation is not observed in aircraft movement volumes. This reflects the fact that during off-peak periods aircraft operate at lower load factors than during the attractive peak-hour slots. The implications in terms of costs and rev-



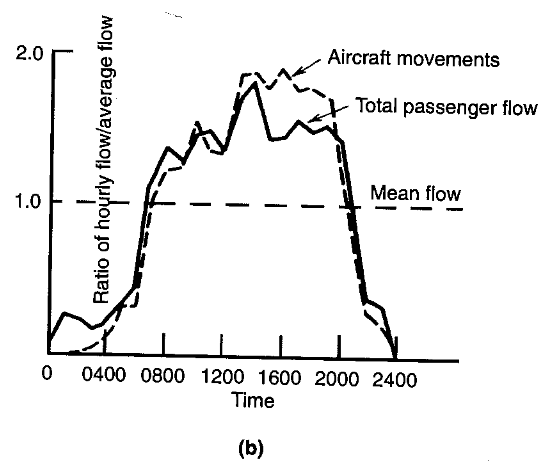


Figure 2.10 *(a)* Idealized relationship of air carrier movements to passenger flow under varying load factors throughout a typical day. *(b)* Observed relationship between aircraft movements and passenger flow at Chicago O'Hare. *(Federal Aviation Administration.)*

enues that are operations-oriented rather than unit passenger-oriented are obvious. Services such as ramp handling, emergency services, air traffic control, runway and taxiway handling, and even some terminal services (e.g., announcements and baggage check) are based on the aircraft unit rather than the passenger. In off-peak hours, these services are provided at a less economic rate per passenger than during peak periods due to low load factors during off-peak periods. Therefore, the airport is faced with a dilemma. Although peak operations would appear to involve high marginal costs in terms of infrastructure, operation at close to peak volumes is highly economic once this infrastructure is provided. This effect is not immediately discernible from an examination of graphs showing total aircraft movements and total passenger flows at a particular airport. Figure 2.10b, which shows total data for Chicago O'Hare on a peak summer day, does not reflect the theoretical graph of Figure 2.10a. It must be remembered that total figures include general aviation aircraft, which might seriously distort the pattern obtained from air carrier aircraft.

2.4 Factors and Constraints on Airline Scheduling Policies

The development of a schedule, especially at a major hub with capacity problems, is a complex problem for the airline. The process involves considerable skill and a clear understanding of company policies and operating procedures. Among the factors to be considered, the following are most important.

Utilization and load factors

Aircraft are expensive items of equipment that can earn revenues only when being flown. Clearly, all other factors being equal, high utilization factors are desirable. However, utilization alone cannot be used as the criterion for schedule development; it must be accompanied by high load factors. Without the second element, aircraft would be scheduled to fly at less than break-even level, which typically is close to 70 percent on long-haul operation of a modern wide-bodied aircraft.

Reliability

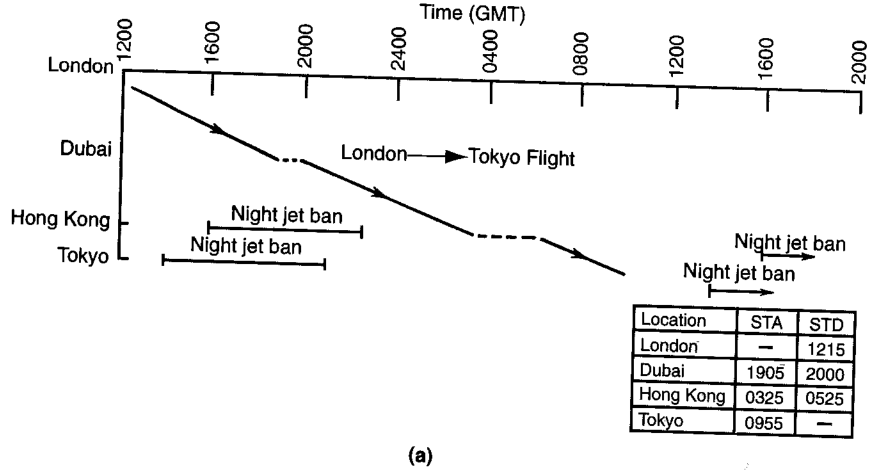
No airline would attempt to schedule using the sole criterion of maximizing utilization of aircraft. Utilization can be maximized, however, subject to the double constraints of load factors and punctuality. As attempted utilization increases, the reliability of the service will suffer in terms of punctuality. Schedule adherence is a function of two random variables: equipment serviceability and late arrivals or departures of aircraft due to en route factors. Computer models are used to predict the effect of schedules on punctuality, and the result is compared to target levels of punctuality set in advance for each season.

Long-haul scheduling windows

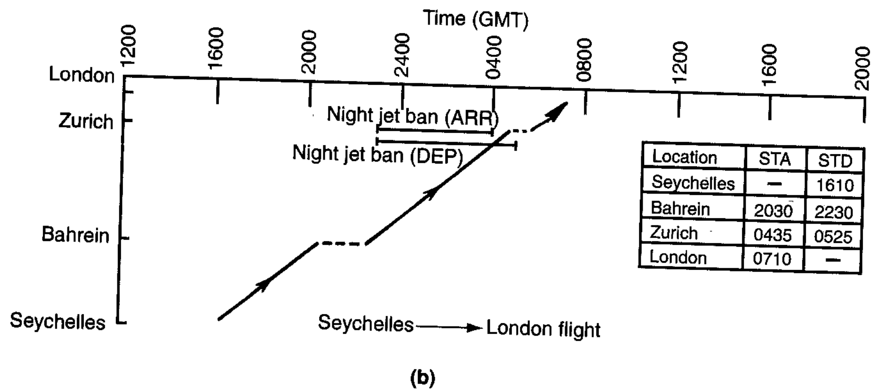
A schedule must take account of the departure and arrival times at the various airports at origin, en route, and at destination. For example, a departure from London destined eventually for Sydney, Australia, via Bombay and Perth could leave in the late afternoon to ensure arrival just after the Sydney curfew lifts at 0600. A morning departure from Heathrow at 0930 would give an arrival time the following evening at 2140, which is only 80 minutes before the 2300 curfew that has no exemptions except emergencies. This is clearly too small a margin for error. Departure times are also set recognizing that passengers must travel from city centers to the airport and must arrive at the airport some reasonable time before the scheduled time of departure.

Figure 2.11 gives examples of scheduling windows for flights to and from London. On the London to Tokyo route, two night jet bans could be involved: Hong Kong (1600 to 2230 GMT) and Tokyo (1400 to 2100 GMT). The schedule is constructed within narrow constraints to ensure arrival at Dubai before the immediate postmidnight hours and avoiding the night bans at both Hong Kong and Tokyo. Long distance schedules of this nature must be constructed to absorb reasonable delays before departure and en route. The Seychelles to London example shows a schedule that might be built around the Zurich night jet ban and a reasonably convenient arrival time at Bahrain. The Zurich night jet ban would determine arrival time in London and departure time from Bahrain. Departure from the Seychelles would be determined by an arrival time just after midnight local time at Bahrain. Even so, the aircraft would be involved in an unnecessarily long turnaround in Bahrain due to a schedule on which there is very little possible variation if commercially attractive times are to be used.

Airport (runway) slots. Runway takeoff and landing slots must also be considered. In many airports, especially in Europe, North America, and S.E. Asia, existing runways are running near to capacity during peak periods of the day. This capacity is due to safety margins required in the separation of arriving and departing aircraft. Many airports near their slot capacity are coordinated. This means that a regulatory authority, such as the FAA or the CAA, has to check and to allocate a number of slots as being available to arriving or departing flights. Actual coordination is carried out semi-annually at IATA slot conferences. A carrier will often have the right only to its historical slots, provided that these are being used. Consequently, at a coordinated airport any carrier will be uncertain whether it will be possible to move from its historic slots or gain more slots. This situation poses prob-



Location	STA	STD
London	—	1215
Dubai	1905	2000
Hong Kong	0325	0525
Tokyo	0955	—



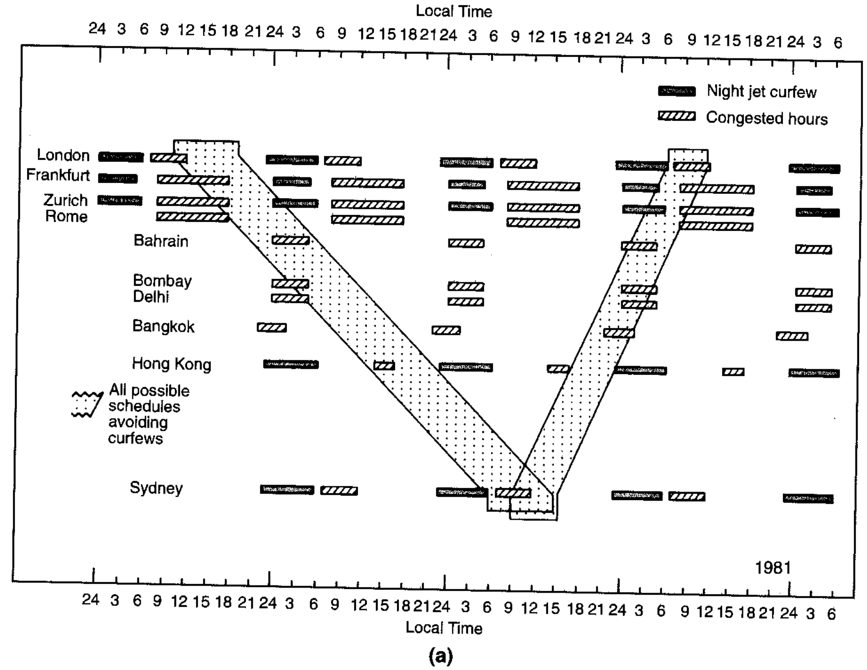
Location	STA	STD
Seychelles	—	1610
Bahrein	2030	2230
Zurich	0435	0525
London	0710	—

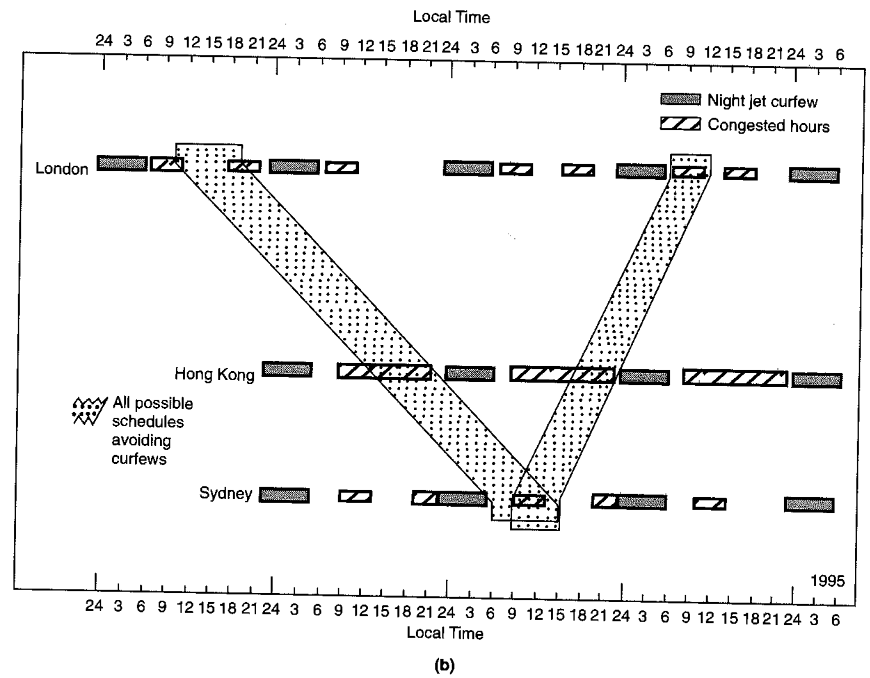
Figure 2.11 Examples of scheduling windows for eastbound and westbound flights.

lems to schedulers who must make assumptions on the likely slots available to them.

Terminal Constraints. Another constraint increasingly faced by schedulers is that of airport passenger apron and terminal capacity. Many airports are running at near to the capacities of these facilities often built 20 or more years ago. In the case of terminals, authorities often limit the number of passengers that can pass through a terminal during a half hourly period, stating that this flow is the "declared capacity." This obviously sets a limit on the number of arrivals, departures or combination of aircraft apron movements that can be scheduled in capacity strained periods, presenting schedulers with yet another constraint.

Figures 2.12a and 2.12b indicate the scheduling limitations on a return flight from London to Sydney, via Hong Kong, in the years 1981 and 1995 re-





Figures 2.12a and 2.12b Scheduling limitations for the London-Hong Kong-Sydney route. *(British Airways)*

spectively, showing very clearly how narrow the scheduling window will be when night curfews and runway congested hours are considered. With the introduction of long-range aircraft, technical refueling stops, which were used in 1981 at airports such as Bahrain, Bombay, and Delhi, are no longer necessary. Consequently, the traffic peaks at these airports have radically changed since they no longer provide intermediate stopping points for European-Asian traffic, stops that frequently occurred at strange early morning hours. However, it can be seen that over the 14-year period shown, the runway at Hong Kong has become congested or curfewed for all but three hours of the day. Congested periods have also increased at London Heathrow while the addition of a second runway at Sydney has eased runway congestion at that airport. It is impossible to schedule this route without the aircraft being on the apron of at least one of the three airports during congested hours.

Long-haul crewing constraints

On long-haul flights, crews may not be used continuously. Typically, a maximum tour of duty could be 14 hours, which includes 1½ hours of pre- or post-flight time; there is also a required minimum rest period (usually 12 hours). Therefore, crews are changed at *slip* posts, and timing must be arranged so that fresh crews are available at these posts to relieve incoming flights that will be continuing their journeys.

Short-haul convenience

Because short-haul flights frequently carry large numbers of business travelers, departure and arrival times are critical to marketing the flights. Short-haul flights that cannot provide a one-day return journey suitably scheduled around the business working day are difficult to market.

General crewing availability

In addition to the special problems associated with layovers of long-haul flight and cabin crews at slip ports all schedules must be built around the availability of maintenance, ground, air, and cabin crews. There is clearly a very strong interrelationship between the numbers of various crew personnel required and the operations to be scheduled, especially in terms of mixed short- and long-haul flights.

Aircraft availability

Depending on the fleet type of aircraft, its age, and the purpose for which it is being used, availability of particular aircraft will differ. Figure 2.13 shows the availability of a short-haul fleet. Maintenance requirements vary greatly

among different types of aircraft. Typically a B747 might be limited to 120 hours of continuous operation. After this, 8 hours of maintenance is required, including terminal and towing times, which could mean 12 hours downtime. A further 24-hour maintenance break is required every three weeks, and at three-month intervals a major maintenance check is necessary. This might be 2½ days , 5 days, or even a month depending on the aircraft's position in its 20,000-hour maintenance cycle.

Marketability

The scheduled times of departure or arrival must be marketable by the airline. Connections are especially important at major transfer points, such as Atlanta and Dallas-Fort Worth. Whenever possible, passengers avoid long layovers at the airport. Other factors that the airline considers are that departure and arrival times at major generating hubs must be at times when public transport is operating and might have to coincide with hotel check-in and check-out times and room availability. It is also important to have continuity of flight times across the days of the week if the flight operates several times a week.

Summer-winter variations

Where there is a large amount of seasonal traffic, usually vacational, there can be substantial differences in scheduling policies between summer and winter operations. The large variation in demand that can occur at airports serving such areas as the U.S. Gulf Coast and the Mediterranean resort areas is substantial and will affect the schedules of airports with which their services link. In general, however, the difference between summer and winter operations has tended to decline over the last 10 years, with winter providing its own peaks around winter holiday periods.

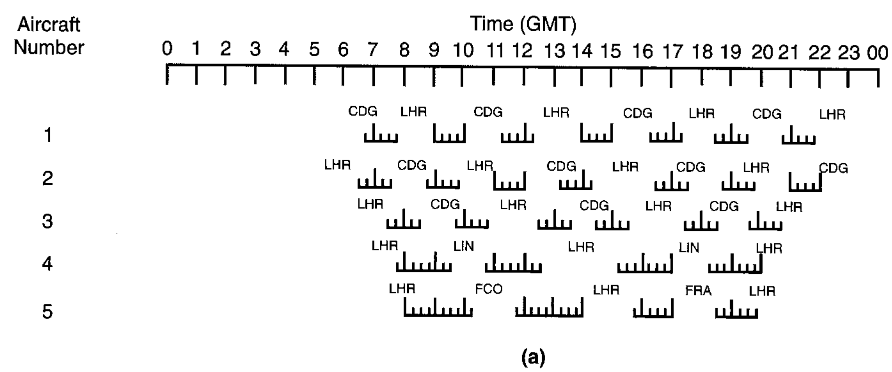


Figure 2.13a Aircraft fleet utilization—Boeing 767 fleet. *(British Airways)*

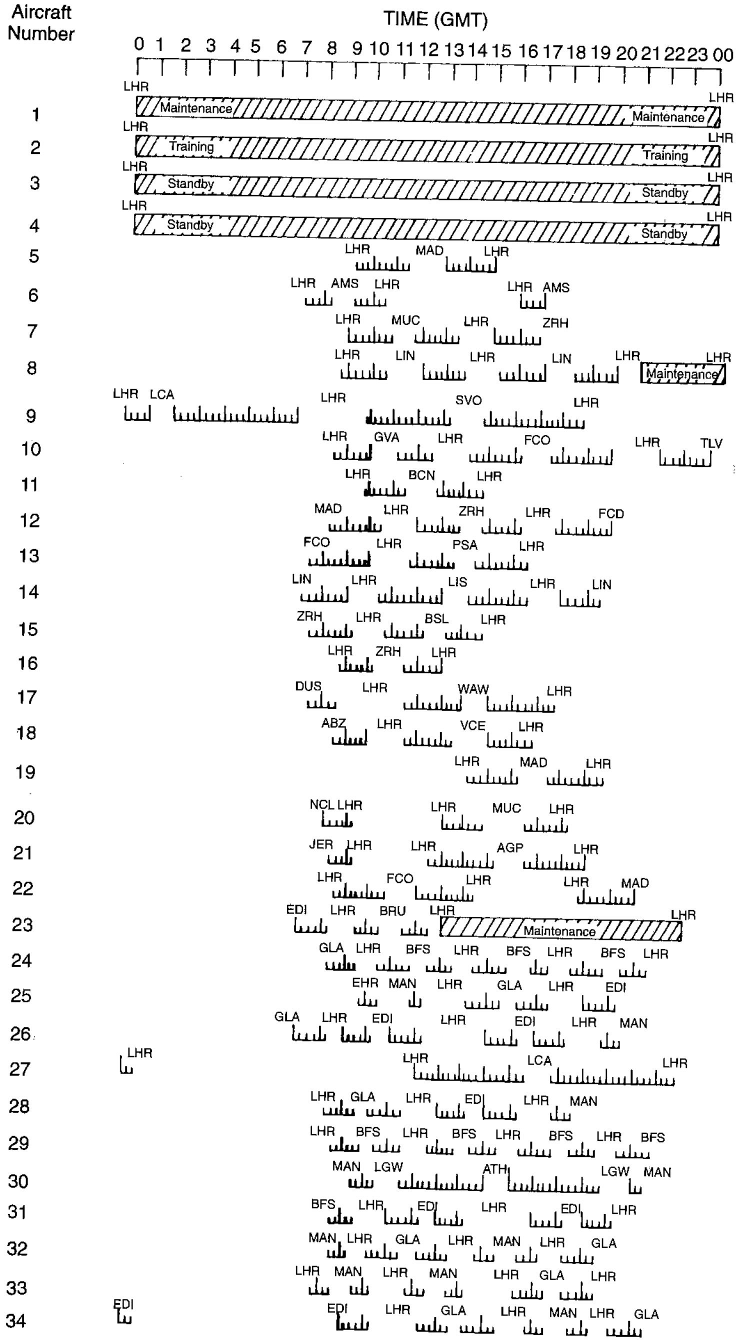


Figure 2.13b Aircraft fleet utilization—Boeing 757. *(British Airways)*

Landing fee pricing policies

At some airports, an attempt has been made to vary landing and aircraft-related fees in order either to use a pricing policy to spread peaking or to recoup extra finance for operations carried out in the economic night hours. An example of the former policy is that which was used by the former British Airports Authority (BAA), which at a stroke adopted punitive peak hour tariffs at London Heathrow to encourage airlines to transfer operations from Heathrow to Gatwick airports and to move operations from the peak period. Under this policy, a typical turn around of a long-range B747 at Heathrow during the peak period was 2.8 times the cost for an operation outside the peak tariff times and 183 percent of the cost that would have been involved had the operation taken place at the less popular London Gatwick airport at the same peak time. The effect of this peak tariff rate was not large, as can be seen in Table 2.3, which shows the operational impact of this particular differential tariff.

In general, there is little evidence to indicate that airlines do reschedule significantly to avoid such tariffs. Airline operators claim that there are far too many other constraints precluding massive rescheduling outside peak demand periods and that, therefore, such tariffs are almost entirely ineffective in achieving their proclaimed purpose.

The truth would appear to lie somewhere between these two positions. Where there is no differential peak pricing, airlines have no particular incentive, other than congestion-induced delay costs, to move operations from the congested peak period. On the other hand, the commercial viability of a flight and its ability to conform with bans and curfews might necessitate operations in peak hours. High differentials for peak operations might at first appear to be a reasonable step for the operator to take to spread congestion. However, any such action should be evaluated in the light of the impact on the based carriers whose operations inevitably represent a very large proportion of the airport's total movements. The short-term economic gain to the airport could put a long-term economic strain on the finances and the competitiveness of the based carriers. Withdrawal of services, movement of the airline base, or even collapse of the carrier will have a serious financial impact on the airport.

TABLE 2.3 Effect of Peak Tariffs on Traffic

	London Heathrow airport: peak passengers as a percentage of total passengers			
	July	August	September	October
1976 (prepeak tariffs)	30.7	30.8	30.4	30.5
1977 (postpeak tariffs)	29.7	26.3	24.5	24.3

Chapter

15

The Airport Operations Manual

15.1 The Function of the Airport Operations Manual

The complexities of today's airports cover a great variety of disparate elements from special purpose buildings to complex equipment needed to meet the needs of aircraft, and passenger and cargo handling. Procedures to enable airports to function are equally complex and involve many different organizations, all of which need to have the fullest possible information if the airport is to operate efficiently. It is for this reason that an *Operations Manual* can provide such a valuable tool for management. Since one of the primary considerations for the air transport industry is safety, in the air and on the ground, a substantial part of any Operations Manual will be devoted to this subject. In most countries the primacy of safety is recognized by a requirement that airports must be licensed before they can be used for air transport. As part of the licensing process, airports might be required to produce and maintain an *airport manual.* An airport manual required by national regulations is usually limited in its contents to those elements of the airport related to the safe conduct of aviation. A particular example is described in Section 15.4.

In Section 15.2 a document of much broader scope is discussed. The Airport Operations Manual here is conceived as a document that describes the operation of the airport across its entirety. In scope it will contain all those aspects required as part of the licensing process, but in addition, all those additional aspects that contribute to the working of the airport *system* (e.g., the facilities and procedures necessary for the safe and efficient movement of passengers, baggage and cargo). The Operations Manual can therefore serve as a basic reference document in which the facilities and procedures of the various operational areas are recorded. It can also serve as a useful introduction training aid for newly hired or transferred personnel.

15.2 A Format for the Airport Operations Manual

Ideally the operations manual will embrace the airport in its entirety, outlining all procedures to be adopted under the various conditions of operation. It will also contain details of the principal infrastructure and equipment for reference purposes. The manual should be seen as the updated standard reference that describes the condition of the airport and how it is operated in all its aspects. A suggested format for a comprehensive operations manual for an airport follows:

A. Introduction

Purpose and scope of manual
Format and table of contents
Licensing bodies
Type of license, terms, and conditions of operation

B. Technical administration

1. Status

Legal identification, addresses of airport, and licensee.
Operating hours.
Latitude and longitude of airport, grid reference, location of airport reference point, elevations of aprons and runway thresholds, airport reference temperature.
Runway lengths, orientation.
Description of aprons and taxiways.
Level of rescue and fire-fighting service protection.
Level of air traffic control.
Level of airport radio and navaids.
System of aeronautical information service available.
Organizational structure of airport administration: names and addresses of key personnel.
Airport movement statistics—passengers, operations, airlines served, based aircraft, aircraft types served.
Airport statistics—staff numbers, visitors, physical areas of facilities by type.

2. Administrative procedures

Procedures for complying with requirements relating to accidents and incidents.
Procedures for promulgation of operational status of facilities.
Procedures for recording aircraft movements.
Procedures for control of construction affecting safety of aircraft.
Procedures for control of access to airport and for control of vehicles while on airport operational areas.
Procedures for control of apron activities.
Procedures for reception, storage, quality, control, and delivery of aviation fuel.
Procedures for the removal of disabled aircraft.

C. Airport characteristics

Plans showing the general layout of the airport, preferably at some scale in the region of 1:2500. Elements to be shown include the airport reference point; layout of runways, taxiways and apron; airport lighting including VASIs and obstruction lighting; location of navigational aids within the runway strips; location of terminal facilities and fire-fighting rescue facilities.
Data necessary for INS equipped aircraft, i.e., INS coordinates for each gate position.
Description, height, and location of obstacles that infringe on the protected surfaces.
Survey data necessary for the production of the ICAO Type A chart, which provides an aircraft operator with the necessary data to permit compliance with performance limitations within the runway, runway strip, clearway, stopway, and takeoff areas.
Data for and method of calculation of each of the airport runway cleared distances (TORA, EDA, TODA, and LDA) with elevations at the beginning and end of each distance. Where reduced declared distances are accepted due to temporary objects infringing on the runway strip, transitional approach or takeoff surfaces, the method of calculating the distances should be indicated.
Operational limitations due to obstructions and so on.
Details of the bearing strengths and surface conditions of runways, taxiways, and aprons.
Temporary markings of displaced thresholds.

D. Operational procedures

Ground movement control procedures—rules of access, right-of-way, and vehicle obstruction marking. Structure of control and duties
Responsibility and procedures for routine operations on apron, including marshaling, docking stand allocation, aircraft servicing
Routine inspection procedures of movement areas, including runway strips, runways, aprons, taxiways, grassed areas, and drainage

Procedures for measurement and notification of runway surface condition—responsibility for reporting, measurement of runway braking action, depth and density of snow and slush, frequency of reporting.

Details of the airport snow plan, including categories of snow warnings: preliminary and final with duration and intensity forecasts; organization and chain of responsibility; standing instructions for procedures in snow conditions; equipment including maintenance and care; training of personnel; procedure or clearing runways, taxiways, aprons, airport roads, and domestic areas; hiring additional equipment.

Procedures for the general cleaning and sweeping of runways, taxiways, and aprons.

Details of bird hazard control plan including methods of control: technical measures, killing, and environment modification. Treatment of runways, taxiways and aprons, grassland, built-up areas and special areas, such as garbage dumps. Control of hazard outside airport boundaries

Procedures for determining the availability of grass runways after heavy rains or flooding.

E. Rescue and fire-fighting services (RFFS) (or emergency orders)

Purpose of emergency orders.

Categories of emergency: aircraft accident, aircraft ground incident, full emergency, local standby, weather standby, aircraft bomb warning, building bomb warning, hijack, act of aggression on ground, building fire, approach alert within 10 miles (15 km) of airport.

ICAO category of the airport.

Range of on-airport and off-airport rescue and fire-fighting services.

Details of appliances and extinguishing media necessarily available on-airport to meet the ICAO category requirements.

Structure of airport emergency services: organization, qualified staffing and chain of command.

The airport emergency procedures, including in-shore rescue where necessary. Rendezvous points, grid map, designation, and maps of remote search areas.

Degree of response of service.

Training program for RFFS.

Procedures and limitation of aircraft operations during temporary depletion of RFFS.

Other responsibilities: fire prevention, storage of dangerous goods.

Procedures for removal of disabled aircraft: general procedures alternative runways, emergency removal, designation of recovery team and responsibilities; formulation of recovery plan; phasing of recovery.

Medical facilities: quantities of equipment available, list of qualified personnel, structure of medical organization and control, arrangements for obtaining external medical assistance, medical procedures in case of accident, allocation of casualties to hospital.

Responsibilities in case of emergency: air traffic control, airport fire service, telephone switchboard, airport security, ground services, motor transport pool, airport engineering, airlines and handling agents, airport authority staff, off-airport services (e.g., fire services, police, medical services)

Location of ministers of religion.

Emergency communications systems; emergency direct lines, radio channels, direct ex-directory lines, radio-equipped vehicles, intercom channels, posted instructions.

F. Airport security plan

General description and rationale of security plan.

Responsibilities for airport security: airport administration and airport director, airlines, and other authorities.

Structure of airport security organization, police, and definition of diversion responsibilities.

Degrees of security (1) nominal, (2) period of heightened tension, (3) alert.

Persons authorized to prevent a flight or order an inspection or aircraft search.

Responsibilities for action in case of security alert at airport: general responsibilities, airport switchboard, airport fire service, police, air traffic control, ground services, airlines, and handling services.

Search procedure for aircraft: positioning, conduct of search, baggage identification, and cancellation of alert.

G. Airport lighting

The lighting scale of each runway, including approach and threshold lights.

The airport lighting system: method of operation, general layout diagram and individual circuit loops, ancillary lighting control, control console, constant current regulators, ac distribution switchboard.

Maintenance and routine inspection procedures.

Procedures for operation, including various brilliancy settings.

Failure maintenance and fault-finding procedures.

Standby power arrangements.

Technical diagrams of all lighting units.

Location of obstacle lighting on and off airport; responsibility for maintenance.

H. Meteorological Services

Organization and structure of meteorological services; staff structure and responsibilities.

Class of service and information provided—form of messages.

Equipment—uses and maintenance.

Supply and use of meteorological services.

I. Air Traffic Control Services

Description of the system for managing air traffic in airspace in the vicinity of the airport including: organization and responsibility of air traffic services; aeronautical information service.
Rules of the air and air traffic control; general flight rules.
Rules governing the selection of the runway in use and the circuit direction.
Standard procedures.
Noise abatement procedures.
Search and rescue alerting.
Method of obtaining and disseminating meteorological information, including RVR, visibility, and local area forecasts.

J. Communications and navaids

Description and procedures for the use of general communications channels; AFTN, SITA, ARINC.
Description and procedures for use of air/ground and operational ground radio where these are not covered by air traffic control procedures.
Description of and operating procedures for radio and radar navigation aids; installation procedures; inspection and maintenance.

K. Signals and marking

Location of the signals area; procedures for display of temporary and permanent signals.
Location of wind socks.

L. Access provision

Airport location plan showing regional road network and public transport routes.
Access routes in immediate vicinity of airport.
Provision of parking: number and location of spaces; contract and obligations of parking operators.
Taxis and car hire: names and contractual obligations of operators.
Passenger Access Information System.

M. Passenger terminal

Organizational structure of terminal administrative staff: description and responsibilities.
Passenger Information System: scale, equipment, maintenance procedure, standard information formats.
General information: airlines operating from airport, passenger and aircraft handling companies, airline interline handling agreements.
Layout of passenger terminal.
Arrivals, method of processing.
Departures: method of processing, definition of permissible cabin baggage, security arrangements, and definition of dangerous goods.
Special handling of passengers: procedures and equipment for handling disabled persons; unaccompanied minors, and VIPs.
Airport services and concessions: procedures for operating airline ticket desks, mishandled baggage procedures; listing of, location of, and contractual obligations of concessionaires such as: duty-free shops, catering, banks, car hire, insurance desks, valet service, shops, hotel booking facilities, postal and telephone services.
Description and operational arrangements of facilities for meeters, senders, and spectators.
Description and operational arrangement of support facilities for airport airline and other staffs working in the passenger terminal area.

N. Cargo handling facilities

Organizational structure of airport authority, airlines, and other cargo handlers in cargo area.
Location of facilities and layout.
Cargo handling procedures: export and import, including customs clearance requirements.
Description of airport and customs computer facilitation system.
Procedures for handling mail.
Procedures for handling airlines' company freight.

O. General Aviation

Description and layout of general aviation facilities.
General regulations relating to general aviation operations.
Inbound procedures.
Outbound procedures.
Scale of fees, method of collection.
Aeronautical Information Services, meteorological services, and lounge arrangements for general aviation.

P. Typical appendices

Amendment procedures.
Distribution list of operations manual.
Necessary telephone numbers, airlines, concessionaires, agents airport staffs, other airports.
Bylaws and regulations of airport.
Two-letter airline codes.
Three-letter airport codes.
Standard information symbols used at airport.

15.3 Distribution of the Manual

The airport operations manual should be regarded by those administering the airport as the definitive document containing a statement of standard operating procedures and a description of airport equipment and facilities. An updated version of the manual should be held by the chief administrator of the principal operations areas of the airport. At a very small airport, the manual would be a rather simple document, and probably only one copy would exist, which would be kept by the director. In a large complex operation, a more likely distribution list for the manual and its subsequent amendments would be:

- Airport director
- Deputy director
- Assistant director operations
- Assistant director engineering
- Assistant director administration
- Chief fire officer
- Chief air traffic control officer
- Airline station managers of based airlines

Whether simple or complex, the updating and amendment of such a manual requires close attention. Sources of information should be carefully checked. It is possible, as in the case of one major U.S. airport, for an accident investigation to discover uncertainty regarding the origin of information on the precise length of a runway.

Updated sections of the manual that are pertinent to their own sections should be available to the line managers of the operations of the passenger terminal, the cargo terminal, the passenger and cargo aprons, air traffic control, engineering meteorology, fire fighting and rescue, and maintenance. It is also useful to use appropriate sections of the manual as instructional aids in the training of the various grades of manual workers.

15.4 U.S. Example: FAA Recommendations on the Airport Certification Manual

In a number of countries, the Airport Operations Manual or the Aerodrome Manual, in some form or another, is linked to certification of the facility as an airport. In the United States, Federal Regulations Part 139, which deals with the certification of land airports serving scheduled carriers (Code of Federal Regulations 1994) requires that each applicant for an airport operating certificate must submit an Airport Certification Manual to the FAA[1]. For the operation of an airport serving unscheduled carriers a *Limited Airport Operating Certificate* can be issued based on the submission of *Airport Certification Specifications.* The administration sets out a number of guidelines on how a manual is to be prepared, recognizing that the suggested format is not all inclusive but is intended to provide broad guidance so that each operator will have flexibility in developing a manual to fit the particular airport. The recommendations are largely related to a description of the data that must be supplied for eligibility for certification and other data to indicate compliance with operational rules. The suggested format for the FAA manual is substantially less broad than that indicated in Section 15.2, and includes the following:

Suggested airport certification manual—FAA format

1. Introduction
   - (*a*) Name and location of airport
   - (*b*) Mailing address of airport manager or operator
2. Personnel
   - (*a*) List of key personnel and job titles
   - (*b*) Brief description of functions
   - (*c*) Organizational chart showing operational lines of succession
3. Airport familiarization
   - (*a*) Brief description of airport and primary activities (e.g., named carriers/equipment)
   - (*b*) Maps and charts showing such things as general layout of the airport terrain features and runway and taxiway system
4. Pavement areas
   - (*a*) Movement areas available for air carriers with their safety areas; use of a map or diagram is recommended
   - (*b*) Describe the procedures for maintaining the paved and safety areas
5. Marking and lighting
   - (*a*) Describe runway and taxiway systems of identification
   - (*b*) Indicate which types of operable lighting systems are installed on surfaces used by air carrier aircraft

[1]For detailed guidance reference should be made to the code of Federal Regulations, Title 14. Parts 77, 105, 139, together with Advisory Circulars in the 139 and 150 series.