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Part 1

AIRPORT PLANNING MANUAL

PART 1

MASTER PLANNING

SECOND EDITION — 1987

Approved by the Secretary General and published under his authority

INTERNATIONAL CIVIL AVIATION ORGANIZATION

Airport Planning Manual

(Doc 9184-AN/902)

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Master Planning

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AMENDMENTS

The issue of amendments is announced regularly in the *ICAO Journal* and in the monthly Supplements to the *Catalogue of ICAO Publications and Audio-visual Training Aids*, which holders of this publication should consult. These amendments are available free upon request.

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FOREWORD

The Council of ICAO on 10 March 1967 (EX-8) approved a proposal of the Secretary General that guidance material be prepared to assist States in planning the expansion of existing international airports and the construction of new ones.

This project was conceived in the realization of the major impact that expansion of air transport was having and would continue to have on facilities throughout the world, it being recognized that, in addition to the major problems of great expansion in absolute volume of passengers, cargo and air traffic, the introduction of very large-capacity aircraft was likely to cause special problems at an increasing number of airports. Existing programmes of ICAO did not provide airport authorities with guidance for the development of airport master plans in all their aspects, nor had it been intended that they should.

The first manual entitled *Manual on Airport Master Planning* was written by three professional airport planners recruited exclusively for this purpose. An advisory group composed of representatives of the following organizations provided invaluable assistance in defining the structure of the manual and reviewing material: Aéroport de Paris; Aerospace Industries Association of America, Inc.; Airport Operators Council International, Inc.; British Airports Authority; Dallas-Fort Worth Regional Airport Board; Department of Transport, Canada; International Air Transport Association; University of California. Additionally, a substantial amount of work was done on it by the regular Secretariat.

In 1976 a general revision of the manual was prepared by the Air Navigation Bureau, assisted under contract by the firm TCB/Morris International, and by the Air Transport Bureau which revised Chapters 3 and 4. The intent of this revision was to incorporate experience gained from use of the original Manual, experience from the introduction into service of large-capacity aircraft and new planning technology. This second edition incorporates changes and additions resulting from an over-all review made by the Secretariat.

It is important to note that the material contained in this manual does not necessarily reflect the views of ICAO nor those who have assisted in its development. It deals in many areas in which there is as yet no certainty or precision and it is planned to update the material in the future. Any suggestions which may assist in improving and updating this material would, therefore, be greatly appreciated. These should be directed to the Secretary General of ICAO.

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INTRODUCTORY NOTES

The rapid growth of air transport is overtaxing the capacity of many airports and giving cause for reconsideration of concepts, processing methods and facilities. Increasing passenger and cargo traffic will make further demands on airports, although aircraft movements may increase more slowly owing to the introduction of larger aircraft.

The result is that the administrations responsible for the world's airports are faced with a heavy programme of improvement and construction to meet these needs in the most efficient manner possible.

This manual is intended to assist airport authorities in the complex task of preparing master plans for the expansion of existing airports and construction of new ones. The manual outlines the planning system and the development of long-term forecasts covering aviation operations, economic factors and other considerations involved in master planning. It explains the need for consultation and co-operative planning by all the agencies concerned, including aircraft operators, national and local government planners, government control authorities (customs, immigration, health, etc.), national and local transport authorities, aircraft and equipment manufacturers and international aviation agencies.

Guidance is given on deciding the type of airport which may be required to meet the needs of a community or region and on the selection and evaluation of airport sites. Stress is laid on the importance of making an economic appraisal when deciding on the provision of an airport and assessing its worth to the community in comparison with other projects.

The need for a systems approach to preparation of the master plan is demonstrated together with the method of preparing the plan, the disciplines needed and the elements to be taken into account. The importance of balancing the respective capacities of the many elements and of ensuring flexibility and expansibility to meet changing needs is shown, together with methods of achieving these objectives. Guidance is provided on assessing the capacity of individual facilities and on planning runway, taxiway and apron configurations, passenger buildings, ground transport links and internal roads, car parks and cargo areas, to permit phased development of the master plan.

An airport master plan should be the most effective framework within which the individual facilities can operate their separate functions at the highest possible levels of efficiency. As explained above, it is not always possible for the best plans for individual facilities to be fitted together in a total plan for the airports without some modifications to make them compatible with each other. This often means some loss of perfection in the individual plans but good planning strikes an optimum balance so that a total plan is produced which is more effective in its operation, and therefore has a higher capacity and efficiency, than would be the case if there were no reconciliation between the plans of the individual facilities. Care must be taken, however, to ensure that compromises do not adversely affect safety.

Planning Philosophy

The most efficient plan for the airport as a whole is that which provides the required capacity for aircraft, passenger, cargo and vehicle movements, with maximum passenger, operator and staff convenience and at lowest capital and operating costs.

Flexibility and expansibility should be considered in conjunction and are fundamental to all aspects of planning. Particular features of some sites may make it necessary to decide that expansibility is not possible but that the plan should still proceed. This is a matter for local judgement relative to local conditions. However, it is never necessary to abandon the requirement for flexibility. Most airports can be planned with inherent flexibility, even though expansibility may not be possible.

The Planning System

Planning of airports is complicated by the diversity of facilities and services which are necessary for the movement of aircraft, passengers and cargo and the ground vehicles associated with them, and the necessity to integrate their planning. These facilities include runways and taxiways, aircraft aprons, buildings where aircraft operators deliver and receive passengers, where government control authorities undertake their inspections and amenities for passengers' comfort and assistance are provided. Additional requirements are buildings and parking areas for aircraft maintenance, roads and parks for vehicles used by passengers, visitors, aircraft operators and all occupants of the airport, and buildings for the dispatch and receipt of air cargo.

The operation of an airport essentially integrates the functions of many of these facilities and, therefore, they should not be planned as separate units. Aircraft apron areas have to be functionally integrated with the buildings with which they are associated. Similarly, vehicle parks need to be related to the activities of the people who use them and the buildings which those people occupy.

Airport planning is the evolution of a compromise between the conflicting features of the best plan for each of the individual facilities. The essential degree of precision and balance in the overall plan varies with the scale of activity which the airport is intended to support. As the rate of aircraft, vehicle and passenger movements increases it becomes more necessary for airport plans to be the optimum compromise, so that the planning of all the individual facilities contributes and combines into the most efficient total plan and provides the greatest degree of flexibility and expansibility for future development.

Purpose of a Master Plan

Definition and planning considerations

A generally accepted definition states that an airport master plan "presents the planner's conception of the ultimate development of a specific airport. It effectively presents the research and logic from which the plan was evolved and artfully displays the plan in a graphic and written report. Master plans are applied to the modernization and expansion of existing airports and to the construction of new airports, regardless of their size or functional role."

In the context of this definition the term "development" is taken to mean inclusion of the entire area of the airport — both aviation and non-aviation uses. It also includes suggested land use on land adjacent to the airport.

It is important to recognize that an airport master plan is only a *guide* for:

1) development of physical facilities of an airport — aviation and non-aviation use;

2) development of land uses for areas surrounding an airport;

3) determination of the environmental effects of airport construction and operation; and

4) establishment of access requirements of the airport.

Actual construction of each physical facility designated on the master plan should be undertaken only when traffic volumes and economics indicate that such facilities are required to meet the demand. Therefore, the master plan should establish a schedule of priorities and phasing for the various improvements described in the master plan. A further elaboration of what master planning is may be found below.

I. *General considerations*

A. An airport master plan is a guide for:
- — development of physical facilities on the airport
- — development of land uses for areas surrounding the airport
- — determination of environmental effects of aerodrome construction and operation
- — establishment of airport access requirements.

B. Among other things, an aerodrome master plan is used to:
- — provide short- and long-range policy/decision guidance
- — identify potential problems as well as opportunities
- — assist in securing financial aid
- — serve as a basis for negotiations between the aerodrome authority/concessionaire interests
- — generate local interest and support.

II. *Types of activity involved in the master plan process*

A. Policy/co-ordinative planning:
- — project goals and objectives
- — develop work programmes, schedules, and budgets
- — prepare an evaluation and decision format
- — establish co-ordination and monitoring procedures
- — establish data management and public information systems.

B. Economic planning:
- — prepare an analysis of aviation market characteristics and forecasts of aviation activity
- — determine representative benefits and costs associated with airport development alternatives
- — prepare an assessment of impact on area economy of various alternatives.

C. Physical planning includes development of:
- — airspace and air traffic control provisions
- — airfield configuration (including approach zones)
- — terminal complex
- — circulation, utility and communications networks
- — support and service facilities
- — ground access systems
- — over-all land use patterns.

D. Environmental planning:
- — prepare an assessment of natural environmental conditions associated with the airport "impact" area (plant and animal life, climate, topography, natural resources, etc.)
- — document present and projected development patterns of relevance to the impact area
- — determine community attitudes and opinions.

E. Financial planning:
- — determine airport funding source and constraints
- — prepare a financial feasibility study of various airport development alternatives
- — prepare preliminary financial plans and programmes for the finally agreed upon concept.

III. *Steps in the planning process*

A. Prepare a master planning work programme.

B. Inventory and document existing conditions.

C. Forecast future air traffic demand.

D. Determine gross facility requirements and preliminary time-phased development of same.

E. Evaluate existing and potential constraints.

F. Agree upon relative importance or priority of various elements:
- — airport type
- — constraints
- — political and other considerations.

G. Develop several conceptual or master plan alternatives for purposes of comparative analysis.

H. Review and screen alternative conceptual plans. Provide all interested parties with an opportunity to test each alternative.

I. Select most acceptable and appropriate alternative. Modify as necessary in response to review process and prepare in final form.

IV. *Plan update recommendations*

A. Master plan and/or specific elements should be reviewed at least annually and adjusted as appropriate to reflect conditions at the time of review.

B. Master plan should be thoroughly evaluated and modified every five years, or more often if changes in economic, operational, environmental and financial conditions indicate an earlier need for such revision.

Limitations of a master plan

It has been stated that a master plan is a guide and nothing more. It is not an implementation programme. The development of an implementation programme follows the development of the guidelines of the master plan, but it is only in those phases of airport planning that follow the master plan stage that specific improvements are actually designed and implemented. A master plan, therefore, does not develop specifics with respect to improvements; it is only a guide to the types of improvements which should be undertaken. For example, the financial plan developed in the master plan is a presentation of alternatives, not a specifically tailored financial programme. The master plan points the direction of development. It does not present a detailed programme of how to get to the actual funding stage of improvement projects.

The completed master plan

To effectively utilize the master plan, the execution of improvements may require parallel planning while the master plan is in process. To make the master plan a useful guideline, it should stress particular local problems and prospects.

In preparing the final master planning document, a principal goal to keep in mind is that it should be developed in such a way that its adoption by appropriate officials and the general public can be assured.

Having completed the master plan the appropriate authorities must now take the broad guidelines of the master plan and translate them into a programme which recognizes specific constraints and opportunities presented in the competitive world in which the airport must exist.

Chapter 1. INTRODUCTION

1.1 AIRPORT MASTER PLANNING OBJECTIVES

1.1.1 This manual is directed at authorities responsible for the planning and development of airports and particularly those which may not have experienced planning departments or staff. It is compiled in a manner intended to be suitable for use by these authorities and their planning staff in such matters as supporting requests to higher authorities for finance and in advising airport consultants, engineers, and planners of the airport authorities' requirements for development work.

1.1.2 In this manual, problems of airport planning are analysed. The widest and most general aspects are treated first, followed by more detailed consideration of specific areas and facilities. From basic premises deductions are made and conclusions drawn by process of analysis and this is continued through all relevant stages. This approach is applicable to both existing and new airports regardless of size or location, and to the initial planning and also subsequent development and expansion of facilities.

1.1.3 One of the problems of airport planning is that basic facts and principles have not been presented comprehensively. This is especially true in respect to passenger facilities. Formal analysis is essential for any reasonably satisfactory future development. Therefore, basic facts need to be stated so that they can be challenged and tested throughout the world and, if found incorrect, replaced by others which can be similarly tested until a faultless body of data is compiled. The deductions made and the principles established should be similarly arrived at by analysis so that the present situation of conflicting "options" is replaced by data. It is hoped that the method of presentation used here may help to lay the foundation for a set of agreed facts and principles on which a general approach to airport problems can be based. From such facts more functional airports may evolve.

1.1.4 Flow planning is the basis of transport, and thus of airport development. Therefore, throughout the document the parts of an airport are dealt with as flow routes and facilities are considered at the appropriate functional stage on the flow routes. Air transport is part of the world's transport system and airports cannot be considered in isolation. Thus this manual includes consideration of factors beyond the airport boundary, but only to the extent necessary for airport planning, as detailed consideration of all aspects of these associated factors would be impossible and inappropriate.

1.1.5 Design solutions are not dealt with. Planning is a specialized phase of airport development which is necessary before design can begin. A clear recognition of the distinction between planning and design is essential for the most beneficial use of this manual.

1.2 USE OF THIS MANUAL

1.2.1 The chapters in this manual can be read as self-contained treatments of the subjects covered by their titles. However, cross references are provided for the benefit of authorities which may be planning more than one airport element, and to avoid duplication and repetition. References to other ICAO documents and to other significant publications are given at the end of each chapter. These references are intended to supplement this manual, giving guidance on the use of specialized skills and methods for airport planning. A glossary of aeronautical terms is presented in the appendix for use by those who may not be familiar with a particular technical terminology.

1.2.2 The document does not attempt to duplicate the large body of information already available on airport design. Its aim rather is to assist in the definition of requirements and in the logical analysis and solution of problems associated with the preparation of a basic overall framework or plan. This, in turn, provides the sound foundation necessary for realization of the maximum advantages of good design, prudent investment and efficient operation and management.

1.3 ORGANIZATION OF THIS MANUAL

1.3.1 This manual is comprised of four principal sections, namely: Airport Planning Process; Air Side Development; Land Side Development; and Airport

Support Elements. Chapters are arranged within each of these sections to present related subject matter in a logical order.

Section One — Airport Planning Process

1.3.2 This section outlines the planning process and the important factors which authorities must consider in preparing an airport master plan. It explains the importance of consultation and co-operative planning and the need to develop a systematic approach in determining future airport requirements. Further, the purpose and objectives of an airport master plan are described together with guidance as to how the master plan should be used, once it has been completed.

1.3.3 Within Section One are four chapters describing the significant features of the airport planning process.

Chapter 2 — Preplanning Considerations. The purpose of this chapter is to identify the most important of preplanning considerations which, if followed, will provide the framework for an effective and feasible airport master plan.

Chapter 3 — Forecasting for Planning Purposes. Aviation forecasts provide basic data for determining the needs and required capacity of an airport and are the basis for projection of airport revenues.

Chapter 4 — Financial Arrangements and Controls. The economic analysis establishes a programme for providing the necessary funding of the aerodrome. This chapter delineates the more significant elements which need to be considered relative to forecasting and economic planning.

Chapter 5 — Airport Site Evaluation and Selection. In order for the airport to have the longest possible useful life and in order to maximize the substantial capital investment required in airport development, sufficient ground area should be available to accommodate progressive development commensurate with the growth in air traffic. This chapter describes the process of site selection and evaluation including an assessment of the shape and size of the area required for the airport, the location of sites having potential for development, and an examination and evaluation of alternative sites.

Section Two — Air Side Development

1.3.4 Before plans can be developed for facilities for the many functional requirements which an airport has to meet, concepts for the various operational systems have to be considered and compared.

1.3.5 The principal factors to be considered are outlined in this section. Because of their physical characteristics and the land required and all the other factors which affect them and limit free choice of layout, runways and taxiways are the first to be considered. After determination of the dimensional criteria, pavement strength, and airfield capacity and configuration, other elements of the air side of the airport, namely the apron and navigation and traffic control aids are covered in turn.

Chapter 6 — Runways and Taxiways. Because of the large areas of land they require and their relationship to the large airspaces necessary for aircraft operations, runways and their associated taxiways serve as a starting point for consideration of airport layout.

A substantial body of information exists on the subject of planning and design of airport runways and taxiways. The information contained in this chapter serves the purpose of informing the airport planner on matters pertaining to dimensional criteria, pavement strength, runway length, and airfield capacity. It illustrates the relationship and importance of these elements in the overall airport master planning process.

Chapter 7 — Aprons. The greater portion of this chapter brings together, in a capsulized manner, the significant concepts and considerations needed to satisfy the planning objectives for aircraft aprons. The chapters cover, *inter alia*: locations, layouts, number of stands required, facilities for passengers and cargo to board and leave aircraft, and facilities for aircraft servicing.

Chapter 8 — Air and Ground Navigation and Traffic Control Aids at Airports. Planning of airports must include provision for facilities which will support the air traffic control system, for navigation aids for aircraft approaching the airport, and finally for control of aircraft and vehicles on the surface of the airport. The purpose of this chapter is to describe the requirements for such control aids as they pertain to airport master planning.

Section Three — Land Side Development

1.3.6 This section provides specific planning guidelines for that area of the airport to which the non-travelling public has free access, as well as for the non-public portions of airline operations and cargo facilities, airport administration and government facilities. Major elements comprising land side development include the passenger building, cargo facilities, and ground transport and vehicle circulation and parking.

Chapter 9 — Passenger Building. This chapter deals with planning for facilities to accommodate those activities associated with the transfer of passengers and their baggage from the point of interchange between ground transportation and the passenger building to the point of connexion with the aircraft, and with the transfer of connecting and in-transit passengers and their baggage between flights. For many airports to which this manual is directed, passenger facilities will be contiguous with one general location on the airport. However, in certain circumstances, particular functions, such as air cargo processing, may be situated at locations remote from the main passenger building. Planning principles, factors affecting the type and scale, and specific planning details of various passenger building functions are among the topics covered in this chapter.

Chapter 10 — Cargo Facilities. The same considerations which influence the siting of the passenger facilities also apply to the cargo area. The priority accorded to this area in deciding the compromise necessary to achieve overall compatibility will depend on the nature of the traffic for which the airport is intended. The purpose of this chapter is to examine some aspects of problems likely to be found when planning cargo facilities. One of the main considerations involved is the space required for this facility.

Chapter 11 — Ground Transport and Internal Airport Vehicle Circulation and Parking. This chapter deals with the planning of that element of the airport which will accommodate the ground transport of passengers, baggage and employees to, from and within the airport. Planning of roadways and vehicle parks to accommodate these airport users will be based upon forecasts developed according to Chapter 3 and upon surveys conducted at the airport.

Section Four — Airport Support Elements

1.3.7 A number of buildings and operations for special purposes are necessary to support the functioning of an airport. The need for all or some of the buildings described in this section will vary from airport to airport, as will the specific space requirements. In general, their number and complexity will depend on the volume of traffic. Their locations in the airport or individual master plans should be determined by the functions they are to fulfil and their compatibility with the major features of the plan.

1.3.8 This section further describes the importance of making adequate provision for airport security.

Chapter 12 — Airport Operations and Support Facilities. Buildings for a variety of operational purposes are required at an airport. These include accommodation for meteorological, air traffic control, communications, rescue and fire fighting services, fuel depot and all the facilities for administration and maintenance, staff, aircraft operators, general aviation facilities and police, etc., and sometimes a hotel. This section describes the function of each of these support facilities and their relationship with other elements of the airport covered in this manual.

Chapter 13 — Aircraft Fuel Facilities. The handling of fuel at airports is an important subject to be taken into account when planning airport facilities since special requirements have to be met with regard to safety, minimizing aircraft gate occupancy times, and movements of large and heavy vehicles. This chapter describes storage capacity, location of fuel storage, various systems for fuelling of aircraft and design requirements related to fuelling systems.

Chapter 14 — Security Considerations. All airports require that a level of security be maintained, the exact level being dependent on the situation existing in a particular State. In order for security to be effective, a systems approach is required and this includes the basic plan for the design of the airport. All the measures listed in this chapter need not be implemented at every airport but they should be considered against the level of security which it is desired to effect and they should be implemented in such a way as will cause a minimum of interference with, or delay to, passengers, crew, baggage, cargo and mail.

Chapter 2. PREPLANNING CONSIDERATIONS

2.1 ABOUT THIS CHAPTER

Successful expansion of existing airports and the development of new airports will result from guidelines established in an airport master plan. Accordingly, if a master plan is to be useful to airport authorities certain preplanning requirements must be understood and followed. It is the purpose of this chapter to identify the most important of these preplanning considerations which, if followed, will provide the framework for an effective and implementable airport master plan. Preplanning considerations include the following:

a) preplanning co-ordination

b) information sources

c) goals and schedules

d) land requirements

e) financing considerations

f) planning team

g) planning organization

h) planning procedure

i) environmental considerations

2.2 PREPLANNING CO-ORDINATION

In the airport master planning process the roles of aviation interests as well as appropriate non-aviation interests must be considered. The airport master plan, with its recommended development projects, will be of interest to a diversity of people and organizations including, *inter alia,* private citizens, local and national organizations, aerodrome users, planning agencies, conservation groups, ground transportation officials, concessionaire interests, and airline and other aviation interests. If these groups are not consulted prior to and during the master planning programme there will be great risk of delay, or even stoppage, of future airport development. Therefore, it is essential that the master planning team co-ordinate its efforts and seek the advice of these interest groups prior to and during the critical stages of the master plan. This co-ordination will help assure acceptance and permit important input from organized interests which will lead to a well integrated and implementable plan.

2.3 INFORMATION REQUIREMENTS

2.3.1 The preparation and collection of meaningful data on the usage of an airport and its components are basic to sound master planning, which also requires reliable forecasting techniques and meaningful statistical data on which future planning can be based. The nature of the data to be collected should not only cover the physical facilities of the airport but should also provide measures of utilization, volume and composition of traffic, the cost of transportation and related tariffs, the financial situation of the airlines using the airport, and government transportation policies and regulations.

2.3.2 Sources of reliable data are many and varied and include, *inter alia,* national banks, international financial institutions, national and local government agencies, International Air Transport Association (IATA) regional offices, Director General Civil Aviation (DGCA) offices, U.S. Federal Aviation Administration, airlines, aviation trade associations, the United Nations and its affiliated agencies, local and national planning agencies, and other ICAO publications. Also, where master planning is being undertaken for an existing airport, records kept by the airport management, airlines and other tenants can be useful. Finally, references listed at the end of each chapter of this manual can provide specific relevant information.

2.4 PRELIMINARY ECONOMIC FEASIBILITY

2.4.1 The financial burden of major airport expansion or development of a new airport can be formidable. In order to determine the significance of this burden and the problems of financing such development, very early determination of economic feasibility is advisable. Since this is a preliminary consideration, only broad order-of-magnitude costs are necessary. Such estimates will indicate to local officials that the project is workable or not workable. Moreover, these preliminary estimates will provide a reasonable basis for discussion with agencies or financial institutions which are likely to be involved in the financing of improvements recommended by the master plan.

2.4.2 Economic feasibility should be determined for each element (runways, buildings, etc.) of the master plan, over a selected time period. A comparison of quantifiable economic benefits and costs, computed by using the appropriate opportunity cost of capital (available from the national government or from the World Bank, see Chapter 4) should be made and the benefit/cost ratio and the rate of return applicable to the anticipated development should be estimated.

2.4.3 Capital costs to be considered at this stage are broad order-of-magnitude estimates, over a period of years. These include, *inter alia,* land acquisition (if required), construction, equipment, parts and maintenance, administration and operating costs, and financing fees. Benefits should include increased airport capability/capacity, increased safety and reliability, and improved public service. Where practicable, an estimate should be made of the saving accruing to passengers, cargo and aircraft as a result of the proposed investment. These savings, including those of time, should be expressed in monetary values. Additionally, the likely impact of the master plan recommendations on the over-all economy of the State should be indicated, including effects on the balance of payments and employment, among others.

2.4.4 All of the broad estimates of feasibility made at this early stage of the master planning process will indicate the propriety of continuing or changing the scope of the master plan. It will also set the general guidelines for extent of development possible, considering the availability of funds to finance recommended development. Guidance on financing arrangements and the need for financial control and accounting during the planning and construction phases is given in Chapter 4 of this manual.

2.5 THE ROLE OF FINANCING IN AIRPORT PLANNING

2.5.1 Indispensable to the over-all planning process is the determination of the sources and extent of the financial means available for the initial provision and continuing operation and maintenance of the prospective airport facilities and services. Government grants or loans (sometimes available in turn from international financial institutions), and to a lesser extent commercially negotiated loans, will be likely to constitute the sole sources for financing capital costs both in the case of construction of a new airport and in the case of major extension of facilities at any existing airport where such reserve funds as may have been accumulated prove insufficient for the purpose. Once the availability of adequate capital has been established, a realistic assessment needs to be made of the financial provision that would be required annually if the airport authority is to discharge its debt obligations (i.e. capital repayment and interest charges) and build up replacement reserves: for these calculations, the useful economic life of the various facilities contemplated should be closely estimated taking into account the differing rates of their anticipated physical depreciation and obsolescence.

2.5.2 For practical planning, careful consideration must be given to the future ability of the airport to meet these annual capital charges and defray its direct operating and maintenance costs. This must be done from the outset in order that the scale of facilities and services contemplated shall not at a later stage prove to exceed the bounds of financial practicability. Aside from any continuing government grants or contributions pledged from other sources, the chief revenue-earning means available to an airport, are, in order of importance: charges for the use of landing and associated facilities; the granting of concessions; and the rental of passenger-building space and other airport accommodation and services. The traffic forecasts utilized in planning the facilities and services to be provided should be seen as serving the double purpose of enabling projections to be made of the income the airport might expect to derive from landing and other charges, the calculations being made for various levels of charges as a basis for judging what proportion of costs remaining to be recovered by such means would be an achievable target. The extent of the contribution to costs realizable from such charges must, of course, depend on the assessment made by the airport authorities concerned of what level of charges it would be practicable and reasonable to impose on users, having regard to the nature of the traffic served and the variety of other circumstances peculiar to the particular airport.

2.6 THE PLANNING TEAM

2.6.1 The skills necessary for airport planning follow from the principal subjects which have to be covered.

These may include economic and operational forecasts for basic and detail planning, operational research surveys, analysis of statistical and sociological data, cost-benefit analyses of alternative solutions, aircraft operations in the air and on the ground, building construction and traffic and road planning. The planning team should not include every specialist whose advice may from time to time be required but should be restricted to those necessary to cover the primary planning aspects, and who are involved at all stages of planning. For example, mechanical engineering systems can affect the size and layout of related areas in addition to the specific area in which they are contained and have to be considered in the basic determination of the over-all operating system for passenger or cargo areas. The disciplines which should generally be considered for inclusion in a planning team are statistician, economist, financier, operational research scientist, architect, civil, mechanical, electrical and traffic engineers, pilot, air traffic controller and airport manager. The advice of all other specialists should be sought as necessary. Of course the specific skills appropriate to particular projects depend upon the scale of the traffic for which the airport is intended, but it is increasingly necessary with the growth of traffic to utilize the skills of as many of these specialists as possible. For over-all co-ordination and direction, a planning team requires a planning co-ordinator who should be an expert in management techniques and who should have a wide aviation background. This co-ordinator should be responsible for the evolution of the optimum overall plan, its progress and cost control. Frequently an aviation consultant will fill this role.

2.6.2 Airport planning should be undertaken in consultation with all other interested agencies and carried out in the closest liaison with national and local government transport and planning authorities and aircraft operators. The civil aviation authorities should act as leaders in bringing together the government-control authorities with the aim of ensuring a high degree of facilitation in passenger handling. Figure 2-1 describes the relationship of the planning team with the over-all planning organization.

2.7 THE PLANNING ORGANIZATION

2.7.1 Establishment of a planning organization for the development of an airport master plan will vary considerably from one State to another and frequently among different airport locations within a given State. Variability will result from political/jurisdictional make-up, the nature of ownership and control over existing airports, organization and effectiveness of central and local government land planning and transport authorities, and the agency legally responsible for financing the planning project.

2.7.2 A most effective organization will be one that is capable of 1) establishing policy which is acceptable within the airport community, 2) bringing together for advisory and co-ordinative purposes all appropriate aviation and non-aviation related interests, and 3) assuring a planning process that is technically sound and responsive to policy and the co-ordinative process. Most importantly, the arrangement should be such that the master plan can be established as an effective, continuing programme capable of implementation.

2.7.3 Unless effective organization, in the above terms, is established at the outset, the goals of airport master planning may not be completely fulfilled. A poorly organized effort will result in 1) fragmented public support, including avoidable or uninformed public controversy, for the master plan's recommendations, 2) unrealistic recommendations that are not acceptable to the aviation community or to those responsible for comprehensive and surface transportation planning, 3) a completed study of no further use, which is not updated in a timely fashion and, most importantly, not implemented. Thus, the importance of effectively organizing the airport master planning effort cannot be over-emphasized, as it may be the most critical step in the process.

2.7.4 In general, the organization should be structured to perform three principal functions, namely, policy formulation, advice and co-ordination, and technical planning, as generally described in Figure 2-1.

2.8 PLANNING PROCEDURE

2.8.1 A master plan for the whole airport should be prepared, defining the basic concepts and over-all layout which will best exploit the potential of the site. The master plan should evolve through consideration of all the factors which affect air transport and which will influence or impinge on the development and use of the airport throughout its working life.

2.8.2 The plan should provide a framework within which future development and expansion can take place and indicate the ultimate over-all size. It should define the aircraft, passenger, cargo and ground vehicle capacities, together with an indication of the major phases of construction which are possible in physical and economic

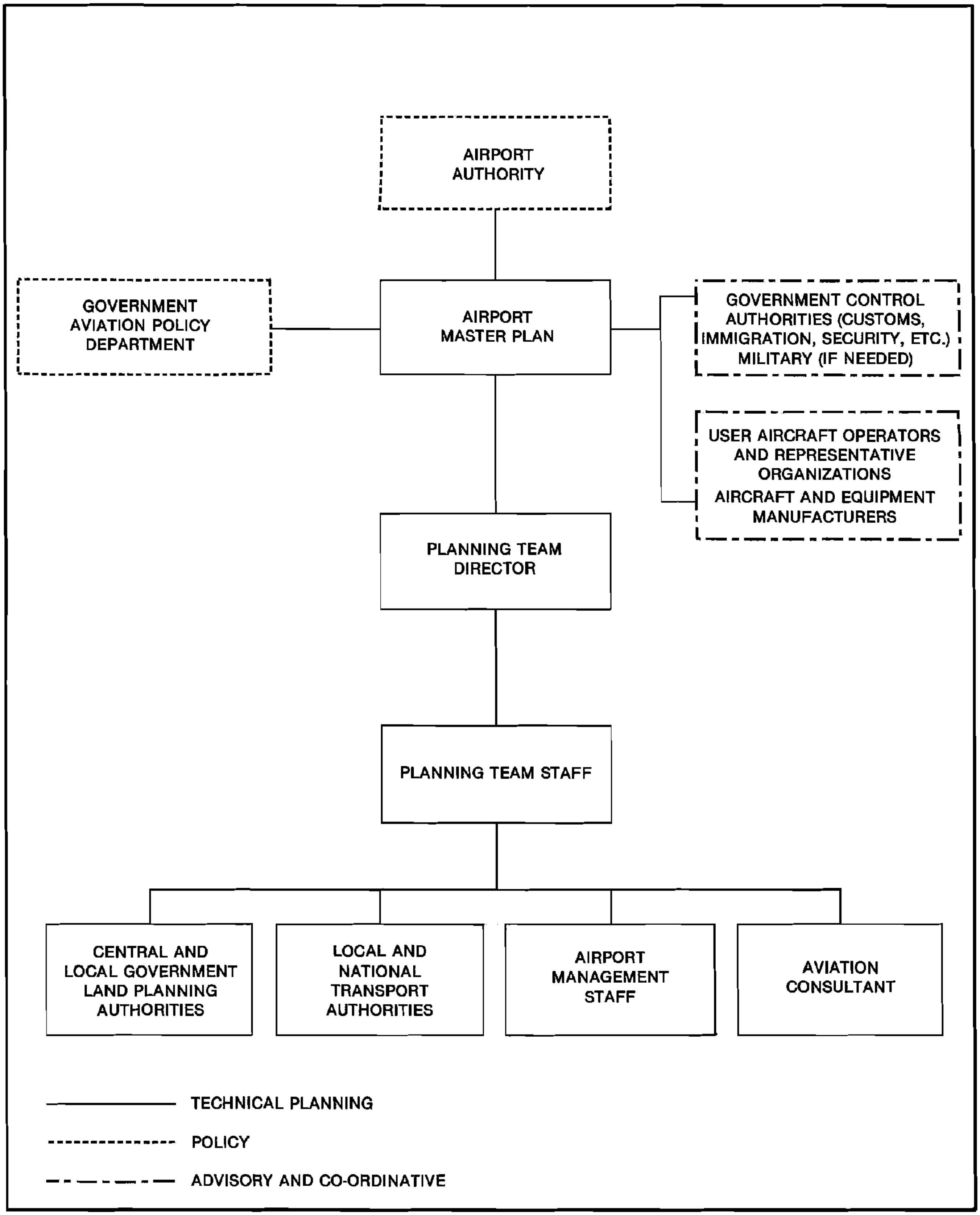

Figure 2-1. Typical airport master planning organization

terms and the dates by which they are forecast to be required. Planning procedures for the individual facilities which make up a total airport are the same as for the airport master plan. These major stages are:

Forecasts: Develop long-term forecasts covering aviation operational, economic and other factors on which future planning can be based.

Systems concepts: Develop concepts for the basic systems of operation and identify the developments that will be required to meet the forecast needs of all airport users.

Airport master plan: Determine an ultimate over-all layout that will best exploit the potential of the site, making the fullest use of any natural features.

2.8.3 At all stages of planning, reasons for particular decisions and the influences supporting particular concepts and lines of progress should be stated and recorded. At subsequent stages the reasons should be tested to ensure that they remain valid and form a coherent and continuous pattern. Through the long and complex process of developing airport plans it is easy to make decisions based on judgements which are entirely valid in themselves but which conflict with the reasoning for earlier decisions. Throughout the planning of a project it is important to ensure that policies, concepts and lines of reasoning are understood and continuously followed.

2.9 GOALS AND POLICY OBJECTIVES

Goals

2.9.1 The airport master planning process involves the preparation of both broad and specific policies, plans, and programmes needed to establish a viable airport. The goals of the airport master planning process should be to:

a) Provide for the orderly and timely development of an airport adequate to meet the present and future air transportation needs of an area or State.

b) Place aviation in its proper perspective relative to a balanced, regional or national multi-modal, transportation system plan or to an area-wide plan. Also to provide a basis for co-ordinating airport plans with other planning efforts — local, regional, and national.

c) Protect and enhance the environment through the location and expansion of aviation facilities in such a way that impairment of the ecology and the intrusion of unacceptable levels of noise and air pollution into the community are avoided.

d) Promote the establishment of an effective governmental organization for implementing the master plan in a systematic fashion.

e) Ensure compatibility with the content, format, standards, and criteria of governmental aviation policy departments, ICAO and IATA, among others.

f) Co-ordinate the specific airport master plan with the state airport system and regional air transportation plans, when they exist.

g) Serve as a basis for co-ordinating plans for air navigation facilities, airspace use, and air traffic control procedures.

h) Inform public and private aviation interests, as well as the general public, of aviation requirements, and create a general awareness of the need for a systematic approach to planning and developing the airport.

i) Develop the aviation portion of long-range state plans and establish appropriate priorities for airport financing in short-term governmental budgeting for public facilities.

j) Optimize the use of land and airspace resources which are inherently limited in some areas.

k) Use air transportation facilities to help guide the growth pattern of the area and the state, according to comprehensive planning goals and objectives promulgated by local authorities.

l) Provide a planning organization which enables affected political entities to participate in the planning of the airport.

Policy Objectives

2.9.2 Having organized for the planning effort and arranged for financial support, the planning process can begin. The process starts with the development of general criteria and policy objectives (sometimes called "policy formulation") and the study design. After these two steps are completed, the technical planning phase begins with an inventory of existing facilities. Next, a forecast of aviation demand is made in order to determine the future facility requirements. Alternative systems to meet the future facility requirements are then developed and evaluated. While this ends the initial planning process, a continuing planning process following these same general procedures is established while implementation of the long-range plan is underway.

2.9.3 The first step in the master planning process is the establishment of ground rules which may be termed policy objectives. For example, it is necessary to state at the outset the time frame, or planning horizons, for which planning is to be accomplished. The geographic limits of the planning area must also be established in order to guide such elements as data collection, forecasting, and potential site selection. Whether adherence to national or international airport design/dimensional standards will be required, should be determined.

2.9.4 In general, there should be an attempt to relate the communities' individual and sometimes unique objectives to the goals in 2.9.1. One should not assume that all policy can be established at the outset. Airport policy development may take place at several points in the master planning process: during preparation, discussion, and initial adoption of an airport master plan; during major reconsideration of the entire plan; and during consideration of the day-to-day development matters which call for the review of general long-range policies.

2.9.5 The long-range time period for the plan is generally 20 years and should include recommended development, timing of development, and order-of-magnitude costs. Precise development needs and costs should not be required, although a reasonable estimate of needs should be expected. Since it may take as long as 10 years for a major airport to be established after its need has been identified, a 20-year horizon is not unrealistic. In establishing the length of time for the long-range planning period, consideration should be given to other local planning efforts such as the transport and land use plans, with consistency as an objective. The intermediate range is normally for a 10-year period and should more precisely determine development requirements and associated cost estimates than specified in the long-range period.

2.9.6 The short-range period is normally for two to five years and planning should include a detailed treatment of facility needs and cost estimates. The latter should be sufficiently accurate to permit financial planning and budgeting that is consistent with the airport financing programmes at the national level, and the local budgeting process.

2.10 USE OF CONSULTANTS

2.10.1 The retention of consulting services by airport management usually involves explaining to higher authority the need for such services, as well as justifying the expense involved. However, at a certain point in the preplanning considerations, employing a consultant is not only desirable but may even be essential.

2.10.2 One common reason for retaining consultant services is a lack of technical expertise within the internal structures of organizations. It is, most often, not practical for a civil aviation agency or authority to maintain, on a permanent basis, all of the skills required to manage all phases of a large master planning programme. Consultants are often used when the airport management has insufficient manpower to perform work of a temporary nature. Rather than increase the permanent staff, consultants are hired to provide additional manpower for a limited period of time. There are also circumstances when assignment of in-house staff to solve a specific problem would derogate the permanent, long-term mission of the staff. Consultants may be engaged for their experience in areas with which the airport management staff is not familiar.

2.10.3 Airport projects may involve tasks programmed over several years. When there is turnover in the airport staff, such long-term programmes can be disrupted by a lack of a single management/planning group with responsibility for the total programme, from start to finish.

2.10.4 If, in the planning process, decisions are to be made which involve considerable risk, the consultant's contribution may be most valuable in the capacity of a judge who can provide both technical expertise and an impartial viewpoint. Consultants can also provide an element of objectivity in aiding airport managers to present their requirements to higher authority.

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Chapter 3. FORECASTING FOR PLANNING PURPOSES

3.1 ABOUT THIS CHAPTER

This chapter describes the role of forecasting in airport master planning. It discusses why forecasts are needed, what forecasts are needed and what they are needed for, where they fit into the planning functions, and how their validity and contribution might be assessed. The chapter is thus one of the philosophy underlying forecasting processes and of practical application of the forecasts themselves, rather than an exposition of forecasting techniques. Descriptions of some techniques are given in the complementary ICAO *Manual on Air Traffic Forecasting*, hereafter referred to as the "Forecasting Manual".

3.2 THE REQUIREMENTS

3.2.1 Forecasting is the heart of planning and control processes. Forecasts are necessary to define the facilities that will be required, the scale of such facilities, and the time at which they will be required. The objective of forecasting is not to predict the future with precision, but to provide information that can be used to evaluate effects of uncertainty about the future. Thus, both for physical planning and for financial assessment purposes, consideration should be given not only to the implications of the forecasts themselves but also to the implications of lack of precision in the forecasts and in the conversion of the forecasts into planning criteria.

3.2.2 In order to ensure consistency in relation to the assumptions underlying the master plan, the forecasts should be fully integrated into the planning process and independent development of forecasts should be treated with caution. Figure 3-1 shows how the forecasting activity might fit into an airport master planning process. Once the objectives (both short- and long-term) of the airport have been determined (see 2.9 above), a broad, provisional plan can be drawn up and evaluated in relation to traffic forecasts. While such forecasts will be influenced by specific aspects of the plan, they will be largely determined by socio-economic factors which lie outside the framework of the plan.

3.2.3 For periods as far ahead in time as those involved between the planning and commissioning of airports, forecasts are generally produced on an annual basis (forecasting smaller time periods is more complex and feasibility is also limited by data availability). But, since capacity utilization of airport facilities becomes most critical during daily and hourly traffic peaks, it is the peak demand rather than the annual demand that must be determined in order to evaluate facility requirements. The basic forecasts thus have to be converted into information relating to peak periods for both aircraft movements (which define runway, taxiway, air traffic control and apron requirements) and for passenger, cargo and mail throughput (which defines terminal and access system requirements when additional analyses concerning numbers of visitors accompanying passengers, spectators, airport and associated workers have been incorporated).

3.2.4 Once facility requirements have been established, capital costs can be determined, and subsequently recurrent costs, for which the original traffic forecasts are used to evaluate total annual handling costs. The original traffic forecasts are also used in determining annual income from both primary sources (handling) and secondary sources (concessions, etc.). The information on facilities to be provided, the cost of providing the facilities and services and the income from their provision may now be compared with the objectives of the airport and the provisional plan, and a cost/benefit analysis carried out if required.

3.2.5 If a systematic planning process is established, the effects of changes in the socio-economic factors which influence the forecasts, the effects of imprecise forecasts, or the effects of alternative policies, may be evaluated.

3.3 FORECASTS REQUIRED

3.3.1 The items to be forecast and the units in which the forecasts are to be made relate to the planning requirements of the individual airport. They are not immediately obvious from consideration of aviation generally. Thus, statistics and forecasts indicating world growth of traffic in terms of passenger- or tonne-kilometres, or proportions of total world aircraft movements defined in terms of jet and propeller aircraft, length of flight sector, or various

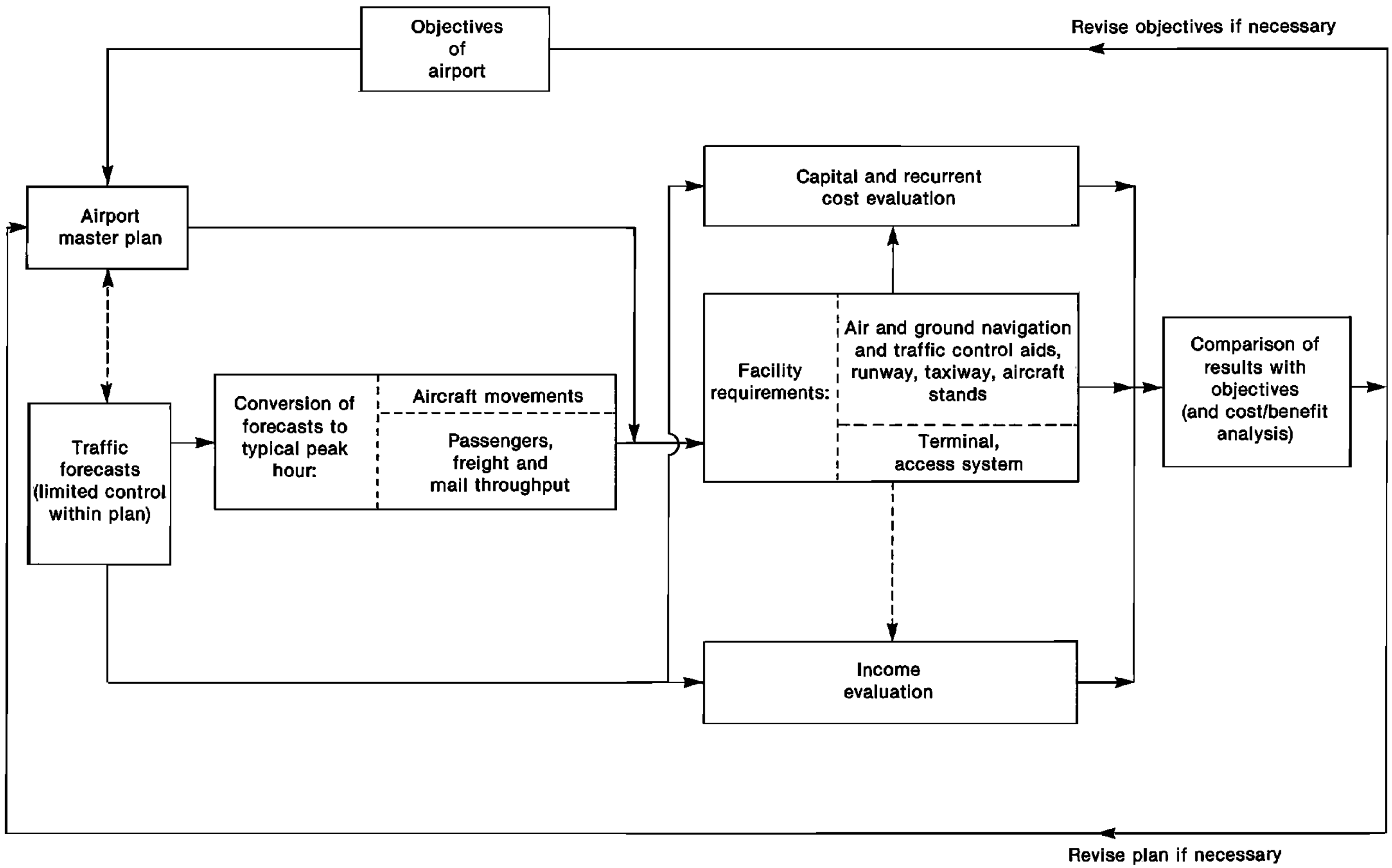

Figure 3-1. The relationship of forecasting to an airport master plan

categories of aircraft ownership, are of little use for airport planning purposes other than to point out over-all trends in the development of aviation. Such trends serve only as general indicators for the longest term considerations and do not provide a basis for the planning of individual airports.

3.3.2 The primary forecast is usually developed in terms of passenger and cargo throughput, since historical data for these items are generally available and the basic demand for use of airport facilities are defined by them. This demand is mainly determined by factors external to the airport planning process itself and hence provides a cornerstone from which to build the plan.

3.3.3 As already mentioned, facility requirements are defined by peak period throughput, and mainly by that in the "typical peak hour". In order not to cater unnecessarily for rare occurrences, the "typical peak hour" is not defined as the peak hour for the year, but is commonly accepted as the 30th or 40th busy hour. Similarly the "typical busy day" is the 30th or 40th busy day. An important relationship which has to be established is that between the primary forecast (Item 1 in the list below) and the typical peak hour forecasts (Item 2 below), a subject which is discussed later in 3.5. The list below also includes other items which may require to be forecast. Some of them will help to define the above relationship, and indeed most of them are interdependent. Provided suitable base data are available, it is worth forecasting major items independently as well as establishing their interaction in order to provide a cross-check on the validity and consistency of the forecasts.

1) Annual throughput of passengers, cargo and mail, categorized by international and domestic, by scheduled and non-scheduled, and by arrivals, departures, transit and transfer/trans-shipment.

2) Typical peak hour aircraft movements and throughput of passengers, cargo and mail, preferably categorized by arrivals and departures as well as combined (the typical peak hour may occur at different times for each item and categorization).

3) Average day of peak month aircraft movements and throughput of passengers, cargo and mail, categorized as in 1) above (for use in facilities planning).

4) Number of airlines serving the airport and their route structures, both domestic and international, in relation to the airport (for provision of check-in, office and maintenance facilities and for cross-checking 1) to 3) above).

5) Types of aircraft using the airport, including the total numbers of each major type and their ratio at busy times.

6) Number of aircraft to be based at the airport by scheduled, and non-scheduled carriers and by general aviation. Base and line maintenance requirements of these and other aircraft (broad estimates only required to evaluate airline service area and access requirements).

7) Access system requirements between the airport and the region which it serves, since this may affect the airport layout on both the air side (e.g. if feeder services are anticipated) and the land side.

8) Number of visitors and number of airport workers by category (for use in facilities planning, possibly including housing requirements).

3.3.4 Specific categorization may need to be made of cargo. Arrival and departure characteristics of cargo often differ appreciably in volume, in timing and in facility requirements. Where cargo is expected to arrive or depart on all-cargo aircraft as well as in combination aircraft (passengers and cargo), categorization is necessary to plan cargo terminal and handling requirements, and the transfer of cargo from the combination aircraft to the cargo terminal. Cargo handling areas are generally planned on the basis of a square metre per tonne handled per unit of time, but this ratio can vary with the traffic mix, degree of containerization etc, and further categorization may be necessary (usually based on analyses of air way-bills). The availability of off-airport consolidation depots can affect the type and duration of throughput. All-cargo aircraft movements themselves should be forecast separately as such aircraft can often be directed away from peak hours by use of suitable policies, although such efforts may be limited by night curfews.

3.3.5 Since volumes of mail traffic are currently relatively small and are generally carried on combination aircraft, a forecast is necessary only to determine space requirements in the terminal building. If policies for the further transfer of surface mail to air become more established in the future, planning for mail can be handled in a similar manner to cargo.

3.3.6 Specific attention may also need to be given to general aviation and charter activities. General aviation activities are particularly difficult to forecast, since they do not necessarily reflect socio-economic characteristics of the region or show smooth trends. However, both general aviation and non-scheduled activities can again usually be redistributed away from the peak.

3.3.7 Selection of the forecasts required in a particular case, and, sequencing of the forecasting tasks in line with proposed methods and activity requirements for the plan, are important features of the forecasting process. The level of detail of the forecast requirements will differ with the time scale. For example, only broad indications will be required in the first phase determination of land requirements for airport site selection or expansion. These forecasts should be made for at least 20 years ahead. Naturally, long-term forecasts of this nature cannot be expected to be precise, particularly as they need to anticipate technological change.

3.3.8 The future requirements for handling traffic over the projected life of the airport can only be broadly judged, but they can afford to be somewhat optimistic so that an area is protected sufficiently to ensure that reasonable development potential of the site is preserved. It may take a longer or a shorter period than forecast for demand to develop to the foreseen levels, but this is not of major importance provided suitable land areas are available to permit development when required (and can be put to good use in the meantime).

3.3.9 Actual construction should be carried out as proven necessary by the growth of traffic and short-term forecasts which are less susceptible to major errors. Thus long-term forecasts provide the broad guidance necessary for master planning. Shorter-term forecasts, say three to five years in advance, provide the basis for actual development work, while medium-term forecasts (from 5 to 20 years, usually in five-year intervals for convenience) bridge the gap to the long-term and provide interim information on probable subsequent phases of development.

3.4 ACCURACY AND LIMITATIONS OF FORECASTS

3.4.1 The degree of accuracy warranted in forecasting can be defined in relation to the increments in capacity for which it is practicable to phase airport developments. These will vary to some degree between airports. If the increments are such that there is no critical dependence on the accuracy of the forecasts, a simple (and inexpensive) forecasting system may then suffice. In forecasting aircraft movements the accuracy required is associated with the capacity offered by each additional runway. In forecasting passenger and freight traffic throughput some greater accuracy is desirable because the units of capacity in which terminal buildings can be built and/or extended are smaller than the units of capacity resulting from the addition of runways. However, if an additional terminal requirement exceeds the physical ability for provision at an existing airport, the unit of capacity again becomes large. Greater accuracy in the forecast (and greater flexibility in the master plan) is similarly required for apron requirements.

3.4.2 Financial feasibility is a much more uncertain factor than the estimation of physical requirements. Financial results depend on the margin between total revenues and total costs which are cumulative over time. A relatively small change in traffic forecasts can have a relatively great effect on finances.

3.4.3 The accuracy of forecasts themselves is subject to a large number of factors, and it is very difficult to estimate precisely the timing and size of future requirements. The longer the period of the forecast the more there is scope for variations in factors which affect the results and the greater the financial risk involved in error (a consistent annual 2 per cent traffic growth under-rating becomes a 49 per cent error after 20 years).

3.4.4 The increasing sophistication of forecasting methodology and an increasing significance of "objective" factors in such methodology should improve accuracy in the future. Nevertheless, there will always be a number of factors which will make forecasting an imprecise science. Such factors include:

1) poor forecasting method;

2) poor base data;

3) poor forecasts of the socio-economic factors which are considered most likely to affect the demand for air transport;

4) unpredicted introduction of new socio-economic influencing factors not previously considered to have been of prime importance; and

5) the influence of factors which are difficult to quantify.

As long as the above limitations are recognized as such, something can be done about them by examining their likely effects in the planning process.

3.4.5 There are two major approaches to handling limitations in forecasting. In order to deal with item 1) in 3.4.4 above, and to some extent with item 2), the approach is to carry out sensitivity tests to establish the range of accuracy that can be expected in a single forecast — in other words, to evaluate the probable errors inherent in the forecasting process given the base data used. The second approach deals with item 3), and to some extent with item 4), and is to prepare alternative sets of assumptions under which the forecasts are made — in other words, to build up alternative pictures of the future socio-economic environment and/or policy and hence alternative sets of estimates of traffic. It may be that one factor alone is considered critical (for example airline operating costs, and hence fares and rates) and changes are made to this factor while leaving the others unchanged.

3.4.6 One feature of the results of establishing alternative sets of traffic estimates is that the upper limit so determined is not necessarily (and indeed not usually) the same amount above the "most likely" estimate as the lower limit is below. This is an important point, as it has an effect on the risks involved in investing in too much capacity as against those involved in investing in equivalently too little capacity. For assessing financial feasibility it is useful to present the most likely forecasts and the ranges in terms of a time scale (as well as in terms of the various volumes of traffic estimated at a particular point in time). For example: "It is most likely that a throughput of 3 million passengers will be reached in 1995; the earliest that it will probably be reached is 1992, and the latest 1997".

3.4.7 Extra work is involved in producing alternative forecasts, but such work is usually marginal in comparison with the work involved in establishing the primary forecast, particularly if a systematic procedure is set up. A compromise may need to be made between applying resources to refining the primary forecast or to producing series of alternative forecasts. With alternative sets of forecasts available, it is possible to use the planning system to evaluate the risks involved in investing according to the criteria suggested by the primary forecast. Estimation of the planning parameters from the forecasts is, of course, also subject to error, a factor which should also be considered in the risk analysis.

3.5 CONVERTING ANNUAL TRAFFIC FORECASTS INTO PLANNING CRITERIA

3.5.1 As mentioned in 3.2.3, it is the peak rather than the annual demand which defines facility requirements. Intensified effort to produce a quality forecast can be negated by poor translation of the forecast into facility requirements — a chain is as strong as its weakest link. Of paramount importance is the conversion of the passenger traffic forecast into annual, seasonal and peak aircraft movement projections, as well as into seasonal and peak passenger flow projections.

3.5.2 It is not possible to lay down specific methods for conversion processes as the method will depend on the individual situation, and will be related to the forecasting method(s) used and vice versa (for example, seasonal rather than annual passenger forecasts might be developed for the short-term as a means of arriving at more accurate peak information). At large airports a systematic procedure can perhaps be used to translate annual data to hourly peaks, but at small airports a single movement of an aircraft could change the whole situation. Indeed the profile over the day might be as important a feature as the peak hour itself as this profile would determine policy and requirements if congestion occurs in the peak hour. Nevertheless, some useful guidelines (on both conversion and on data requirements) are given by the methods used to obtain primary criteria from annual data quoted below:

A. Estimates of peak hour aircraft movements

1) Total annual seats from the airport for the most recent year for which actual data is available (the "base" year) are forecast to increase at the same rate as the forecast of the enplaned passengers (i.e. no change in enplaned* load factor).

2) Total seats so forecast are then distributed among the types of aircraft the carriers are expected to operate in the forecast year. Seat totals by aircraft type are divided by average seating capacities to obtain the number of aircraft operations. Total annual aircraft operations are determined by summing the operations by aircraft type.

3) The number of seats required during the peak hour for the forecast year are determined by first multiplying the annual seats required by the ratio of seats in a typical busy day in the base year to seats in the base year as a whole.

   The busy day seats required are then multiplied by the base year peak hour percentage of the busy day.

4) The peak hour seats required are allocated among the various types of aircraft the carriers are expected to operate during the forecast year, based

* Attention is drawn to the distinction between enplaned passenger load factor and the passenger load factor definition generally used by carriers (passenger-km divided by available seat-km).

on the distribution of total seats offered by aircraft type during the base year.

5) The seats required by aircraft type are then divided by an average capacity to determine the aircraft operations required. The total number of peak hour aircraft operations is the sum of operations by aircraft type.

B. Example of peak hour planning methods

1) Identify the peak day (for aircraft movements) over several years.

2) Analyse the peak day movements and determine by inspection the peak hour for passenger movements on the basis of the recorded aircraft passenger manifests.

3) Relate the total peak hour passenger traffic recorded on the peak day over several years to the total peak day traffic, to obtain a weighted proportion of peak hour/peak day traffic.

4) Determine the two peak traffic months in the year from an analysis of seasonal variations.

5) Calculate the number of passengers using the airport on the average day during the two peak months; hypothesize that this average day is representative of the 30th — 40th busy day of the year.

6) Relate the peak hour traffic ratio to the typical busy day, to determine the typical peak hour passenger figure by type of service.

7) Divide the typical peak hour by the average number of enplaning/deplaning passengers per movement to determine the typical peak hour movements figure, noting that the "average" is likely to be higher than usual during peak periods.

3.5.3 There is also a technique commonly referred to as the "triggering" method for adding flight frequencies on a route segment. This method is based on the assumption that when traffic reaches a level which implies some specified average load factor, an additional flight is triggered on that segment.

3.5.4 Each of these methods and/or other methods can obviously not be precise, and each could lead to different results from a given set of data (and, indeed, data availability may be a major factor in determining the method used). Further analyses may also need to be carried out regarding variations in the peak due to delays, weather restrictions, etc. Again, as long as the inadequacies of the method chosen are recognized, they need not pose a problem in that alternatives and cross-checking procedures may be developed. In specific cases, aspects that should be treated with particular care are the fact that the distribution of traffic categories may differ between the peak and other periods; and that particularly sharp peaking appears to be endemic to long-haul operations, as a consequence of time zones and the advantages of maintaining high aircraft utilization. Sharp peaking often occurs also where local operations are carried out predominantly by carriers based at the airport in question (e.g. morning departure and evening arrival peaks).

3.6 FACTORS AFFECTING TRAFFIC GROWTH

3.6.1 Much of the development work in the forecasting field is aimed at making forecasts more explanatory rather than simply descriptive. There is naturally a greater feeling of confidence in a forecast based on an understanding of the process generating the observed traffic variables. The preliminary phases in a forecasting procedure are thus usually concerned with identifying, isolating and quantifying the effects of the factors underlying air traffic activity.

3.6.2 Such factors may be classified into four broad subject headings: economic, social/demographic, technological/systems and commercial/political. General indicators in each of these areas are often used for determining total national and international air traffic activity (for example, gross national product is often used as one economic indicator), but more specific indicators at a regional or even finer level may need to be examined in the case of a particular airport. It is preferable where possible to categorize the air traffic demand itself by reason for travel, since the motivations, and hence the underlying indicators, will differ (for example, between business and non-business trips, between high-income and low-income travellers, between emergency and planned air freight movements, etc.).

3.6.3 In the Forecasting Manual there is a table listing a number of factors thought to influence the demand for air transport, categorized by specific aspects. These were limited to those whose values over a period of time are often readily available from published data, and are again intended only as a guideline. Use of a single indicator or group of indicators, particularly if chosen by reason of measurability, should not preclude further examination of the activity which it represents. For example, while the gross national product of a particular country might continue to grow according to historical precedent, the effects of inflation and floating currencies might affect its relationship to air traffic growth. Similarly, international air freight is particularly affected by specific trade tariff and quota changes.

3.6.4 Factors connected with consumer decision-making processes are particularly difficult to quantify. The "quality" of service defined in terms of speed, regularity and convenience is one factor which appears to be significantly changed by technological development. Where considered important, its impact may have to be assessed on a subjective basis, perhaps founded on precedent and/or sophisticated concepts (e.g. "value of time").

3.6.5 It is important to distinguish between exogenous factors (those external to the planning function, which cannot be altered within this context) and endogenous factors (which can be influenced by the plan, up to and possibly including public transport policy of the region in question).

3.6.6 Assessing the role which an individual airport is going to play in relation to other airports may prove to be an intricate task. The distribution of the population and the locations of the airports in relation to prevailing directions of the air traffic flows will be important factors. Apart from the local interaction between neighbouring airports, the future relative roles of the airports in a network may depend on demographic developments, on regional developments of business, on the relative growth rates for the demand and the aircraft sizes, on the development of aircraft flying ranges and on the relative developments of terminal costs and en-route costs for the aircraft. Because of the sensitivity of demand to frequency of service and to the "quality" of the services being supplied, a small change in the relative demand at two airports (e.g. due to demographic changes or due to a changed accessibility of one of them) may be greatly amplified by resulting differences in the services being supplied. This may ultimately lead to a substantial redistribution of the roles for the two airports.

3.6.7 The efficiency of existing airports is also a factor which may require particular examination. In a demand forecast which is to be used for technical planning of an airport, effects of congestion and/or other inadequate functioning should not be taken into account, since the objective is to estimate the traffic which the airport should serve adequately. This means if past traffic trends are to be used in the forecasting process, they should be adjusted where necessary for congestion effects.

3.7 PRINCIPLES OF FORECASTING

3.7.1 The process of forecasting is usually one of co-ordinating a number of inputs (including historical traffic data, historical and anticipated influencing factors) and carrying out analyses to measure their relative impact on future air traffic flows. It may be likened to piecing together a jigsaw puzzle. In general it is more important to take into account all the significant factors than to use elaborate methods when dealing with some of them.

3.7.2 The method(s) of forecasting will depend on the available data, on the time and resources available to carry out the forecast, and on the purpose for which the forecast is being developed (with which are associated the accuracy requirements discussed under 3.4 above). A forecast or forecasting system has therefore usually to be tailor-made to the needs of a situation. It is therefore only possible to make general observations rather than point out any particular method or procedures.

3.7.3 The forecaster should endeavour to take advantage of all the significant statistics and other information which may be produced in order to approach the problem from many sides and check the results of each approach. In order to obtain a reliable background of economic, demographic, trade and technical forecasts to support the demand forecasts, a close liaison with planning bodies in other fields is highly desirable. A list of sources of reliable data was given in 2.3.2. If resources are available, such sources can be supplemented for forecasting purposes by market analyses of existing data from carriers (for example, of passenger ticket coupons and/or air way-bills) and/or by setting up market surveys.

3.7.4 As previously discussed, the sophistication of the method used should be determined with a view to the inevitable margin of error in the final result. Different methods might be used for the short and long term time-scales, since a more accurate peak traffic flow could be produced if forecasts incorporating seasonality trends are used in the short term.

3.7.5 An important distinction can be drawn between "top down" and "bottom up" forecasting. "Top down" methods project an aggregate figure and then use fractional coefficients and other approaches to break it down into lower level estimates. "Bottom up" forecasting consists of synthesizing forecasts of categorized units. It has the advantage of being more easily relatable to cause and effect, but the categorized activities are often subject to wide fluctuations, summation of a number of forecasts leads to a wider variation in the confidence limits of the aggregate, and the cost of processing a lot of finely disaggregated data is high. "Bottom up" forecasts are usually more accurate and useful in the short term, and "top down" in the longer term. Where feasible, both approaches may be used and the results compared. Indeed, it generally is a good idea to use more than one approach to forecasting, both as a cross-check procedure and in order to estimate possible variations due to inaccurate forecasting methodology.

3.7.6 A specific distinction must also be drawn between forecasting for an existing airport and for an entirely new airport. In cases where the airport concerned has been in operation for several years, where the region to be served is in a state of stable development, and where the aircraft operators' network connecting the airport with others is well developed, the forecasting may largely be based on historical data for the airport, the air transport system and the region concerned. Fairly reliable preliminary forecasts may be made by projection of past traffic trends, and refined forecasts may be developed by analysing the factors that have affected the past development.

3.7.7 An entirely different problem is to produce forecasts for a new airport, particularly if the transport environment is unstable and the region is in a stage of rapid economic development. In such cases the methods and approaches will also have to be entirely different. The assessment of central traffic flows may prove to be more critical than the forecast itself. The approaches used for new airports include ratio methods (relating categorized levels of aviation activity for a particular airport to that of the region or nation as a whole) and cross-sectional analyses (analyses and comparisons with other airports and environments). In the case of a new airport the role of market analyses and market surveys is likely to be significant.

3.8 FORECASTING METHODS

3.8.1 As mentioned in 3.1, the Forecasting Manual exists as a handbook on techniques; only a brief resume of some of those which are relevant to airport master planning is given here.

3.8.2 Informed judgement of an individual or group of people is the original forecasting "method", and it is still the most comprehensive in that it usually implies the consideration of a wide range of variables. A large amount of personal judgement is inevitable, whatever the basic forecasting method used. Judgement can introduce subjective and often unsubstantiated bias, but is useful for checking that the results of other forecasting methods make sense, and in estimating effects of factors which are difficult to quantify. One specific feature which might be worth incorporating in the forecasting process is a check that the evaluation of the long term is not influenced too greatly by recent or current short-term events.

3.8.3 Trend extrapolation consists of trying to identify some long-term underlying growth pattern of a form which fits the behaviour of air traffic in the past. The growth pattern considered over time is usually a straight line (implying a constant absolute change between successive time periods), or asymptotic (implying that development proceeds towards some limiting level at a gradually decreasing rate). A time series of historical data has first to be smoothed to account for unusual effects such as labour strikes, special events, etc. The chosen growth pattern is then fitted to the smoothed data and projected. Fitting can be done using statistical techniques, but can also be carried out roughly by eye on graphical plots of historical traffic data. Trend extrapolation assumes that all factors influencing air traffic in the past (except the unusual effects mentioned above) will continue to operate in the same way in the future. This is often not the case. Trend extrapolation also poses a problem when the historical data shows a recent kink, as shown in Figure 3-2. Nevertheless, trend extrapolation is a useful tool, in that it introduces a degree of objectivity into forecasting. It is also relatively easy to carry out and imposes a discipline in presenting the situation in a simple form which can aid further analysis and/or provide a basis from which to check the validity of forecasts developed independently by other techniques. Indeed if described as trend analysis it becomes a valuable analytical tool in its own right.

3.8.4 Econometric modelling is one approach used to attempt to explain air traffic developments in terms of underlying causes. By using statistical techniques, it has been shown that just a few of the quantifiable major factors influencing air transport demand can explain most of the variation in this demand, and the contributory effect of each factor can be isolated to a certain extent. The method can be used both for historical time-series data and/or for "cross-sectional" data. Forecasts of the contributory factors, which are generally less sensitive than those of air transport demand itself, can then be used to produce an air transport forecast. Econometric modelling

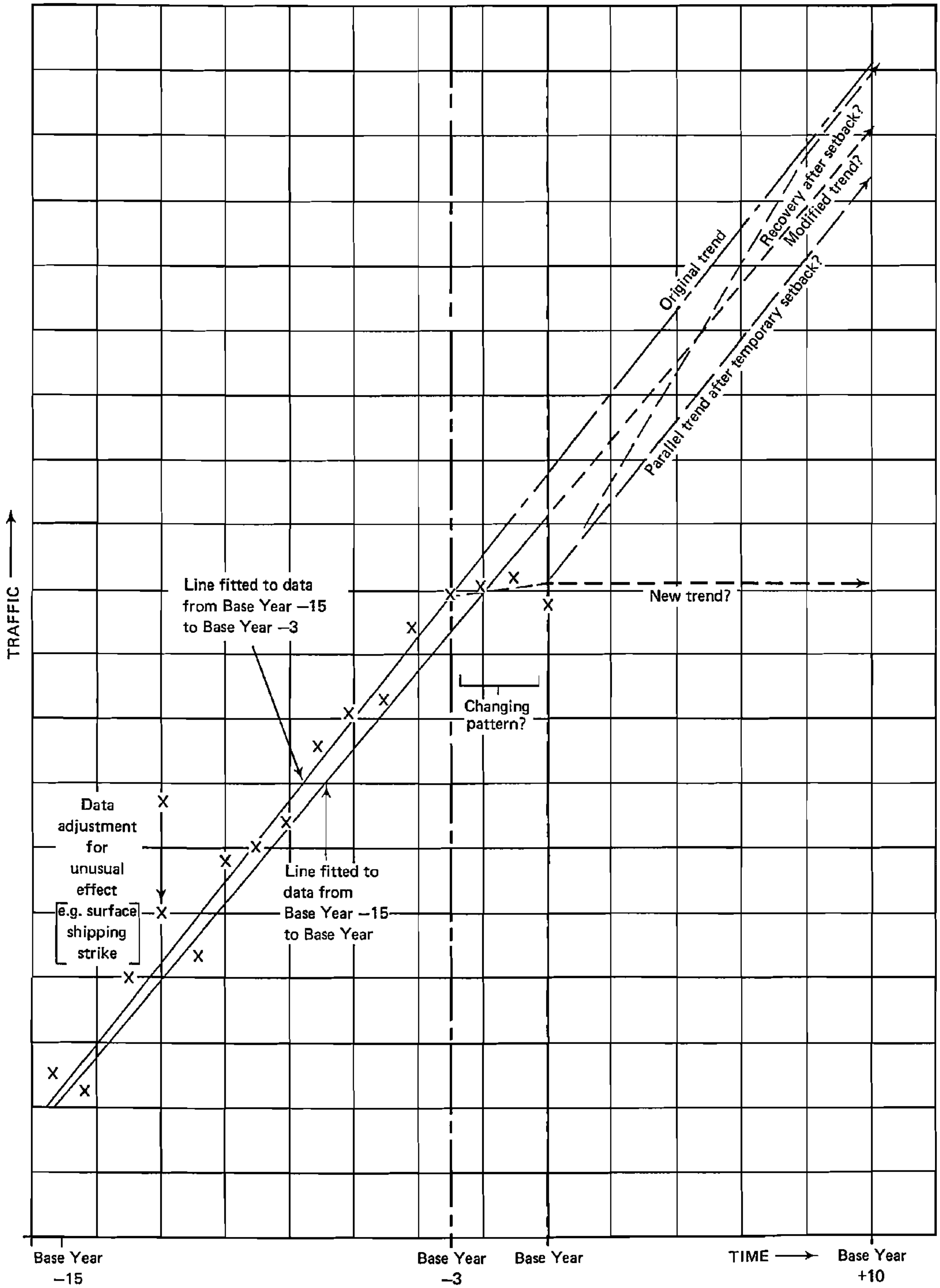

Figure 3-2. Trend extrapolation and some of its limitations

has technical limitations. Also the factors chosen for inclusion are a reflection of the model-builders' representation of cause and effect, and too much confidence can be attached to the action of easily quantifiable factors to the detriment of less readily quantifiable factors. But such models do have a particular value in planning processes since, once they have been developed, it is a relatively simple matter to assess the sensitivity of the forecasts to the various input factors and the effects of alternative policies. As noted in the Forecasting Manual, data and resource availability, and the specialized nature of many operations restrict the effective use of econometric modelling to a limited number of airports.

3.8.5 Market survey methods are used to obtain primary data from the source of the demand for airport facilities — the users themselves. Surveys are probably the only methods that have universal application, and surveys of passengers, shippers and airlines can be a very effective tool for the airport planner. However, satisfactory and meaningful surveys depend upon properly structured questions, the elimination of bias, and last but not least, the calibre of the individuals devising and carrying out the surveys. Surveys are also relatively expensive. Market surveys have been used, both directly in the design of airports to reduce subjective bias in other forecasting methods by testing theories, and as a basis themselves for forecasting airport traffic.

3.8.6 In the situation of developing countries, as mentioned in the Forecasting Manual, a preferred approach is to base forecasts on market studies, including examination of the development of the structure of the economic activity in the country, its policy with regard to tourism, and its trade pattern.

3.8.7 Whatever method is selected, it is likely that data gathering and analysis (such as validity testing and smoothing) will take up most of the time allocated to the forecasting activity.

3.9 PRESENTATION OF FORECASTS

3.9.1 Within the limits of available resources, it is helpful to use more than one method in producing a forecast. Whether one or several methods is or are used, however, it is essential to record explicitly and clearly the assumptions, data used, and technique(s) on which each forecast is based. Any adjustments made on the basis of personal judgement should be clearly stated.

3.9.2 The forecasts should be presented in a consistent form which allows for periodical updating. The forecasts should be reviewed annually if possible, and revised if necessary (possibly leading to revision of general or specific aspects of the master plan itself). Deviations of the forecasts from actual data, or anticipated changes in the assumptions relating to influencing factors may well suggest reviews of the forecasting method as well as of the forecasts.

References

Manual on Air Traffic Forecasting (Doc 8991).

"Planning and Design of Airports" (Third Edition), Robert Horonjeff and Francis X. McKelvey, McGraw-Hill Book Company, 1983.

Chapter 4. FINANCIAL ARRANGEMENTS AND CONTROLS*

4.1 ABOUT THIS CHAPTER

This chapter explains the significance of financing arrangements and financial control and accounting in airport master planning, and provides guidance for developing practical approaches in these matters. It discusses the financing of projects in terms of capital and operational costs, the requirements for domestic and foreign funds to finance the capital investment, the various channels and arrangements through which such financing may be secured, and the sources of income available to an airport for defraying its costs once it becomes operational. The treatment of financial control and accounting brings out the close relationship of these two functions and also the purposes that financial control serves. Alternative systems of accounting for recording expenses by cost item or by airport area and service are described in some detail and their relative merits examined. The presentation of assets and liabilities in balance sheet form is described and a final section devotes itself to budgeting as the medium through which financial control is accomplished.

4.2 FINANCING ARRANGEMENTS

4.2.1 The preplanning consideration given to the questions of economic feasibility and financing (see 2.4 and 2.5) should have produced order-of-magnitude estimates of the costs that will be incurred over time by the proposed airport development project and should also have broadly identified possible sources of the funds required to defray those costs. As the master planning process proceeds, the magnitude of such costs and when they will be incurred become more definitive. Forecasts of expected traffic volumes and the definition of potential revenue sources also become more detailed, making meaningful revenue projections possible (see 3.2). These data in turn become essential inputs into the preparation of the project's financing plan. The financing plan is in essence a blueprint indicating how the costs associated with the project are to be defrayed, and in its preparation thought therefore has to be given to both capital costs and operational costs: the former constitute the investment that the project represents up to its completion, and the latter are the costs that are incurred on a continuing basis once the project, or any part of it (e.g. the first of two planned runways), becomes operational. These two kinds of costs involve different financing considerations and hence need to be dealt with separately.

Capital Costs

4.2.2 As far as capital costs are concerned (operational costs are dealt with in 4.2.22 and 4.2.23), the financing plan needs to provide such basic information as:

a) estimates of the component costs (i.e. labour, materials, equipment, etc.) of each distinct part of the over-all project;

b) the amounts of funds requiring to be disbursed at various stages in the project's progress;

c) the currencies in which payments are to be made; and

d) the sources from which the funds are to be forthcoming, and the applicable conditions (i.e. interest rate, repayment period, etc.).

4.2.3 No further elaboration seems called for concerning a), the estimation of costs having already received adequate treatment, or b), since the relevance of such data is self-evident. Something does however need to be said about currency requirements, item c), and sources of funds, item d), even though such guidance as can be offered in these matters will necessarily have to be of a generalized nature.

Currency requirements

4.2.4 Where, as will often be the case, project costs call for payment in foreign funds and the national currency is not freely convertible, it is essential to establish at an

* ICAO is in the process of developing a manual on airport economics. This Chapter has therefore not been revised pending completion of that manual.

early stage that it will be practicable to obtain the foreign exchange required. The provision of such exchange will need to be examined with the appropriate fiscal authorities of the government, and for this purpose a statement should be prepared detailing as fully as possible both the foreign currency payments involved and the extent to which prospective sources of financing for the project can be expected to accommodate foreign exchange problems. While arrangements securing the loan of foreign funds or even the provision of foreign goods and services on extended credit terms, serve initially to reduce exchange problems, all such arrangements nevertheless remain a legitimate concern of the fiscal authorities of government since repayment of the debt involved ultimately constitutes a demand on foreign exchange reserves.

4.2.5 The extent to which payment of project costs can be made in domestic currency or will involve foreign exchange, depends on the many and varied factors present in each situation, and it is therefore only possible to give the following general guide as to the kinds of costs that might typically be expected to fall into each category.

4.2.6 Costs typically payable in domestic currency include:

a) construction work and other services performed by domestic contractors and firms;

b) land acquisition including associated costs of any easements (e.g. rights of way over another's property), etc.;

c) salaries, wages and other related costs of national employees;

d) domestic materials, supplies and equipment of which the country is not a net importer;

e) interest on domestic credit; and

f) taxes.

4.2.7 Costs typically payable (wholly or partially) in foreign currency include:

a) construction work and other services performed by foreign contractors and firms;

b) imported equipment, materials and supplies;

c) domestic materials of which the country is a net importer;

d) wages, salaries, allowances and other related costs of expatriate personnel; and

e) interest on foreign credit.

Note.— Policy directives and contractual arrangements seeking maximum use of domestic labour and materials can be effective restraints on foreign currency requirements.

Sources of funds

4.2.8 A survey of potential sources of funds to finance the project and the selection of which to approach, should be done as early as possible in the planning process. It is important to do so in order to have from the outset an indication of the probability of financing being available; to provide adequate time for completion of the usually lengthy preliminaries preceding the conclusion of specific financial arrangements; and to become versed in the procedural and other requirements of such arrangements, in time to incorporate those requirements directly into the planning process itself wherever compliance therewith would be facilitated by so doing.

4.2.9 Potential sources of funds will vary considerably from State to State. Which of such sources are to be approached has to be studied and decided individually for each project with particular reference to the domestic and foreign currency requirements in each case.

Domestic financing

4.2.10 Costs to be met in domestic currency may be financed by various means available within the country itself, and include loans and sometimes grants from government sources, commercial loans negotiated through banks and other domestic financial institutions, and the extension of credit by contractors and other firms engaged in the project. The higher rates of interest attaching to commercial loans will usually make these the most expensive form of financing. Government assistance in the form of interest-free loans or even grants can appropriately be sought in recognition of the local, regional and national benefits derived from the airports' existence and development. Where, as is presently the situation at most international airports, revenues are insufficient to cover total operational costs, including depreciation and interest, the execution of any new development project will inevitably depend on government assistance in some measure, and in securing such assistance the benefits just mentioned could therefore well play a role of particular importance. Their evaluation, even though only practicable in broad terms, should therefore not be neglected (see 2.5). Financial assistance in recognition of such benefits may of course be sought from government at both national and local levels (e.g. state, provincial, municipal), but in so doing the airport should be prepared to demonstrate that the particular communities falling within such jurisdictions do in fact derive distinct benefits additional to those realized nationally.

4.2.11 Where an airport seeks commercial loans directly from banks or other domestic financial institutions it can expect that forecasts of its future operating costs and revenues will be required as a basis for assessing its ability to repay such loans. Where that ability is judged adequate, such commercial financing will probably be obtainable against an appropriate pledge of future airport revenues, but to the extent that it is found lacking it is likely that the loan will only be forthcoming if repayment is backed by government or some other acceptable guarantor.

Foreign financing

4.2.12 Project costs payable in foreign funds constitute a demand on the State's reserves of foreign exchange and as such their financing will usually have to be arranged through, or with the approval of, the appropriate fiscal authorities of government.

4.2.13 Depending on the magnitude of the costs involved and the state of exchange reserves, it may prove possible to obtain the required financing through such domestic institutions as have already been mentioned above, but more often than not this will not be the case and foreign sources will need to be found. In any event, quite apart from foreign exchange considerations, such sources should always be explored as a matter of course, since financing may be available from them on terms more favourable than those procurable from domestic institutions (i.e. lower interest rate, repayment over a longer period, etc.).

4.2.14 One of the simplest ways of dealing with costs payable in foreign funds is to place the responsibility for financing arrangements on foreign contractors and suppliers who stand to benefit directly from the project. In foreign commercial dealings it is often the practice for suppliers to be required to state as part of their bid the financing arrangements they are prepared to extend, and for contractors to be given the responsibility of securing the most favourable terms. When applied, such practices will not only help to reduce the financing problems encountered in airport projects, but will also enable the acceptability of bids to be evaluated from all aspects, including the financing one: for the latter purpose the bids should of course be required to quote supply prices separate from the financing charges involved, in order that such charges may be compared with the cost of financing through any alternative source. In the financing of costs in such a manner there is, however, a hazard particularly needing to be guarded against, and this is that in the process of selecting bids a firm's financing capability may be allowed to assume an importance disproportionate to that of other considerations more basic to the project's successful execution.

4.2.15 Banks, investment houses and other traditional commercial credit institutions operating in the private sector of the country of the contractor providing goods and services for the airport project, may of course themselves be approached directly for financing assistance but the cost and other terms of such credit as may be obtainable in this manner are in general likely to be more onerous than those procurable from the various public sources which are mentioned hereafter. Commercial institutions of the kind just mentioned exist in a variety of forms in different countries, and for any particular country the specific ones likely to assist with an airport project are probably best ascertained directly from the government concerned.

4.2.16 Foreign financing may also be available from foreign governments in the form of loans negotiated directly with the government of the recipient country, or may otherwise be facilitated by particular agencies of government which have been established for the primary purpose of promoting the nation's export trade. The development of transport facilities and the consequential benefits to the national economy as a whole which are envisaged as resulting from any given project, may evoke the provision of such assistance for various reasons, among them being the desire to promote trade and cultural relations between the two countries. Additionally, as mentioned, the wish to facilitate the export of technology and equipment required for the project and available in the assisting State, may be a further reason for interest. Usually the availability of such assistance, as well as any negotiations subsequently involved, will need to be pursued through the appropriate governmental authorities of the State in which the project is being undertaken.

4.2.17 In the case of developing countries in particular, such assistance may be forthcoming through the specific aid programmes which certain governments have established to promote economic and social development in various areas of the world; these programmes extend assistance in such forms as loans on preferential terms and the direct provision of supplies, equipment and technology. Illustrative of programmes of this nature are those administered by the Canadian International Development Agency, the Overseas Economic Co-operation Fund of Japan, and the United States Agency for International Development. For projects not qualifying for aid from such sources as these, assistance in meeting the requirements for foreign financing may otherwise be available through the special export-promoting agencies created by certain governments: assistance from these sources takes various forms, including direct loans by the agency itself, guarantees covering private loans, and insurance of the risk assumed by national enterprises in providing goods and services on credit terms. Examples of agencies of this character are the Export Development Corporation of Canada, the Export-Import Banks of Japan and the United States, and the Export Credits Guarantee Department of the United Kingdom.

4.2.18 Additionally and, over-all, probably of most importance among the possible sources of foreign financing available to developing States, are the international institutions that have been established to assist in the financing and execution of projects seeking to promote national economic development. Prominent among these are the International Bank for Reconstruction and Development and its affiliates — the International Development Association and the International Finance Corporation; the various regional development banks; and the Commission of the European Communities for the European Development Fund. The locations of these particular institutions are as follows:

International Bank for Reconstruction and Development, Washington, D.C., United States
International Development Association, Washington, D.C., United States
International Finance Corporation, Washington, D.C., United States
African Development Bank, Abidjan, Côte d'Ivoire
Asian Development Bank, Manila, Philippines
Caribbean Development Bank, Bridgetown, Barbados
Inter-American Development Bank, Washington, D.C. United States
Commission of the European Communities for the European Development Fund, Brussels, Belgium.

4.2.19 As in the case of financing by foreign government, the possibilities of financial assistance being forthcoming from the above institutions for any particular airport development project, and the procedures to be followed in applying for such assistance, will need to be ascertained through the government of the country in which the project is being undertaken. Any approach to the various development banks, the International Development Association or the European Development Fund will inevitably entail government involvement. In general, this likely will be so for two reasons. First, any loan or grant that may be extended will be made either to a government or government agency, or to a private entity with the support and guarantee of the government. Second, usually the first test of suitability of a project is whether the sector of the economy in which it falls, and the project itself, are of high priority for development and are so recognized in the government's development plans.

4.2.20 The International Finance Corporation, for its part, has a quite distinct role, which supplements that of the International Bank for Reconstruction and Development, its purpose being to further economic development by encouraging the growth of productive private enterprise in member countries, particularly in the less developed areas. Briefly, the means selected for achieving this aim are: to assist, in association with private investors, with the financing of such private enterprise by making investments, without guarantee of repayment by the member government concerned, in cases where sufficient private capital is not available on reasonable terms; to seek to bring together investment opportunities, domestic and foreign capital, and experienced management; and to seek to stimulate the flow of domestic and foreign private capital into productive investment in member countries. The Corporation's role is clearly such that airport projects cannot be expected to attract any direct financing assistance from this source, but conceivably there could be situations where domestic financial institutions, endeavouring to find foreign capital for projects of this nature, might find themselves able to benefit from its services.

4.2.21 Finally, to be borne in mind by developing countries as a source of assistance in financing airport project costs payable in foreign currency as well as in national currency, is the United Nations Development Programme (UNDP). The various kinds of expertise required for the consideration, planning and execution of airport development projects, such as will be entailed in the necessary feasibility and cost-benefit studies, in the preparation of master plans and in the actual construction phase itself, may all be requested from the country's programme of UNDP funded technical assistance. As well as expertise, funding for necessary airport equipment may also be obtained through the UNDP. Where such technical assistance is to be sought for any airport development project the specific requirements will need to be formulated and submitted to the national government for approval within the country's over-all programme of development projects for which technical assistance is being requested.

Operational Costs

4.2.22 Brief mention has already been made in 2.5 of the need for careful consideration to be given in the planning process to the future ability of the airport to meet the recurring costs which have to be defrayed once the airport project, or any part of it, becomes operational. Broadly, such costs comprise operating, maintenance and administrative costs; interest and depreciation or amortization chargeable in respect of capital assets; interest on investment; and any taxes that may be payable on income or property. For convenience these may be collectively termed operational costs. They will be found described in more detail as to their components in 4.3.14 through 4.3.18.

4.2.23 Consideration of the means by which such operational costs are to be financed needs to be undertaken on the basis of as close an estimation of their expected magnitude, year by year, as can be made in the planning process. Indispensable to such estimation will, of course, be the traffic forecasts prepared for the project and the adjustment of operational costs otherwise needing to be made on account of anticipated changes in future price levels. With the magnitude of costs established, the sources of revenue available to the airport for defraying them have then to be identified and, this done, the yields expected from such sources will need also to be estimated as closely as possible, with the traffic forecasts again being used for this purpose.

Sources of income

4.2.24 The sources of earned income, as distinct from any grants or subsidies forthcoming from governmental or other sources, which are available to an airport are various. For purposes of considering the financing of costs it will be useful to classify these according to the two broad kinds of activity engaged in by an airport, namely its air traffic operations and its ancillary (non-aeronautical) operations.

4.2.25 Charges for facilities and services provided to meet the basic operational needs of aircraft operators will usually constitute the main source of earned income which is available to an airport for financing its costs. Typical and of principal importance among such charges, are:

Landing charges: covering the use of approach, landing and take-off facilities and services (i.e. air traffic control, runways, taxiways, aprons, etc.)

Passenger and cargo charges: covering the use of terminal and other facilities for charges processing passengers and cargo (often such facilities are not the subject of separate charges but are included in the cost base used for setting landing charges)

Parking and hangar charges: covering the use of parking space and airport-owned charges hangars, and the provision of associated aircraft towing service.

4.2.26 No precise guidance can be given for setting the level of such "user" charges as the foregoing, since this will depend in each case on the magnitude of the airport's operational costs, the income it derives from other sources (particularly those of a "non-aeronautical" nature dealt with later), the volume and character of the air traffic it serves, and a variety of other considerations. Certain principles and other guidelines relating in particular to the bases on which "user" charges should be established, have however been developed by ICAO for application to international civil aviation, and this material, to be found in *Statements by the Council to Contracting States on Charges for Airports and Route Air Navigation Facilities* (Doc 9082), should in itself prove useful to airport authorities in general when they come to determine which costs are to be recovered through such charges and which particular kinds of charges they should establish for this purpose.

4.2.27 The other source from which earned income can be derived by the airport consists of what has been collectively referred to above as its ancillary or non-aeronautical activities. Described in more detail in 4.3.12, the various revenues accruing from these activities include:

1) concession fees from aviation fuel and oil companies and other commercial concerns doing business at the airport;

2) revenue from the rental of airport land, premises and equipment;

3) income derived directly from the airport's own operation of shops and services; and

4) fees charged the general public for escorted tours and for admission to reserved areas.

4.2.28 The kinds of concessions and commercial concerns operated at airports throughout the world exhibit great variety, ranging from the commonplace ones, such as duty-free shops, restaurants, bars, parking facilities and fuel concessions, to those less usual, such as dry-cleaning establishments, dance studios, swimming pools and tennis courts. Which particular ones are likely to be the most appropriate and of optimum financial benefit for any given airport, is something that each airport has to determine for itself in the light of its own operational circumstances.

4.2.29 In their over-all planning of financing arrangements, airports should bear in mind that user charges and revenues from non-aeronautical sources constitute means not only for defraying operational costs but also for earning foreign exchange. Thus, to the extent that costs, as well as payments falling due in respect of capital loans, have to be met in foreign currency and the country is experiencing a scarcity of foreign exchange, the condition may be imposed that user charges collectible in respect of international operations*, as well as rental or other fees due from concessionaires of foreign ownership, shall be paid in other than national currency. Where payments made in this form come from such foreign enterprises as are accumulating earnings in national funds from their business activities in the country, the net effect of such a condition will be an increase of foreign exchange resources available to the State.

4.3 FINANCIAL CONTROL AND ACCOUNTING

4.3.1 The remainder of this chapter describes the scope, interrelationship and purposes of financial control and accounting in airport planning and management, and examines in this context the practical applications of data entered in the financial accounts. Broad descriptions are given of accounting systems designed to serve specific functions, but no attempt is made to describe in detail any specific accounting scheme or the mechanics of managing it: for this purpose the reader is invited to consult the extensive reference material existing in the field of accountancy, a selection of which appears at the end of the chapter. It should be noted that in the guidance material that follows, the financial control and accounting mechanisms outlined are intended to serve the needs of management while the project is under planning and construction as well as when it has become fully operational.

Scope of Financial Control and Accounting

4.3.2 Financial control of an airport project means the monitoring of its progress in financial terms so as to ensure that the magnitude of expenses, and when and at which location they were incurred, are in accord with a previously designed plan, and that the inflow of income is behaving equally according to design. Such a previously conceived plan expressed in monetary terms is normally referred to as a budget and is discussed later in 4.3.21 to 4.3.23. Thus, in essence, the exercise of financial control comprises firstly a comparison of actual revenues and expenses with those planned, and secondly, where the two differ significantly, a determination as to whether the cause lies within the budget itself or in the implementation of the project, and what corrective measures need to be taken.

4.3.3 Financial accounting on the other hand refers to the system, scheme, or pattern according to which revenues and expenses are recorded and then collated so as to present an over-all picture of the financial situation of the project to which they relate. How elaborate and detailed an accounting scheme should be depends on the extent of the information sought from it and the size of the airport project concerned.

4.3.4 At the end of the accounting period, which as a rule covers a one-year period, the entries in all individual financial accounts are totalled for presentation in two complementary forms or tables, the profit and loss statement and the balance sheet. The former summarizes all revenues and expenses with the difference between the two totals being either profit or loss. The balance sheet on the other hand summarizes assets and liabilities with the difference between the two being an increase or decrease in the net worth of the airport. Since this change in the net worth depends on whether a profit or loss was made during the accounting period, the balancing item on both the profit and loss statement and the balance sheet will be identical.

Relationship Between Financial Control and Accounting

4.3.5 Financial control and accounting, although separable as concepts, are, of course, interrelated since management cannot exercise financial control effectively without having at its disposal the data made available by a sound financial accounting system. Thus it is essential that any procedure being established to provide financial control be accompanied by a thorough examination of the accounting system to ensure that the latter can adequately serve this purpose.

4.3.6 If the planned airport project is an extension of an existing airport or a new airport coming under an airport authority already operating other airports, an accounting system most likely already exists and the examination therefore involves determining whether it

* To avoid conflict with Article 15 of the Chicago Convention, such a condition would need to apply to international operations in general, not just those performed by foreign operators.

adequately serves the basic requirements for effective financial control of the new airport project. If not, the decision will have to be made as to what modifications are required so as to enable the extraction of the data required for the degree of financial control sought. On the other hand, if the project is new, it will then be necessary to design an accounting system that meets the project's requirements.

Purposes of Financial Control and Accounting

4.3.7 The purposes of financial control are many, but the basic one is to ensure that all the resources are being prudently, effectively and honestly utilized. Ensuring such control is not only of primary concern for those directly involved in the management of the airport project, but is also an important prerequisite for obtaining outside financing for the project on the most favourable terms. If there is a sizeable difference between the actual and planned (or budgeted) costs of any part of the project, management must determine whether the original plan or budget contained inaccuracies or was unrealistic in its predictions, or whether there were other causes accounting for the difference, so that steps may be taken to avoid discrepancies arising elsewhere for similar reasons. Any substantial divergence from the original budget for a specific portion of the project will itself also normally call for review of the whole budget so as to determine whether this divergence will alter the over-all costs of the airport project. To the extent that such reviews disclose deficiencies in the original planning of capital requirements, they will also be useful in providing lead-time for procuring the additional financing found to be required. This will be of particular benefit where the shortfall would otherwise ultimately cause delays in execution of the project.

Accounting

4.3.8 The first step in establishing a basic knowledge of the financial situation of any project is to develop a structure for identifying various types of financial outlays and receipts, otherwise known as the accounting system. Basically this involves drawing up a number of individual accounts, each showing a specific type of revenue, expense, asset or liability. The number of accounts established for any specific system will depend on the degree of detail sought, i.e. the more elaborate the system, the greater will be the subdivision of accounts established.

4.3.9 It should not be assumed that an elaborate and highly sophisticated accounting system is always the most desirable. The managing of any accounting system involves its own expense which may become substantial, particularly when electronic data processing and computerization are involved. The basic decision to be made in this context is therefore what financial information is a) essential and b) desirable or optional. The choice of design of the system to be instituted should focus primarily on its ability to generate the information under a). As it is, however, always possible to design a basic system in more than one way, some variant may be found which lends itself to extension in such a way as to yield b) type information at little or even no added expense. In general, any basic system can of course be amplified to provide additional data, but given that accounting remains a tool of financial control, the criterion justifying more complexity must always be that the added cost entailed will be commensurate with the value of the extra data obtained.

4.3.10 Accounting data have two primary uses. The first, and generally the better known, is in presenting the financial position of a project, i.e. to show the profit or loss situation during a given period and the status of the project with regard to its assets and liabilities. The second and equally, if not more, important use is to serve as a basic tool for financial control of the project, as has been mentioned earlier.

4.3.11 A general statement which can be made with respect to airport accounting is that the identification and subsequent recording of items can, as a rule, be more easily accomplished for revenues than for expenses. This is chiefly because airport revenue sources tend to be fewer in number than expense items, and because each revenue item, with few exceptions, is often easily identifiable with only one source, whereas one expense item can frequently be identified with several major expense categories. The information required in an airport accounting system can vary considerably in detail and layout, but there is a basic itemization of revenues and expenses that may perhaps be considered a minimum and this is described in the following sections.

Revenues

4.3.12 The itemization of revenues detailed below may be considered essential to meet the basic data needs of an airport management.

1. Air traffic operations

1.1 Landing charges (including lighting charges)	____	
1.2 Passenger and cargo charges	____	
1.3 Parking and hangar charges	____	
1.4 Other charges on air traffic operations	____	
Total		______

2. Ground handling charges ______

3. Ancillary operations

   3.1 Aviation fuel and oil concessions (including throughput charges) ______
   3.2 Other concessions ______
   3.3 Rentals ______
   3.4 Other revenues from non-aeronautical activities ______

   Total ______

4. Grants and subsidies ______

5. Other revenues ______

Total revenues ______

Explanation of items

1. Air traffic operations:

   1.1 Landing charges including lighting charges: charges and fees collected for the use of runways, taxiways and apron areas, including associated lighting.

   1.2 Passenger and cargo charges: charges and fees collected for the use of air terminal and other passenger-processing facilities (e.g. for passengers embarked or disembarked), and any charges collected in respect of cargo for the use of the airport's freight-processing facilities and areas.

   1.3 Parking and hangar charges: charges collected from aircraft operators for the parking of aircraft and their housing in airport-owned hangars, including any rentals from the leasing of such hangars to aircraft operators. Towing charges, if imposed, should also be included under this heading.

   1.4 Other charges on air traffic operations: all other charges and fees collected from aircraft operators for facilities and services provided at the airport for the operation of the aircraft.

2. Ground handling charges: charges and fees collected from aircraft operators for the use of facilities and services provided at the airport for the handling of aircraft.

3. Ancillary operations:

   3.1 Aviation fuel and oil concessions (including throughput charges): all concession fees, including any throughput charges, payable by oil companies for the right to sell aviation fuel and lubricants at the airport.

   3.2 Other concessions: fees payable by other commercial enterprises for the right to sell goods and services at the airport.

   3.3 Rentals: rentals payable by commercial enterprises and other entities for the use of airport-owned building space, land or equipment. Such rentals should include those payable by aircraft operators for airport-owned premises and facilities (e.g. check-in and sales counters and administrative offices) other than those already covered under air traffic operations (see item 1 above).

   3.4 Other revenues from non-aeronautical activities: all other revenues the airport may derive from non-aeronautical activities. These include gross revenues earned by shops or services operated not by concessionaires but by the airport itself. Also included are any public admission fees charged for entry to areas of special interest (e.g. terminal observation areas) or for guided tours within the airport area.

4. Grants and subsidies: any payments received and not requiring the transfer of assets or provision of services in return.

Expenses

4.3.13 Accounting for airport expenses can be undertaken in two different ways, either by expense item (salaries, supplies and services, etc.), or by the airport area or service to which the expenses relate (aircraft movement areas, passenger and cargo terminals, etc.). The former method has the advantage of being mechanically simpler since each expense incurred can as a rule be entered under one item, e.g. the purchase of cement can be entered under supplies and services. The shortcoming of this method of cost accounting is that it does not permit management to be readily aware of the development of costs incurred for each of the major functions carried out at the airport. For this reason, there is an increasing number of airports opting for the second type of accounting scheme, where each expense is allocated to the airport function it serves, that is to say by airport area or service (e.g. the recording of a salary would depend on where at the airport the individual receiving it worked). To explain more specifically the distinction between the two systems, examples basically typical of each are provided hereunder.

4.3.14 *Expenses by item*. An accounting system based on expense items would in a simple form contain the individual accounts indicated and described below.

1. Salaries ______

2. Supplies and services ______

3. Depreciation and/or amortization ______

4. Interest ______

5. Administrative overheads ______

6. Taxes ______

7. Other expenses ______

Total expenses ______

Explanation of items

1. Salaries: direct remuneration to personnel and such other costs as social and medical insurance, pensions, remuneration in kind (e.g. board and accommodation), travel subsistence allowances, etc.

2. Supplies and services: costs of spare parts and consumable materials actually incorporated or expended in providing all airport facilities and services and in operating and maintaining fixed assets (including durable equipment such as vehicles, machinery, furniture and fixtures, tools, etc.). Included also are the costs of supplies and services required for heating, air-conditioning, lighting, water, sanitation, postage, etc. Payments made to other agencies or enterprises for provision of airport facilities and services should also be included under this item.

3. Depreciation and/or amortization: the amount by which the value of the assets has decreased during the year due to physical deterioration, obsolescence and such other factors as limit their productive life. Also to be included are amounts by which intangible assets (e.g. developmental and training costs) have been written off during the year.

4. Interest: interest paid or payable on debt during the year as well as any interest computed on capital assets.

5. Administrative overheads: the costs of common administrative services such as over-all management, economic planning, etc., to the extent that they are not included under items 1 and 2.

6. Taxes: any national or other governmental taxes (e.g. property and income taxes) payable by the airport as a taxable entity and not already reported elsewhere. Not to be included are any sales or other taxes collected from third parties on behalf of government taxing authorities (e.g. sales tax on goods and services sold in airport-operated shops and income tax deductions from staff salaries).

4.3.15 *Expenses by area or service.* An accounting system design to reflect costs by airport area and service entails the maintenance of two sets of accounts, namely, main accounts devoted to particular cost items as just described, and subsidiary accounts devoted to the various areas and services under which it is intended to redistribute the costs recorded in the main accounts. Thus, for example, salaries paid to maintenance staff would be entered both in the main account for salaries and also in the subsidiary accounts for different areas on a prorated basis according to the hours of maintenance devoted to each. Entries in the main and subsidiary accounts will best be made at the same time where any cost is of a non-recurring nature, but where particular costs are repetitive, such as salary payments, and are attributable to more than one area, the necessary cross-entries to subsidiary accounts may be done periodically, say monthly, to economize on the work of prorating.

4.3.16 A useful minimum classification of subsidiary accounts for an accounting system recording costs by area and service would be as indicated below:

1. Aircraft movement areas (e.g. runways, taxiways, aircraft parking areas) and their associated lighting ______

2. Passenger and cargo terminal facilities (owned by the airport) ______

3. Hangar and maintenance areas (owned by the airport) ______

4. Fire-fighting, ambulance and security services ______

5. Air traffic control (including communications) ______

6. Meteorological services ______

7. Other expenses ______

Total expenses ______

Explanation of items

The following explanations point out the more significant elements of maintenance, operating and administrative costs typically associated with the areas and services enumerated above. Intended merely as a guide, they are far from being exhaustive of the variety of costs falling within these particular expense categories.

Not mentioned in the notes, but dealt with in 4.3.14 in the explanation of items 3, 4 and 7 are depreciation and/or amortization, interest and taxes. It should be understood that these costs will also need to be redistributed from the main to the subsidiary accounts if a comprehensive record of the full costs attributable to each area and service is to be established.

1. Aircraft movement areas: all maintenance, administrative and operating costs attributable to these areas and their associated vehicles and equipment, including the expense of all labour (skilled and unskilled), maintenance materials, power and fuels.

2. Passenger and cargo terminal facilities (owned by the airport): all maintenance, operating and administrative costs for

terminal facilities, including, where applicable, such expenses as relate to any airport-operated shops and services located in the terminals (e.g. staff salaries, costs of stock sold and any spoilage, and the cost of utilities and general upkeep provided in such cases), but excluding any costs of work which, under particular leasing arrangements, are borne by lessees.

3. Hangar and maintenance areas (owned by the airport): all related maintenance operating and administrative costs, excluding any costs of work which, under particular leasing arrangements, are borne by lessees (e.g. maintenance of hangars).

4. Fire fighting, ambulance and security services: all operating, maintenance and administrative costs attributable to these services, including staff salaries and the expense of maintaining the associated vehicles and equipment.

5. Air traffic control (including communications, i.e. fixed and mobile services and radio navigation aids): all related maintenance, operating and administrative costs, including in particular the expense of power and any spare parts consumed by radars, receiving and transmitting stations, NDBs, VORs, ILS, and other equipment employed.

6. Meteorological services: all operating, maintenance and administrative costs of any meteorological services provided by the airport itself.

4.3.17 From the foregoing explanations it will be clear that the two systems described may be regarded as alternatives, the accounting for expenses by airport area or service being in essence a regrouping of the various sub-items constituting an accounting system recording expenses by item. In the case of the latter, the individual accounts indicated in the example given in 4.3.14 above do, of course, represent a basic minimum, and where as will generally be the case, greater accounting detail is called for, their further subdivision into sub-items will be necessary. Salaries for example may be subdivided into direct remuneration, social and medical insurance, pension fund payments, etc., and further subdivided by employee group or airport area, etc. Similarly, supplies and services and other main items may be broken down into numerous other accounts.

4.3.18 The extent to which the accounting for costs by expense items is developed depends on the information an airport management considers essential for monitoring purposes, and similar considerations will determine whether the accounting system is to be established on an expense item basis or an airport area and service basis. The system of accounting by area and service is more complex and hence more costly to operate, and this added expense is something needing to be assessed and carefully weighed when the type of system to be introduced is being decided.

Assets and liabilities

4.3.19 The systematic presentation of assets and liabilities in the form of a balance sheet is a less common practice among airports than the preparation of statements of revenues and expenses. An important reason is that airports are for the most part not operated as private or stock companies, but tend to be part of a department or agency of government whose accounting requirements normally do not call for preparation of a formal balance sheet. However, airports run by public or other autonomous bodies are generally more likely to provide this type of information since in many instances there will exist a statutory requirement for them to do so.

4.3.20 While assets and liabilities may not generally be as readily available as revenue and expense data, any airport management should have certain basic compilations of such data at its disposal. The most significant items would generally be such as indicated below:

ASSETS	
1. Current assets	______
2. Reserve and other special funds	______
3. Depreciated value of fixed assets	______
4. Investments	______
5. Other assets	______
Total assets	======

Explanation of items

1. Current assets: cash and bank balances available for current expenses and debts; accounts and notes receivable due within one year, less reserves provided for bad debts, and short-term investments also due within one year; interest and dividends receivable; grants due from public funds; the cost of all tools, materials, supplies, etc., in stock, and any amounts expended on uncompleted work for others; prepayments of salaries, insurance, interest, taxes; other current and accrued assets.

2. Reserve and other special funds: any funds that may be specifically set aside (in special bank accounts, investments, etc.) to provide for such future commitments as additions and improvements to existing fixed assets, debt servicing and retirement, etc.

3. Depreciated value of fixed assets: the aggregated book value of all fixed assets as depreciated up to the end of the current year.

4. Investments: any investment in stocks, bonds and long-term notes other than those already included in item 2.

LIABILITIES

1. Current liabilities ______

2. Long-term debt
   2.1 owing to governments (federal, state, municipal, etc.) ______
   2.2 owing to others ______

3. Other liabilities ______

Total liabilities ______

Explanation of items

1. Current liabilities: accounts and notes payable due within one year; salaries and wages accrued and unpaid; interest, dividends, insurance and taxes accrued and unpaid; other current and accrued liabilities.

2. Long-term debt: the value (excluding accrued interest) of mortgages, bonds, trust certificates, debentures, notes and other long-term debt (i.e. contracted for a term exceeding one year) issued or assumed by the airport, in the hands of others.

Budgeting

4.3.21 A prerequisite for effective financial control is the establishment of a budgeting process as a complement to whatever accounting system is instituted. Essentially, a budget is a projection of expected revenues and expenses over a pre-determined period of time, and as such, it serves not only as an instrument for financial control, but also to establish a series of financial objectives to be achieved during the budget period. Budgeting thus has to be seen as a continuing operation which should be instituted at the outset of the planning process and continued through both the construction phase of the airport project and its operational future.

4.3.22 The budget should be structured on the accounting system employed for recording revenues and expenses, and its itemization should basically identify with the various accounts comprising that system. This will ensure the affinity in make-up between budgeted and actual figures that is essential to give validity to comparisons between the two, and in so doing will obviate the troublesome reconciliation of disparate figures that would otherwise have to be undertaken. Some latitude in conformity between the individual accounts and the budget itemization can, however, be allowed to the extent that comparability of the figures is not jeopardized. For example, where the accounting system is extremely detailed with an extensive breakdown of accounts into various sub-accounts, the budget estimates may not always need to be broken down to the same extent since the effort and consequential expense involved may not justify the information required.

4.3.23 Finally, in budgeting it must be remembered that a budget is built up on a foundation of sub-item data. The reliability of the over-all budget and any financial obligations based thereon depend on the reliability of the procedures employed in predicting the monetary magnitude of the budget's sub-items. If the procedures and scope are not systematically and carefully designed at the outset, the budgeting process will fail or even mislead management in its decision making, since sophisticated application of data cannot compensate for unreliability in the data itself.

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Chapter 5. AIRPORT SITE EVALUATION AND SELECTION

5.1 ABOUT THIS CHAPTER

5.1.1 The provision of a new airport or the development of an existing one involves substantial capital investment and large-scale construction work. In order to avoid premature obsolescence and waste of valuable financial and material resources, it is important that they should have the longest possible useful life. To achieve this, sufficient ground area should be available for progressive development in step with growth in air traffic demand. In addition to sufficient ground area it is also necessary, for realization of maximum benefits from the investment, to ensure the safety of aircraft operations and to avoid hazards or discomfort to the surrounding community without limiting the growth or the efficiency of an airport. Therefore, sites should be chosen with land areas which offer the best potential for long-term development at least financial and social cost.

5.1.2 The starting point in selection of an airport site or the assessment of the suitability of an existing site is the definition of the purpose for which the airport is required. This requires consideration of forecast future demands and the quantity and type of traffic to be accommodated. These details are derived from the operational and economic forecasts (Chapter 3). It is then necessary to define the type of airport and the operational systems for the forecast passenger and cargo traffic. Based on this information, the actual process of site selection falls into several major steps commencing with an assessment of the shape and size of the area required for the airport, the location of sites with potential for development, followed by examination and evaluation of these sites.

Major Steps in the Site Evaluation and Selection Process

5.1.3 The major steps involved in any site evaluation or selection process whether for an existing airport or for an entirely new airport include:

a) broad determination of the land area required;

b) evaluation of factors affecting airport location;

c) preliminary office study of possible sites;

d) site inspection;

e) environmental study;

f) review of potential sites;

g) preparation of outline plans and estimates of costs and revenues;

h) final evaluation and selection;

i) report and recommendations.

5.2 BROAD DETERMINATION OF THE LAND AREA REQUIRED

5.2.1 Before inspection of any potential sites, including existing sites, it is necessary to make a broad assessment of the land area likely to be required. This can be achieved by considering the space necessary for runway development which generally forms the major proportion of land required for an airport. This requires consideration of the following factors:

— runway length;

— runway orientation;

— number of runways;

— combination of length, number and orientation of runways to form an outline runway scheme for rough assessment of the order of magnitude of land required.

Runway Length

5.2.2 The ICAO *Aerodrome Design Manual*, Part 1 — Runways, provides an explanation of the parameters affecting runway length together with nomograms for calculation of runway lengths for specific aircraft for airport planning purposes. It also explains the concept of using a combination of runway, stopway and clearway as a stage in long-term development.

5.2.3 To avoid imposing unnecessary aircraft operating restrictions and incurring disproportionate construction and maintenance costs, adequate space should be provided to permit runways to be developed to meet long-term requirements. Consequently, the performance characteristics of both current and future critical aircraft, i.e. those with the maximum requirements within the broad group of aircraft anticipated to use the airport, are significant. Even if aircraft planned for introduction within the foreseeable future when operating over similar stage lengths were not to require longer runways than current large civil aircraft, such factors as the possibility of longer direct flights and relegation of current large aircraft to secondary routes, with a need for runway extension and development, requires consideration.

5.2.4 For long-term planning detailed runway length requirements cannot be defined with certainty. Nevertheless, planning would be seriously deficient unless reasonable provision were made for the future. Adequate land should be acquired or protected to provide for possible ultimate runway development, including protection of approaches and provision for associated visual and radionavigation (non-visual) aids. When considering long-term requirements, advice should be obtained from the aircraft operators regarding their future aircraft operating characteristics. Although it is possible that all the land reserved for long-term use may not be required, errors of underestimation may prove insoluble.

Runway Orientation

5.2.5 Annex 14, Chapter 3 and Attachment A, provides details of various aspects concerning runway orientation.

5.2.6 In broad terms, runways should be oriented so that aircraft are not directed over populated areas and obstructions are avoided. Subject to all other factors being equal they should be oriented in the direction of the prevailing wind when it blows consistently from one direction.

5.2.7 As a general rule, the primary runway at an airport should be oriented as closely as practicable in the direction of the prevailing winds. When landing and taking off, aircraft are able to manoeuvre on a runway as long as the wind component at right angles to the direction of travel (defined as cross-wind) is not excessive. The maximum allowable cross-wind depends not only on the size of the aircraft but also on the wing configuration and the condition of the pavement surface. Transport category aircraft can manoeuvre in cross-winds as high as 56 km/h (30 kt), but it is quite difficult to do so; hence lower values are used for airport planning.

5.2.8 Annex 14 specifies that runways should be oriented so aeroplanes may be landed at least 95 per cent of the time with cross-wind components as follows:

Cross-wind component	*Aeroplane reference field length*
37 km/h (20 kt)	1 500 m or over
24 km/h (13 kt)	1 200 m or up to but not including 1 500 m
19 km/h (10 kt)	less than 1 200 m

An exception to the above for runways 1 500 m or over is that when poor runway braking action owing to an insufficient longitudinal coefficient of friction is experienced with some frequency, a cross-wind component not exceeding 24 km/h (13 kt) should be assumed.

5.2.9 After the maximum permissible cross-wind component is selected, the most desirable direction of runways for wind coverage can be determined by examination of the wind characteristics for the following conditions:

a) The entire wind coverage regardless of visibility or cloud ceiling; and

b) Wind conditions when ceiling is between 60 m and 300 m and/or the visibility is between 0.8 km and 4.8 km.

The first condition represents the entire range of visibility, from excellent to very poor. The next condition represents various degrees of poor visibility requiring the use of instruments for landing. It is important to know the strength of the winds when the visibility is restricted. Normally when the visibility approaches 0.8 km and the ceiling is 60 m, there is very little wind present, the visibility being reduced by fog, haze, smoke, or smog. Sometimes the visibility may be extremely poor, yet there is no distinct cloud ceiling; for that matter, no clouds need be present at all. Examples of this condition are fog, smoke, smog, haze, etc.

5.2.10 The "95 per cent" criterion recommended by ICAO is applicable to all conditions of weather; nevertheless, it is still useful to examine the data in parts whenever this is possible.

5.2.11 Weather records can usually be obtained from government weather bureaux. The velocities are generally divided into 22.5 degree increments (16 points of the compass). The weather records contain the percentage of time certain combinations of ceiling and visibility occur (e.g. ceiling, 500 to 274 m; visibility, 4.8 to 9.7 km), and the percentage of time winds of specified velocity occur from different directions, (e.g. NNE, 4.8 to 8.5 km/h (2.6 to 4.6 kt)). The directions are in reference to true north.

5.2.12 Often wind data for an entirely new location have not been recorded. If that is the case, records of nearby measuring stations should be consulted. If the surrounding area is fairly level, the records of these stations should indicate the winds at the site of the proposed airport. If the terrain is hilly, however, the wind pattern is often dictated by the topography, and it is dangerous to utilize the records of stations some distance from the site. In that event, a study of the topography of the region and consultation with long-time residents may prove useful.

5.2.13 The directions of the runways can be determined graphically as follows. Assume that the wind data for all conditions of visibility are those shown in Table 5-1. From these data a wind rose can be plotted as shown in Figure 5-1.

5.2.14 The percentage of winds which corresponds to a given direction and velocity range is marked in the proper sector on the wind rose. Optimum runway directions can be determined from the wind rose by the use of a strip of transparent material on which three parallel and equally spaced lines have been plotted. The middle line represents the runway centre line, and the distance between the outside lines is, to scale, twice the allowable cross-wind component (in the example, 48 km/h or 26 kt).

5.2.15 The transparent strip is placed over the wind rose in such a manner that the centre line on the strip passes through the centre of the wind rose. With the centre of the wind rose as a pivot point, the transparent overlay is rotated until the sum of the percentages included between the outside lines is a maximum. When one of the outside lines on the transparent strip divides a segment of wind direction, the fractional part is estimated visually to the nearest 0.1 per cent. This procedure is consistent with the accuracy of the wind data.

Table 5-1. Wind data

Wind direction	Percentage of winds 7∼24 km/h (4∼13 kt)	 26∼37 km/h (14∼20 kt)	 39∼76 km/h (21∼41 kt)	Total
N	4.8	1.3	0.1	6.2
NNE	3.7	0.8	---	4.5
NE	1.5	0.1	---	1.6
ENE	2.3	0.3	---	2.6
E	2.4	0.4	---	2.8
ESE	5.0	1.1	---	6.1
SE	6.4	3.2	0.1	9.7
SSE	7.3	7.7	0.3	15.3
S	4.4	2.2	0.1	6.7
SSW	2.6	0.9	---	3.5
SW	1.6	0.1	---	1.7
WSW	3.1	0.4	---	3.5
W	1.9	0.3	---	2.2
WNW	5.8	2.6	0.2	8.6
NW	4.8	2.4	0.2	7.4
NNW	7.8	4.9	0.3	13.0
Calms — (0∼6 km/hr (0∼3 kt))				4.6
Total				100.0

5.2.16 The next step is to read the bearing of the runway on the outer scale of the wind rose where the centre line on the transparent strip crosses the direction scale. Because true north is used for published wind data, this bearing usually will be different from that used in numbering runways which are based on the magnetic bearing. In reference to Figure 5-1, it will be noted that a runway oriented 150 to 330 degrees (S30°E true) will permit operations 95 per cent of the time with the cross-wind components not exceeding 24 km/h or 13 kt.

5.2.17 Thus far the procedure has been illustrated as it applies to wind records with a velocity break at 24 km/h or 13 kt. However, it can also be used to obtain estimates of wind coverage for any other velocity break. The concentric circles on the wind rose are drawn to scale and represent breaks in the wind velocity data. Suppose the break was at 19 km/h instead of 24 km/h (10 kt instead of 13 kt). Then the two parallel lines representing the 24 km/h or 13 kt maximum allowable cross-wind component would not be tangent to the 19 km/h or 10 kt circle but would lie outside of it. An estimate must then be made of the fractional percentage segment between the 19 km/h (10 kt) circle ahead of the 24 km/h (13 kt) parallel lines and added to the percentage segment between the 19 km/h (10 kt) circle and the 24 km/h (13 kt) parallel lines and added to the percentage lying within the 19 km/h (10 kt) circle.

Low visibility wind analysis

5.2.18 The next step is to examine wind data during the restricted visibility conditions cited previously and plot a wind rose for this condition. From this analysis it can be ascertained whether the runways are capable of accepting aircraft at least 95 per cent of the time when restricted visibility conditions prevail. The analysis will also yield information on the percentage of the total time each of the conditions prevails. An example of the form on which restricted visibility data are tabulated is shown in Figure 5-2. Figure 5-2 represents observations of winds in one compass direction only, in this instance from the northeast. The total number of observations for all compass directions is 24 081, of which 1 106 are for winds from the northeast. To complete the analysis, charts of this type would have to be plotted for other compass directions. For the purpose of the example it was assumed that a ceiling of 290 m was equivalent to 300 m. The circled number 7 means that there were seven observations made

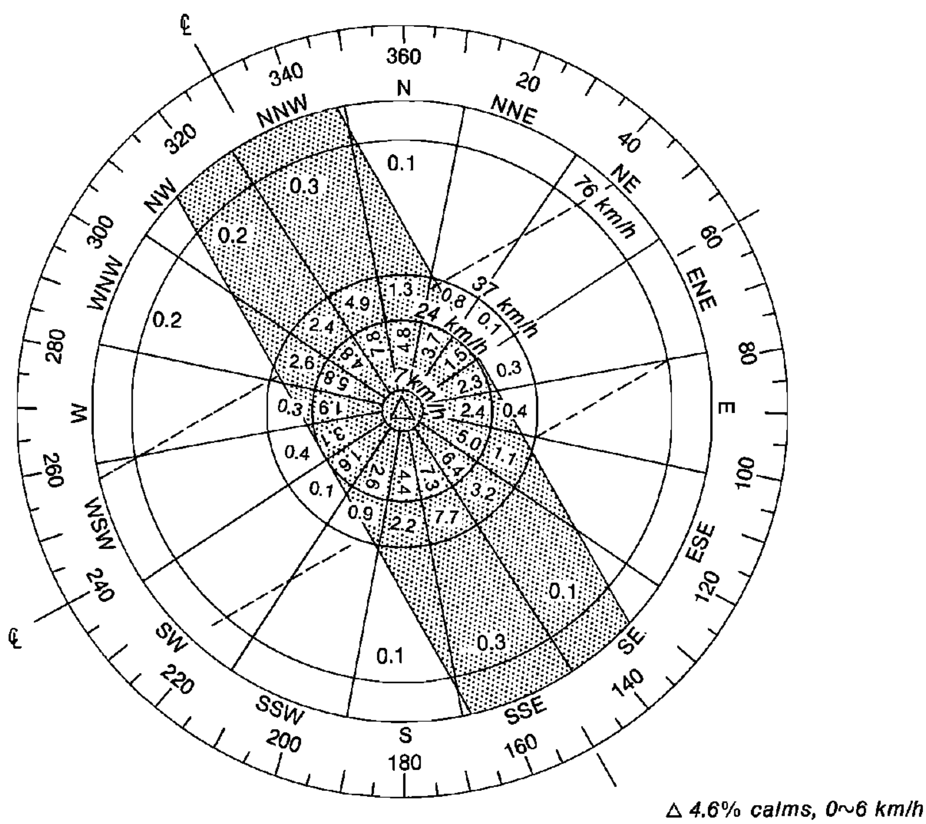


Figure 5-1. Typical wind rose

NE wind									Total observations: 24 081
Ceiling groups in metres	Velocity groups in km	Visibility — metres							
		0~400	400~800	800~1 200	1 200~1 600	1 600~2 400	2 400~4 800	4 800+	Total obs.
300	1~7	4		1	2	4	14	202	227
	8~15	1	5	1	3	6	17	383	416
	16~23	2			1		5	277	285
	24~47							114	114
	48+								
	Total	7	5	2	6	10	36	976	1 042
180 thru 270	1~7		1			1		1	3
	8~15			1	1	1	1	8	12
	16~23				1		3	4	8
	24~47								
	48+								
	Total		1	1	2	2	4	13	23
150	1~7			1				1	2
	8~15						2		2
	16~23								
	24~47								
	48+								
	Total			1			2	1	4
120	1~7			1					1
	8~15				1	1	2		4
	16~23						1		1
	24~47								
	48+								
	Total			1	1	1	3		6
90	1~7	1	1		1	1	1		5
	8~15	1						1	2
	16~23						1	1	2
	24~47								
	48+								
	Total	2	1		1	1	2	2	9
60	1~7					1			1
	8~15	1	1	1			1	1	5
	16~23						1		1
	24~47				1				1
	48+								
	Total	1	1	1	1	1	2	1	8
30	1~7	3							3
	8~15	7	1						8
	16~23		3						3
	24~47								
	48+								
	Total	10	4						14
	% by velocity groups		1.6~7 km 10	8~15 km 19	16~23 km 12	24~47 km 5	48 km		

Observations to be considered because of ceiling conditions
Observations to be considered because of visibility conditions
Observations to be considered because of ceiling and visibility conditions

Figure 5-2. Sample of data for analysing wind coverage in a specific direction during periods of restricted visibility when the wind was from the northeast with velocities varying from 8∼15 km/h (4 to 8 kt), ceiling between 0 and 30 m, and visibility between 0 and 400 m. The crosshatched area conforms to the ceiling and visibility criteria previously cited.

Number of Runways

5.2.19 Annex 14, Chapter 3 and Attachment A, contains information regarding the factors affecting the number of runways. A sufficient number of runways is required to meet the forecast aircraft traffic demand, i.e. the number of aircraft, mixture of aircraft types and the mixture of arrivals and departures to be accommodated in one hour during the busiest periods.

5.2.20 The 95 per cent usability specified in Annex 14 with regard to surface cross-wind velocity is a minimum. At busy airports, an inability to operate for the remaining period of 5 per cent, potentially 18 days per year, can represent a serious disadvantage. Consequently, in addition to the primary runways, one or more secondary runways may need to be planned to accommodate aircraft traffic under strong cross-wind conditions. Secondary runways may be provided where airport maintenance work is considered likely to prove disruptive to the regularity of air service desired. However, as cross-wind runways would require to be used only under high headwind components, their length can be considerably shorter than the main runways.

5.3 EVALUATION OF FACTORS AFFECTING AIRPORT LOCATION

When a general assessment has been made of the land area required, based on a tentative layout capable of satisfying the airport master plan, collection of background material is begun. This information can be equally useful in evaluating an existing airport site or a potential site for a new airport. Factors on which information should be collected and evaluated include:

a) Aviation activity — consult aircraft operators, potential operators, and pilot organizations.

b) Development of surrounding area — contact planning authorities and agencies to obtain plans of existing and future land use.

c) Atmospheric conditions — obtain data on presence of fog, haze, smoke, etc., which may consequently reduce visibility and the capacity of an airport. List any special local weather factors; for example, variations in weather pattern, prevailing winds, fog, low cloud, rainfall, snow, turbulence, etc.

d) Accessibility to ground transport — note the location of roads, railways, and public transport routes.

e) Availability of land for expansion of an existing airport or for a new airport — availability of suitable land for the future expansion of an airport is necessary. Study aeronautical, land, road and topographical maps and aerial photographs, etc. Study topographical maps to ascertain areas with suitable slopes and drainage. Review geological maps showing distribution of soil and rock types. Ascertain location and availability of construction materials, quarries, etc. Ascertain general land values for various areas and usage (residential, agricultural, pastoral, industrial, etc.).

f) Topography — note significant factors affecting cost of construction such as the need for excavation or filling, drainage and poor soil conditions.

g) Environment — note locations of wildlife reserves and migratory areas. Also note noise-sensitive areas such as schools and hospitals.

h) Presence of other airports — note locations of existing airports and ATS routes together with their associated airspace and any future plans to change them.

i) Availability of utilities — note locations of main power and water supplies, sewage and gas mains, telephone services, fuel, etc.

5.4 PRELIMINARY STUDY OF POSSIBLE AIRPORT SITES

After the approximate size and type of airport has been determined as in 5.2 and locational factors have been tabulated as in 5.3, the next step is to analyse these factors, and having done so, to plot possible new airport sites or additional land requirements for an existing airport, on charts and maps. This preliminary study should eliminate undesirable sites or determine the adequacy of an existing site before costly site inspections are undertaken.

5.5 SITE INSPECTION

5.5.1 After listing all the potential sites considered worthy of further investigation, a thorough field and aerial inspection is required to provide a basis for assessment of the advantages and disadvantages of each site. Airports should be sited so that aircraft operations can be carried out efficiently and safely, so that they are compatible from a social viewpoint and so that the cost of development is kept at the optimum level, taking all factors into account. The factors of major importance may be grouped under operational, social and cost considerations.

Operational Considerations

Airspace

5.5.2 Annex 14 and the *Procedures for Air Navigation Services — Aircraft Operations* contain detailed information on holding and approach-to-land procedures and instrument approach systems and aids — procedures and obstacle clearances.

5.5.3 Adequate airspace is so important for the efficient operation of an airport that special attention is required to ascertain that each site is satisfactory in this regard and, if not, to determine the extent and likely effect of any restrictions. A site close to a demand centre but with some restrictions on airspace may be preferable to a site with no airspace restrictions but so remote or difficult of access that it creates little or no traffic demand. Such factors have to be weighed to achieve the best balance. When two airports have to share the same airspace, their combined aircraft movement rates may be restricted. Instead of being able to operate completely independently of each other to the limit of their individual capacities it will be necessary to phase aircraft movements, each airport with the other, in order to maintain the necessary physical separation between aircraft. Therefore, new airports should be located so that any overlap with the airspace required for aircraft using other airports, and the resultant limitation of total capacity, is minimized. For the same reason, potential airport sites need to be studied in relation to ATS routes so that similar problems are avoided.

Obstacles

5.5.4 Details of obstacle restriction requirements are included in Annex 14, Chapter 4. The *Airport Services Manual,* Part 6 — Control of Obstacles, provides further information including guidance on obstacle surveys.

5.5.5 In general, because of the large areas of land involved — 15 km on the axes of runways from the airport boundary, it is difficult to obtain sites which provide all the clearances desired and, consequently, features such as high terrain, trees and structures which constitute obstacles need to be avoided. It is important to maintain clearance from masts and similar inconspicuous skeletal structures because, although marking and lighting can assist in directing attention to them, it does not offer complete protection particularly during conditions of reduced visibility.

5.5.6 Any objects which limit the available flight path may limit the efficiency of operations. If tall structures exist in, or near, areas otherwise suitable for instrument approaches, non-standard procedure heights may need to be adopted, with consequent effect on the duration of approach procedures and the demand of useful altitude allocations to aircraft in associated holding patterns. Such structures may furthermore limit desirable flexibility of radar vectored initial approaches and the ability to turn en-route during the departure climb.

5.5.7 In assessing the potential of any site to provide clear approaches, the approaches should be gauged against the maximum runway lengths envisaged in the master plan. If the site is suitable for maximum planned lengths, it will likely place few restrictions, if any, on earlier phases of the plan.

Hazards

5.5.8 Local factors can be important in relation to the location of individual sites. For instance, industry can produce smoke which may be concentrated in certain directions by the prevailing wind. As a result, visibility in some areas may be restricted and VFR operations precluded. Sites adjacent to wildlife reserves, lakes, rivers and coastal areas, refuse dumps and sewage outfalls, etc., may not be desirable because of the danger of aircraft collision with birds. This is of special importance where faster, larger aircraft are involved. The location of sites relative to the migratory patterns and routes of birds, especially large birds such as swans and geese also requires consideration. The *Airport Services Manual,* Part 3, contains detailed information on assessing the potential bird hazard at a site.

Weather

5.5.9 Weather conditions can vary significantly between sites in the same general area. Wind distribution in association with visibility and ceiling are of primary importance in deciding on runway orientation and the need to make provision for operations under all-weather or only visual conditions. Particular localities may be subject to fogs, turbulence or higher rainfall which can affect the efficiency and regularity of operations.

Approach and landing aids

5.5.10 For details of visual aids, see Annex 14, Chapter 5 and the *Aerodrome Design Manual,* Part 4. See Annex 10 for references regarding siting and clearance requirements for radio-navigation (non-visual) aids. Aids to navigation, approach and landing are an essential element of the air transport system. Non-visual (electronic) aids for guidance, especially under low cloud ceiling and restricted visibility conditions, are more significant from an airport siting viewpoint because of the clearances required from objects (power lines, large buildings, moving vehicles, etc.), which can affect their reliability of operation. They have to be sited relative to the airports, airspace and aircraft flight paths to be served and potential sites should include suitable areas for their installation.

Social Considerations

5.5.11 Airports need to be sited very carefully relative to adjacent populated areas, and runways should be aligned so that flight paths do not pass over concentrations of population while aircraft are below certain heights. However, airports also need to be located adjacent to the towns and commercial areas they serve. Generally, a compromise between these two opposing principles will be required to obtain the site with the best over-all merit.

Proximity to demand centres

5.5.12 Airports should be conveniently situated in terms of travelling time and distance from both existing and future population centres and the commercial and industrial areas which they are intended to serve. The location of potential sites requires consideration, therefore, from the over-all viewpoint of passengers, shippers of air cargo, aircraft operators and staff, labour force, etc. The acceptability of the location of a site relative to the areas it serves can be measured in terms of journey time and cost. As a guide to the relative merits of individual locations, time contours for the various travel modes can be drawn in relation to the centres of the various areas of demand. For example, by considering road transport and the speed limits on roads connecting the areas of demand, time contours in convenient increments of, say, 5 to 10 minutes can be plotted for both present and future.

Ground access

5.5.13 Fast and convenient access facilities for passengers and freight are essential for an airport to provide efficient service. Potential airport sites with inefficient or inadequate transport systems which do not permit smooth flow of traffic at all times will necessitate expenditures to overcome these deficiencies. Locations offering convenient connexion to an adequate road network, and, as appropriate railways and waterways, are preferable, all other factors being equal.

5.5.14 The authorities responsible for roads and public transport systems should be informed of any proposals for construction of new airports and major extensions to existing airports during the early stages of investigation. Their assistance should be sought in acquiring details of existing facilities and their planned development. This will ensure that these authorities are fully informed and will establish an environment for future co-operation.

5.5.15 When ground travel times are approximately equal between several potential sites, the journey cost is a major factor. The convenience of passengers who travel by surface to the airport is also a point for the most careful consideration. For example, a multi-lane road with limited cross traffic is obviously preferable to a congested road with numerous traffic lights or a narrow mountainous road. In addition to private motor vehicles, it is important to take account of public transport systems such as public bus, rail, taxi or, in certain cases, vertical or short take-off (V/STOL) aircraft.

Noise

5.5.16 Aircraft noise in the vicinity of airports is a serious problem. Factors to be included in airport planning include the measurement and description of aircraft noise, land-use control, ground run-up and flight noise abatement operating procedures, aircraft noise certification, human tolerance to aircraft noise, the effect of increased traffic and the introduction of future aircraft types on noise in the vicinity of airports.

5.5.17 It is not always feasible to site an airport sufficiently far away from population centres to prevent an adverse social reaction. Remotely located airports are both unrealistic and costly and defeat the objective of reducing over-all door-to-door travel times. It is important, therefore, to obtain or control sufficient land to overcome or reduce the noise problem for both the airport and the population. The potential degree of noise disturbance needs to be assessed in terms which will indicate the relationship between the level and duration of the noise exposure and human reaction.

5.5.18 In attempting to assess the extent of future noise disturbance at potential sites, the forecast aircraft movement rate and timing of airport development, and the aircraft types and hours during which aircraft operations will take place are important. However, long-term estimates and assessments of noise disturbance can be expected to be somewhat speculative and less reliable than those for a short term. More detailed information on noise evaluation may be found in Annex 16, Volume I — Aircraft Noise.

5.5.19 The noise level produced by aircraft operations at and around the airport is generally considered a primary environmental cost associated with the facility. Most noise exposure lies within the land area immediately beneath and adjacent to the aircraft approach and departure paths. Noise levels are generally measured through some formulation of decibel level, duration, and number of occurrences. A large number of noise measuring techniques exist (see Annex 16). Proper site selection and adjacent land use planning can serve to greatly reduce, if not eliminate, the noise problem associated with the airport.

Land use

5.5.20 The advantages and disadvantages of different sites will be influenced by the surrounding forms of land use. Airports should be located so that a compatible situation is created or preserved and existing forms of land use are not affected by aircraft operations. This may obviate the need for costly land acquisition and facilitate the introduction and administration of land control measures which may be considered necessary to avoid noise or obstruction problems. In general, sites with approaches over water, but free of bird hazards, and where aids to approach can be installed where necessary etc., should prove preferable to those locations adjacent to residential areas.

5.5.21 In the case of a potential site where changes of land use are necessary, there may be obvious social problems and also legal and economic difficulties. Purchase or compulsory acquisition with the attendant legal technicalities and delays may be necessary in certain instances, but arrangements with the appropriate authorities to exert control of development to preserve existing compatible land use may offer less of a future problem. The *Airport Planning Manual,* Part 2, provides more detail on land use.

Cost Considerations

5.5.22 In order to achieve suitable returns from the investment necessary for their construction, airports should be located so that the cost of development work is minimized. Thus, topography, soil and construction materials, availability of services and land values are of particular importance.

Topography

5.5.23 Topography is important because the slope of the terrain, the location and variation of natural features such as trees and water courses, and the existence of structures such as buildings, roads, overhead lines, etc., can affect the requirements for clearing, filling, grading and drainage. Natural slope and drainage of the land are important from a design and construction point of view because they determine the earthworks and grading operations necessary to produce the desired gradients and thus the cost of preparing the site. Terrain which conforms closely to desirable levels and which is well drained may produce significant cost advantages.

5.5.24 In areas where tropical diseases are endemic, airport planning should include the practical considerations whereby the possibility of disease vectors penetrating into aircraft is nil, taking into account internationally accepted mosquito flight ranges. Recommendations in this respect are specified in the World Health Organization's *Guide to Hygiene and Sanitation in Aviation* referring to vector control at airports. To keep the area within the perimeter of an airport free from *aëdes aegypti* in their larval and adult stages it is necessary to maintain active anti-mosquito measures within a protective area extending for a distance of at least 400 m around that perimeter. Water areas which cannot be eliminated and may breed mosquitos will need to be treated accordingly.

Soil and construction materials

5.5.25 Classification of natural soils at potential sites is important from a cost viewpoint. General soil surveys and sampling are necessary to allow the mapping of various soil types and to locate extensive areas of rock. The location of water supplies is also relevant because their availability and the distance over which they have to be carried will affect the cost of construction. Expert advice should be sought in these matters.

Services

5.5.26 Potential airport sites should, if possible, be adjacent to power and water supplies, sewage and gas mains, drainage and telephone lines, etc. Availability of these services may eliminate the need to provide them specifically for the airport and so reduce costs.

Land values

5.5.27 Airports require adequate space for future development and the value of land is a factor to be considered. In general the demand for air transport is related to the population it serves, and, as a result, a large proportion of future airport development work can be expected adjacent to metropolitan areas. With the growth of urban populations, rising standards of living and more extensive road systems, areas occupied by metropolitan districts will continue to expand. Land values generally increase significantly as areas change from rural to urban use so that early reservation of suitable sites will often enable airports to be better located and at lower costs.

5.5.28 Construction of new roads and utilities required for an airport often pass through, or adjacent to, unused land which then becomes attractive to develop. The number of personnel employed at larger airports creates a demand for housing and servicing industries which, if allowed to develop indiscriminately, could adversely affect the efficiency of the airport. When the suitability of a site is being considered, unless planning control over the area can be exerted to prevent its development for incompatible purposes, the question may arise whether adequate land for future development is available. Initial acquisition of all land considered necessary safeguards the possibility of future expansion and may often prove to be the cheapest course of action. However, simply comparing the estimated costs of purchasing land at the present and in the future ignores the important factor of time and is not a satisfactory basis for deciding whether to buy land in advance. Money paid immediately is worth more than money spent in the future because if expenditure is deferred, the money can be invested and produce an immediate return. A sound basis for decisions can be provided by converting future payments to a common time basis of present worth. Current land values and movements in property prices and the possibility of housing, industrial, agricultural or other developments which may increase values require consideration.

5.6 ENVIRONMENTAL STUDY

5.6.1 Environmental factors should be carefully considered in the development of a new airport or the expansion of an existing one. Studies of the impact of the construction and operation of a new airport or the expansion of an existing one upon acceptable levels of air and water quality, noise levels, ecological processes, and demographic development of the area must be conducted to determine how the airport requirements can best be accommodated.

5.6.2 Aircraft noise is the most severe environmental problem to be considered in the development of airport facilities. Much has been done to quiet engines and modify flight procedures, which has resulted in substantial reductions in noise. Another effective means for reducing noise is through proper planning of land use for areas adjacent to the airport. For an existing airport this may be difficult as the land may have already been built up. Every effort should be made to orient air traffic away from built-up areas.

5.6.3 Other important environmental factors include air and water pollution, industrial wastes and domestic sewage originating at the airport, and the disturbance of natural environmental values. An airport can be a major contributor to water pollution if suitable treatment facilities for airport wastes are not provided. The environmental study must consider how water pollution is to be overcome.

5.6.4 The construction of a new airport or the expansion of an existing one may have a major impact on the natural environment. This is particularly true for large developments where streams and major drainage courses may be changed, the habitats of wildlife disrupted, and wilderness and recreational areas reshaped. The environmental study should indicate how these disruptions might be alleviated.

5.7 REVIEW OF POTENTIAL SITES

At this stage, sufficient information should be available to reduce the number of sites to those meriting detailed consideration. At this point the planner should review the results of the office study and field investigation. Based on this review, sites which are unsuitable and which do not warrant further examination should be omitted.

5.8 PREPARATION OF OUTLINE PLANS AND ESTIMATES OF COSTS AND REVENUE

Consideration of the relative merits of the remaining sites requires:

— detailed site surveys, including obstacle surveys;

— preparation of outline airport layouts for each site;

— preparation of broad cost estimates covering the total capital and operating expenditure required including all associated off-airport items such as access roads, communications to population centres, planning control of surrounding areas and estimates of annual percentage changes in land values for the probable life of the airport; and the anticipated phasing of expenditure.

— when expansion or abandonment of existing sites is in question, the determination of the depreciated and current values of any existing installations together with the value of all other off-airport associated assets including easements, public utilities, noise zones, etc.

5.9 FINAL EVALUATION

5.9.1 At this stage when a number of alternative sites are under consideration, the question of cost plays a large part in the final choice. If all potential sites were of equal merit, logical decisions would be possible on the basis of least cost. Unfortunately, a clear-cut situation does not normally arise in practice and it is usually necessary for varying degrees of advantage and disadvantage to be weighed before reaching a decision. Economic factors are of great importance because the rate and pattern of growth of an economy are influenced not only by the level of capital investment but by the manner in which capital is used. Generally, capital is scarce and can be employed in a number of alternative ways. Capital can be wasted by diversion to uneconomic uses but when employed intelligently and efficiently, a lesser amount may achieve a given result.

5.9.2 The authority responsible for financing airport development may face at any time requests to increase expenditure for many other purposes. Whatever the intrinsic merit of individual projects when considered in isolation, the problem which often occurs is that not all proposals can be accommodated simultaneously within the over-all finances available. Proposals for expenditure on airports need to be considered on their own merits, but it may also be necessary to consider them against the relative merits of competing proposals. The need for cost effectiveness has led to increasing attention being given to the measurement and weighing of benefits and costs through the technique known as cost-benefit analysis. Cost-benefit studies endeavour to compare benefits from projects with their costs in a way which overcomes the difficulties associated with the time phasing of the project. By analysing the estimated stream of benefits and costs over the anticipated useful life of the airport it is possible to determine cost-benefit ratios which serve as a guide to the value of the project and the choice of the best site.

5.9.3 Two different types of cost-benefit analysis are necessary — an operational cost-benefit analysis and a social cost-benefit analysis. The final evaluation requires an assessment based on the comparison of operational, social and cost efficiencies:

Operational:

- land availability;
- airspace availability;
- effect of any restrictions on operational efficiency;
- potential capacity.

Social:

- proximity to demand centres;
- adequacy of ground access;
- potential noise problems;
- current land use and need for control measures.

Cost:

- cost-benefit analysis.

5.10 REPORT AND RECOMMENDATIONS

A comprehensive report supported by drawings, etc., should be prepared, containing:

1) the results of the site inspection and evaluation;

2) ranking of sites in order of merit, supported by reasons for selection; and

3) recommendations for further action.

References

Annex 10 — *Aeronautical Telecommunications.*

Annex 14 — *Aerodromes.*

Annex 16 — *Environmental Protection.*

Aerodrome Design Manual (Doc 9157).

Airport Services Manual (Doc 9137).

PANS-OPS — Aircraft Operations (Doc 8168).

"Airport Master Plans", U.S. Federal Aviation Administration, AC 150/5070-6A, June 1985.

"Airport Planning Manual", Part 2 — Land-Use and Environmental Control, ICAO Doc 9184, Second Edition, 1985.

"Planning and Design of Airports", 3rd Edition, Robert Horonjeff and Francis X. McKelvey, 1983, McGraw-Hill Book Company.

"Airplane Characteristics", Manuals published by all airframe manufacturers, detailing aircraft size, dimensions, operations, etc.

SECTION TWO — AIR SIDE DEVELOPMENT

INTRODUCTORY NOTES

Before plans can be developed for facilities for the many functional requirements which an airport has to meet, concepts for the various operational systems have to be considered and compared. At the earliest stage some concepts for individual systems may be incompatible but among those which are compatible the optimum combination can only be determined as the individual plans and the master plan develop in parallel.

The principal factors to be considered are outlined herein but some aspects of the plan may require more detailed and intensive study with reference to local conditions and other factors. Because of their physical characteristics and the land required and all the other factors which affect them and limit free choice of layout, runways and taxiways are the first to be considered. After determination of the dimensional criteria, pavement strength, and airfield capacity and configuration, other elements of the air side of the airport, namely, the apron and navigation and traffic control aids are covered in turn.

The forecasts will have indicated the rate of aircraft movements for which the airport should provide, the nature of the traffic, type of aircraft, and the other factors which have to be taken into account in planning the layout and dimensions of the runways, access taxiways, and aprons. When over-all layouts for runway and taxiway systems and aprons have been developed, all the possible primary schemes should be considered in conjunction with passenger and cargo buildings and aircraft maintenance areas so as to choose the best schemes and to identify the areas where compromise may be necessary to integrate the planning of the individual facilities.

Chapter 6. RUNWAYS AND TAXIWAYS

6.1 ABOUT THIS CHAPTER

6.1.1 The statement of policies and long-term forecasts provide a broad guide to identification of the facilities necessary to meet the future demands on the air transport system. Although the demand is defined basically in terms of passenger and cargo, it has to be expressed in various forms depending on the particular element of the airport under consideration. Considerations of airport layout are necessary to produce a framework to accommodate the major facilities required, including provision for their expansion. Schemes for an airport should be restricted to the optimum stage of development so that large additional costs are not incurred without producing comparable advantages. However, subject to this provision, planning should provide, unless there are good reasons to the contrary, for development up to the practical limit of capacity of an individual airport site.

6.1.2 Because of the large land area and airspace requirements, runways and their associated taxiways serve as a starting point for consideration of airport layout. They have to be planned, however, in relation to the other major operating elements such as passenger and cargo areas including aprons and buildings, vehicle parking, ground access and air traffic services, with the objective of maintaining all parts of the system in balance. This is a process requiring continuing reviews and adjustments in order to produce an airport configuration offering the maximum over-all efficiency. Since runways and taxiways are the least flexible of the airport elements, they are considered first.

6.1.3 A substantial body of information exists on the subject of planning and design of airport runways and taxiways. The information contained in this chapter serves the purpose of informing the airport planner on matters pertaining to dimensional criteria, pavement strength, runway length, and airport capacity. It illustrates the relationship and importance of these elements in the over-all airport master planning process. For more detailed information, the reader is referred to Annex 14 and the *Aerodrome Design Manual,* Parts 1 and 2.

6.2 RUNWAY AND TAXIWAY PHYSICAL CHARACTERISTICS

Dimensional Criteria

Runways

6.2.1 In order to provide a guide for airport planners and a certain amount of uniformity in airport landing facilities, criteria have been established by ICAO (Annex 14). Any criteria involving widths and gradients of runways and other features of the landing area must incorporate wide variations in aircraft performance, pilot technique, and weather conditions.

6.2.2 For the purpose of identifying standards for various sizes of airports and the functions they serve, reference codes have been developed. The intent of the reference code is to provide a simple method for interrelating the numerous specifications concerning design characteristics so as to provide a series of airport facilities that are matched to the aeroplanes that can operate on the runway. The basis for the code is the runway basic length, and wing span and wheel span of aircraft as shown in Table 6-1.

6.2.3 Runways are normally identified by the following principal elements:

a) the structural pavement which supports the aeroplane load;

b) the shoulders adjacent to the structural pavement, which are designed to resist erosion due to jet blast and to accommodate maintenance equipment and patrol;

c) the runway strip, which includes the structural pavement, shoulders, and an area that is cleared, drained, and graded. This area should be capable of supporting fire, crash, rescue, and snow removal equipment under normal conditions as well as providing support for aircraft in case they veer off the pavement;

Table 6-1. Aerodrome reference code

CODE ELEMENT 1		*CODE ELEMENT 2*		
Code number	*Aeroplane reference field length*	*Code letter*	*Wing span*	*Outer main gear wheel span*[a]
(1)	*(2)*	*(3)*	*(4)*	*(5)*
1	Less than 800 m	A	Up to but not including 15 m	Up to but not including 4.5 m
2	800 m up to but not including 1 200 m	B	15 m up to but not including 24 m	4.5 m up to but not including 6 m
3	1 200 m up to but not including 1 800 m	C	24 m up to but not including 36 m	6 m up to but not including 9 m
4	1 800 m and over	D	36 m up to but not including 52 m	9 m up to but not including 14 m
		E	52 m up to but not including 65 m	9 m up to but not including 14 m

a. Distance between the outside edges of the main gear wheels.

d) the blast pad, which is an area designed to prevent erosion of surfaces adjacent to the ends of runways which are subjected to sustained or repeated jet blast. This area is either paved or planted with turf;

e) the runway end safety area is an area intended to reduce accidents of aircraft undershooting or overrunning the runway. Some of the runway specifications adopted by ICAO are summarized in Table 6-2. For additional information the planner is directed to Annex 14 and the *Aerodrome Design Manual,* Part 1.

f) a stopway is an additional length of pavement which extends beyond the end of the runway. The stopway pavement must have adequate strength to support occasional aircraft loadings. The length of the stopway is not included in the published length of the runway; however, the airport authority can specify that the stopway may be used by aircraft operators to determine the allowable take-off mass for an aircraft. The additional take-off pavement length will permit aircraft operators to increase the take-off mass of aircraft by using the length of the runway plus the length of the stopway to calculate the total length of pavement available in the event of an aborted take-off. A detailed description of stopway requirements can be found in the *Aerodrome Design Manual,* Part 1.

g) A clearway is an unobstructed, unpaved area also beyond the end of the runway which is controlled and maintained by the airport authority. By designating an area off the end of the runway as a clearway an aircraft operator can increase the allowable take-off mass of an aircraft because the climb rate requirement of the aircraft can be reduced because the operator is assured that no obstructions exist in the clearway. A detailed description of clearway requirements can be found in the *Aerodrome Design Manual,* Part 1. It should be noted that the use of clearways and stopways in determining allowable take-off mass for an aircraft is not common operating procedure for most aircraft operators; however, they can be effective methods for increasing allowable take-off mass under certain conditions.

Table 6-2. Runway and runway strip specifications

	Code number			
	1	*2*	*3*	*4*
Width of runway				
Code letter A	18 m	23 m	30 m	—
Code letter B	18 m	23 m	30 m	—
Code letter C	23 m	30 m	30 m	45 m
Code letter D	—	—	45 m	45 m
Code letter E	—	—	—	45 m
Width of runway plus shoulders	Where the code letter is D or E, the over-all width of the runway and its shoulders shall not be less than 60 m			
Runway				
maximum longitudinal slope	1.5%	1.5%	1.25%	1.25%
maximum effective gradient	2%	2%	1%	1%
maximum longitudinal slope change	2%	2%	1.5%	1.5%
maximum transverse slope	2% where the code letter is A or B; and 1.5% where the code letter is C, D, or E			
Width of runway strip				
precision and non-precision runway	150 m	150 m	300 m	300 m
non-instrument runway	60 m	80 m	150 m	150 m
Strip				
maximum longitudinal slope	2%	2%	1.75%	1.5%
maximum transverse slope	3%	3%	2.5%	2.5%

Taxiways

6.2.4 Since the speeds of aircraft on taxiways are considerably less than on runways, dimensional criteria are not as stringent as for runways. Also the lower speeds permit the width of taxiways to be less than that of runways. Taxiway width standards are described in Table 6-3.

6.2.5 Taxiway shoulders are constructed because jet blast from taxiing aircraft cause the areas adjacent to the taxiways to erode. The requirement to build taxiway shoulders will depend on the frequency of jet operation, the condition of the soil, and the cost of maintaining the grass areas adjacent to the taxiways. More detailed discussion of taxiway shoulders can be found in Annex 14 and the *Aerodrome Design Manual,* Part 2.

6.2.6 The function of exit taxiways, or turnoffs, is to minimize runway occupancy time by landing aircraft. Exit taxiways can be placed at right angles to the runway or at some other angle. When the angle is 25 to 45 degrees, the term rapid exit taxiway is used to denote that it is designed for higher speeds than other exit taxiway configurations. It is important to provide a straight distance after the turn-off curve on a rapid exit taxiway to allow an exiting aircraft to come to a full stop clear of any intersecting taxiway or runway.

6.2.7 The location of exit taxiways depends on the mix of aircraft, the approach and touchdown speeds, the exit speed, the rate of deceleration, which in turn depends on the condition of the pavement surface (wet or dry) and the number of exits. The rapidity and the manner in which air traffic control can process arrivals is an extremely important factor in establishing the location of exit taxiways. The location of exit taxiways is also influenced by the location of the runways relative to the terminal area.

6.2.8 In over-all taxiway system planning efforts should be made to avoid unnecessary taxiing since this

Table 6-3. Taxiway width

Code letter	Taxiway width	Over-all width of taxiway and its shoulders
A	7.5 m	—
B	10.5 m	—
C	15 m if the taxiway is intended to be used by aeroplanes with a wheel base less than 18 m; 18 m if the taxiway is intended to be used by aeroplanes with a wheel base equal to or greater than 18 m	25 m
D	18 m if the taxiway is intended to be used by aeroplanes with an outer main gear wheel span of less than 9 m; 23 m if the taxiway is intended to be used by aeroplanes with an outer main gear wheel span equal to or greater than 9 m	38 m
E	23 m	44 m

Note.— Above figures are for straight portion of a taxiway.

increases taxiing time, fuel consumption and aircraft wear, and extremely long distances may result in dangerous high temperature tire conditions.

Pavement Strength

6.2.9 The operation of an aircraft cannot be undertaken with safety, in so far as ground handling is concerned, without full knowledge of the loading characteristics of the aircraft and the load bearing properties of the airport pavement on which it is to operate. The evaluation of pavements is a very complex process, with several possible analytical approaches; these are described in the *Aerodrome Design Manual,* Part 3.

Aircraft Characteristics, Performance and Runway Length

Aircraft characteristics

6.2.10 A general knowledge of aircraft is essential in planning facilities for their use. Aircraft used in airline operations have passenger capacities ranging from 20 to over 500. General aviation aircraft, on the other hand, are normally much smaller in size. In order to present a perspective of the variety of aircraft which make up the airline fleet, Table 6-4 summarizes their principal characteristics in terms of size, mass, capacity, and necessary runway length. The list is by no means complete, but it does include the principal aircraft in use. In a similar manner some typical general aviation aircraft (including those used for corporate purposes) are shown in Table 6-5. It is important to recognize that such items as operating mass empty, passenger capacity, and runway length can be approximated only in a very general way since there are many variables which can affect these items.

6.2.11 The characteristics shown in Tables 6-4 and 6-5 are important in the following manner for the design of airports:

a) *Mass.* Aircraft mass is important for determining the thickness of runway, taxiway, and apron pavements.

b) *Size.* The wingspan and the fuselage length influence the size of parking aprons which in turn influences the configuration of the passenger buildings. Size also dictates width of runways and taxiways as well as distances between these traffic ways.

Table 6-4. Characteristics of principal transport aircraft

Aircraft	Manufacturer	Wingspan (m)	Length (m)	Max. structural take-off mass (kg)	Max. landing mass (kg)	No. and type of engine[1]	No. of seats[2]
A-300	Airbus Industrie	44.83	54.08	165 000	138 000	2TF	267-375
A-310	Airbus Industrie	43.89	44.66	153 000	123 000	2TF	210-280
B707-120B	Boeing	39.88	44.22	116 727	86 183	4TF	137-174
B707-320B	Boeing	43.41	46.61	151 318	67 132	4TF	141-189
B720B	Boeing	39.88	41.68	106 277	79 379	4TF	131-149
B727-200	Boeing	32.92	46.69	76 657	68 039	2TF	134-163
B737-200	Boeing	28.35	30.48	45 586	44 452	2TF	86-125
B737-300	Boeing	28.88	32.18	61 220	51 700	2TF	122-149
B747SP	Boeing	59.64	53.82	294 835	204 117	4TF	288-364
B747-100B	Boeing	59.64	69.80	351 534	255 826	4TF	362-513
B747-300	Boeing	59.64	69.80	340 100	255 800	4TF	522-624
B747-400	Boeing	(62.)[3]	(69.8)[3]	(386 000)[3]	N.A.	4TF	N.A.
B757-200	Boeing	38.06	46.97	108 800	89 800	2TF	178-217
B767-200	Boeing	47.57	47.24	142 900	123 400	2TF	216-290
B767-300	Boeing	47.57	54.94	159 210	136 070	2TF	254-312
BAC 111-200	BAC[4]	26.97	28.19	35 834	31 298	2TF	65-79
BAe 146-100	BAe	26.34	26.19	37 308	32 817	4TF	82-93
BAe 146-200	BAe	26.34	28.60	40 579	35 154	4TF	82-109
Caravelle-B	Aerospatiale	34.29	32.99	56 001	49 501	2TF	86-104
Concorde	BAC Aerospatiale	25.55	61.65	176 447	108 862	4T	108-128
Dash 7	De Havilland Canada	28.35	24.58	19 958	19 051	4TP	48-52
DC-10-10	Douglas	47.35	55.55	195 045	164 881	3TF	270-345
DC-10-30/40	Douglas	50.39	55.35	251 744	182 798	3TF	270-345
DC-8-61/71	Douglas	43.41	57.12	147 418	108 862	4TF	196-259
DC-8-62/72	Douglas	45.23	46.18	158 757	108 862	4TF	189
DC-8-63/73	Douglas	45.23	57.12	161 025	117 027	4TF	196-259
DC-9-32	Douglas	28.44	36.37	48 988	44 906	2TF	115-127
DC-9-50	Douglas	28.44	40.23	54 431	49 895	2TF	130
F-27-500	Fokker	29.00	25.06	20 412	19 051	2TP	52-60
F-28-6000	Fokker	25.07	27.40	33 112	31 300	2TF	65-85
Ilyushin-62	USSR	43.21	53.11	161 937	105 233	4TF	168-186
L-1011	Lockheed	47.35	53.75	195 045	162 386	3TF	256-330
MD 81	Douglas	32.87	45.06	63 503	58 060	2TF	115-172
MD 82	Douglas	32.87	45.06	67 812	58 967	2TF	115-172
MD 83	Douglas	32.87	45.06	72 575	63 276	2TF	155-172
MD 87	Douglas	32.87	39.75	63 503/67 812*	58 060/58 967*	2TF	109-130
Mercure	Dassault	30.53	33.99	52 000	49 002	2TF	124-134
Super VC-10	BAC[4]	42.67	52.32	151 953	107 501	4TF	100-163
Trident 2E	Hawker Siddley	29.87	34.98	65 091	51 256	3TF	82-115
Tupolev-154	USSR	37.54	47.90	90 000	84 000	3TF	128-158

1. T = turbojet; TF = turbofan; TP = turboprop
2. Approximate number of seats; depends on seating configuration and location of galleys
3. Preliminary figures only
4. British Aircraft Corporation

* Optional

Table 6-5. Characteristics of general aviation and commuter aircraft

Aircraft	Wingspan (m)	Length (m)	Max. take-off mass (kg)	Max. no. of seats[1]	No. and type of engine[2]	Runway length[3] (m)
Beech 23-Musketeer(s)	9.98	7.62	997.90	4	1P	420
Beech V35-Bonanza	10.19	8.03	1 542.21	6	1P	400
Beech 58-Baron	11.53	9.07	3 073.09	6	2P	725[4]
Beech B80-Queen Air	15.32	10.82	3 991.61	11	2P	550
Beech B200-Super King Air	16.61	13.34	5 670.00	15	2TP	867[4]
Beech Model 1 900	16.61	17.63	7 530.00	21	2TP	994
Bellanca 260C	10.41	6.99	1 360.78	4	1P	305
Cessna 150	9.96	7.01	725.75	2	1P	420
Cessna 172 Skyhawk	10.90	8.20	1 043.26	4	1P	465
Cessna 180 Skylane	10.92	8.53	1 338.10	4	1P	410
Cessna T310	11.25	8.99	2 494.76	6	2P	545
Cessna Conquest II	15.04	11.89	4 468.00	11	2TP	751
Cessna Citation III	16.31	16.90	9 525.00	11	2TF	1 435
Dassault-Jet Falcon 20T	16.54	18.29	13 199.54	28	2TF	1 350
Gulfstream II	20.98	24.36	26 081.56	22	2TF	1 240
Lear Jet 25	10.85	14.50	6 803.89	8	2T	1 580
Lockheed Jet Star	16.59	18.42	19 050.88	12	4T	1 490
North American Sabreliner-60	13.54	14.73	9 071.85	12	2T	1 485
Piper PA-23-250 Aztec	11.33	9.22	2 358.68	6	2P	380
Piper PA180 Cherokee Archer	9.75	7.32	1 110.00	4	1P	495
Piper PA-28R-201 Cherokee Arrow III	10.67	7.62	1 247.00	4	1P	488
Piper Twin Comanche C	10.97	7.67	1 632.93	6	2P	570
Piper PA-31T2	12.40	11.18	4 297.00	8	2TP	896
Piper PA-42	14.53	13.23	5 080.00	11	2TP	928[4]
Piper T 1040	12.52	11.18	4 082.00	11	2TP	808

1. Number of seats includes pilot
2. P = piston engine; T = turbojet; TF = turbofan; TP = turboprop
3. Maximum distance in nearest 5 m to reach height of 15 m for take-off or land from height of 15 m
4. Landing length governs

c) *Capacity.* The passenger capacity has an important bearing on facilities within and adjacent to the passenger building.

d) *Runway length.* The length of runway influences a large part of the land area required at an airport. The lengths provided in Tables 6-4 and 6-5 are only approximate. For more precise values appropriate references listed at the end of this chapter should be consulted. It is also of utmost importance to determine specific air carrier requirements at the earliest possible date.

6.2.12 An examination of Tables 6-4 and 6-5 reveals the following. Maximum take-off mass of principal airline aircraft varies from 33 000 to 351 000 kg. For small general aviation aircraft the range in mass is from 900 to 3 600 kg, while corporate aircraft vary from 6 800 to 25 800 kg. The maximum number of passengers carried by airline aircraft varies from 20 to over 500. On the other hand, small general aviation aircraft seat from 2 to 6 people, and corporate aircraft from less than 10 to nearly 30 persons depending on the configuration of the interior. Runway lengths for typical airline aircraft vary from 2 100 to 3 600 m, but it is important to note that it is not valid to assume that the larger the mass of an aircraft, the longer the runway length required. For large aircraft, especially, the trip length has an influence on take-off mass and also the required runway length. Therefore in the analysis of runway length requirements, an estimate of trip length is very important. Runway lengths for small general aviation aircraft seldom exceed 600 m, while for corporate aircraft they are about 1 500 m.

6.2.13 In Tables 6-4 and 6-5, aircraft are referred to according to the type of propulsion and thrust-generating medium. The term "piston engine" applies to all propeller-driven aircraft powered by gasoline-fed reciprocating engines. Most small general aviation aircraft are powered by piston engines. The term "turboprop" refers to propeller-driven aircraft powered by turbine engines. A few twin-engine general aviation aircraft and a few of the earlier airline aircraft are powered in this manner. The term "turbojet" has reference to those aircraft which are not dependent on propellers for thrust, but which obtain the thrust directly from a turbine engine. The early jet airline aircraft, particularly the Comet, B707 and DC-8, were powered by turbojet engines, but these were discarded in favour of turbofan engines principally because the latter are far more economical. When a fan is added in the front or rear of a turbojet engine, it is referred to as a "turbofan". Most fans are installed in front of the main engine. A fan can be thought of as a small-diameter propeller driven by the turbine of the main engine. Nearly all airline transport aircraft are now powered by turbofan engines for the reason just cited.

Aircraft performance

6.2.14 The factors which have a bearing on runway length may be grouped into three general categories:

1) performance requirements imposed by the government on aircraft manufacturers and operators;

2) environment at the airport;

3) those items which establish the operating take-off and landing gross mass for each aircraft type.

6.2.15 Certain conditions at the airport also influence runway length. The more important of these conditions are:

a) *Temperature.* The higher the temperature, the longer the runway required because high temperatures reflect lower air densities, resulting in lower output of thrust. For a more detailed discussion of temperature effect on aircraft performance and definition of "aerodrome reference temperature" refer to Annex 14 and the *Aerodrome Design Manual,* Part 1.

b) *Surface wind.* The greater the headwind down a runway the shorter the length, and conversely, a tailwind increases the length of runway required. For airport planning purposes, it is desirable to use no wind, particularly if only light winds occur at the airport site.

c) *Runway slope.* An uphill gradient requires more runway length than a level or downhill gradient; the specific amount depends on the elevation of the airport and the temperature. Reference should be made to the average correction factors in Annex 14. For airport planning purposes only, Annex 14 uses an "average longitudinal slope" defined as the difference in elevation between the highest and lowest points on the actual runway centre line divided by the length of the runway.

d) *Airport altitude.* All other things being equal, the higher the altitude of the airport, the longer the runway required. For planning purposes an increase from sea level of 7 per cent/300 m of altitude will suffice for most airport sites except those that experience very hot temperatures or are located at high altitudes.

e) *Condition of the runway surface.* A contaminated runway surface will increase the length of runway required for take-off or landing. The specific amount depends on the type of contaminant. A study of the climatological condition will indicate whether water, snow, slush, ice, etc. may be expected to be frequently found on a runway.

How much these conditions affect runway length can only be approximated; however, "orders of magnitude" can be beneficial for planning and are therefore presented in that context.

Runway length determination

6.2.16 Compute runway length at airport "A" based upon an aircraft flight from airport "A" to airport "B" as follows:

1) obtain operating mass empty of aircraft;

2) determine payload;

3) determine fuel reserve;

4) add items 1), 2) and 3). This is the landing mass of the aircraft at city B. This mass should not exceed the maximum structural landing mass of the aircraft;

5) compute fuel requirements for climb, cruise, and descent;

6) the take-off mass of the aircraft is obtained by adding item 5) to item 4). This should not exceed the maximum structural take-off mass of the aircraft;

7) determine temperature, surface wind, runway slope, and altitude at airport of departure;

8) with the data outlined in items 6) and 7), and by using the approved flight manual for the specific aircraft, determine the runway length.

These steps can be illustrated by an example using a Boeing 707-320B for a 3 000 nautical mile trip between airport "A" and airport "B", under the following assumed conditions:

Cruise altitude	9 450 m
En-route, climb, and descent	standard conditions
Headwind in cruise	37 km/h (20 kt)
Speed	0.82 Mach
Airport altitude	sea level
Airport surface wind	zero
Runway slope	level
Airport temperature	16°C
Operating mass empty	61 235 kg
Payload	16 330 kg
Fuel reserve	5 443 kg

Step 1 The operating mass empty is 61 235 kg.

Step 2 The payload is 16 330 kg.

Step 3 The fuel reserve is 5 443 kg.

Step 4 The landing mass is 61 235 + 16 330 + 5 443 = 83 008 kg. It does not exceed the maximum structural landing mass which is 97 522 kg.

Step 5 Fuel required to climb to cruise altitude is equal to 4 560 kg; to descend to the airport, 545 kg; and to cruise at an altitude of 9 450 m at a speed of Mach 0.82, 34 020 kg. Total fuel burnout is then equal to 4 560 + 34 020 + 545 = 39 125 kg.

Step 6 The take-off mass is equal to 83 008 + 39 125 = 122 133 kg. This does not exceed the maximum structural take-off mass, which is 151 317 kg.

Step 7 The airport conditions are listed in the statement of the problem.

Step 8 Using the approved flight manual for the Boeing 707-320B (advanced), check if the climb-limited mass is less than 122 133 kg. In this case it is not and one can determine the runway length using the airport conditions cited in the problem. The required runway length is 2 135 m.

6.3. AIRPORT CAPACITY

6.3.1 The Federal Aviation Administration (FAA) has a procedure to compute airport capacity and aircraft delay for airport planning and design. It defines "capacity" as the throughput rate, i.e. the maximum number of operations that can take place in an hour, and "delay" as the difference in time between a constrained and an unconstrained aircraft operation. These definitions take into account that delays occur because of simultaneous demands on the facility. The acceptable level of delay will vary from airport to airport.

Background

6.3.2 The throughput method for calculating airport capacity and average delay per aircraft is derived from computer models used by the FAA to analyse airport capacity and reduce aircraft delay. Calculations of hourly capacity are needed to determine average delay. Since airport and airport component hourly capacities vary throughout the day due to variations in runway use, aircraft mix, ATC rules, etc., a number of calculations may be needed. Figure 6-1 provides the ranges of hourly capacity and annual service volume for different runway use configurations. The values vary within each range depending on the aircraft mix, percentage of arrivals, visibility, etc. for each runway use configuration. For details refer to FAA Advisory Circular "Airport Capacity and Delay".

Runway Capacity

6.3.3 The annual capacity of a single runway airport configuration could exceed 195 000 operations with suitable taxiway, apron and air traffic control facilities. An airport runway system that is primarily used by locally based aircraft will probably not attain an annual demand of more that 150 000 operations if its based aircraft total is less than 200. However, the development of an additional runway based on capacity requirements may be considered for airports with a current demand level below 150 000, if traffic is increasing. Besides the capacity requirements, importance of the airport to the community it serves (e.g. airport for State capital) may warrant an additional runway to avoid total airport closure in case of accident, runway repair, snow removal, partial unlawful seizure of an airport, etc.

6.3.4 The following criteria may be used to determine the need for an additional runway to increase capacity:

a) a parallel runway may be planned when the demand is forecast to reach the existing runway capacity during the ensuing five years;

b) a short parallel runway may be justified at an airport forecast to have, within five years, a demand greater than 60 per cent of existing runway capacity. Taxiing distances between the new runway and the terminal area must be favourable. Otherwise the extra long taxiing distances will result in reduced demand for the new runway. A "short" parallel runway should be long enough and wide enough to provide sufficient capacity so that additional construction for capacity purposes due to changes in airport population would not be required within five years;

c) a short parallel runway to serve small aircraft may be planned for an airport having 75 000 operations consisting of 30 000 or more transport type aircraft;

d) when demand reaches or is expected to reach 75 per cent or more of the capacity of the existing parallel runway configuration within five years, a short parallel runway can be extended to increase capacity;

e) although intersecting or open V runways are not generally recommended for the purpose of increasing capacity, consideration of terrain, noise, obstacles may make these layouts more practical. It should be shown that the configuration chosen will provide sufficient runway capacity to accommodate demand into the foreseeable future or will provide a substantial increase in runway capacity at a much reduced cost compared to a parallel runway. A comparison of capacities with a parallel runway configuration should be made.

Taxiway Capacity

6.3.5 The addition of taxiway facilities to the runway configuration increases airport operational efficiency by allowing the runway to realize its maximum capacity potential.

a) A stub taxiway to the apron and turnaround pads or turnarounds at both ends of the runway are recommended for the minimum taxiway system.

b) Parallel taxiways may be justified when any one of the following criteria is forecast to be reached within five years. (The normal peak hour referred to below is the peak hour of the week averaged for one year; however, as applied to instrument approaches it is the average of the highest 10 per cent of the hours during which time instrument approaches are being made):

1) there are four instrument approaches (those which are counted toward annual instrument approaches) during the normal peak hour;

2) the annual operations total 50 000;

3) the normal peak hour itinerant operations total 20; or

4) the hourly total (itinerant plus local) operations are:

— 30 operations per normal peak hour — for runways serving more than 90 per cent small aircraft and where there are less than 20 per cent touch and go operations; 40 operations per normal peak hour where there are more than 20 per cent touch and go operations (each touch and go is considered two operations).

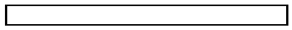
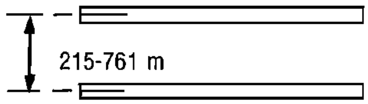
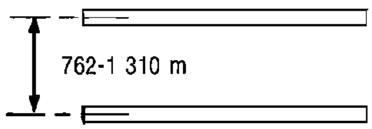
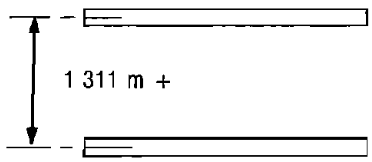
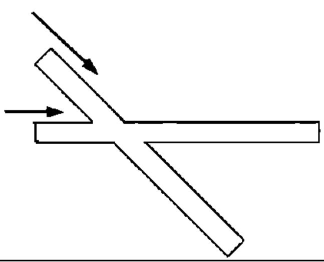
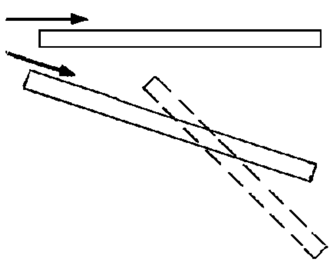
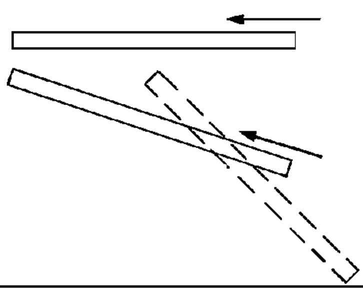
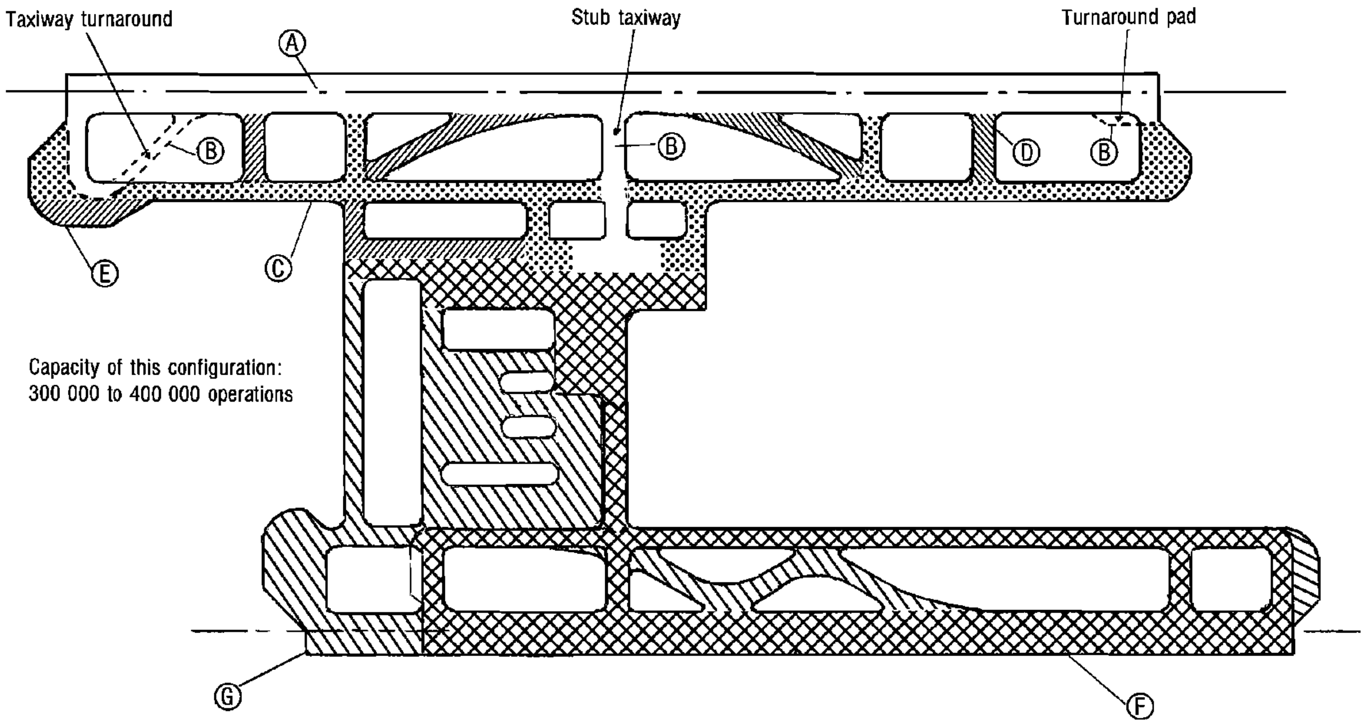
Number	Runway use configuration	Hourly capacity ops/h		Annual service volume ops/h
		VFR	IFR	
1		51-98	50-59	195 000-240 000
2		94-197	56-60	260 000-355 000
3		103-197	62-75	275 000-365 000
4		103-197	99-119	305 000-370 000
5		72-98	56-60	200 000-265 000
6		73-150	56-60	220 000-270 000
7		73-132	56-60	215 000-265 000

Figure 6-1. Hourly capacity and annual service volume for long-range planning



ITEM	LOCATION OF CRITERIA
	SECTION
A	6.3.2
B	6.3.5 a)
C	6.3.5 b)
D	6.3.5 c)
E	6.3.5 d)
F	6.3.4 a) to c)
G	6.3.4 d)

LEVEL AT WHICH TO BUILD

- Up to 20 000 to 30 000 operations
- 30 000 to 60 000 operations
- 50 000 to 99 000 operations
- 75 000 to 150 000 operations
- 150 000 to 250 000 operations

* The above ranges represent activity levels typical of values that would be obtained by use of these instructions. Although computed values would most likely fall in these ranges, this tabulation does not represent criteria.

Figure 6-2. Typical phased development sketch

— 30 operations per normal peak hour — for runways serving 60 per cent to 90 per cent small aircraft.

— 20 operations per normal peak hour — for runways serving 40 per cent to 100 per cent large aircraft.

Parallel taxiways provide safety benefits in addition to increased efficiency. These safety benefits cannot be easily assessed. However, the criteria given are based on having stage development following the construction of taxiway turnarounds.

If the construction cost of a parallel taxiway does not exceed the cost of turnarounds by more than one third, it should be the preferred development. A partial parallel taxiway, or equivalent (as can be obtained by intersecting runways), provides satisfactory efficiency as well as safety to aircraft operations. In many instances, adequate capacity can be attained by the construction of a partial parallel taxiway. This solution can prove especially desirable where construction costs are high. A partial parallel is generally economically justified at activity levels equal to 60 per cent of the values given for full parallel. If a full or partial taxiway is strongly preferred over taxiway turnarounds it may be planned if current operations are 20 000 per year, if there are no turnarounds existing, and if cost is less than half the average costs.

c) Exit taxiways beyond a basic layout of one at the runway ends and one in between are usually justified if demand is forecast to exceed 40 per cent of the runway capacity providing taxiway costs are average, and at 75 per cent of capacity if costs are high. A sufficient number of exits should be planned so that additional exits would not be required within five years following the completion of construction.

d) Holding bays and by-pass taxiways enhance airport capacity. These facilities seldom, if ever, constitute restraints on the attainment of full airport capacity within the existing airport property since land areas are normally always available to permit their construction. However, the need for these facilities should be determined sufficiently in advance to prevent delays that would occur due to a lack of these facilities. The following criteria should be applied in determining the need for holding bays and by-pass taxiways, once a parallel taxiway has been justified.

When activity is forecast to reach 30 total operations per normal peak hour, or 20 000 annual itinerant operations or 75 000 total operations, a holding bay should be planned, giving due consideration to other factors. These factors are:

1) Mixture of types of aircraft such as air carrier or military aircraft operations simultaneously with general aviation aircraft.

2) The airport layout (i.e. from the standpoint of "as built" conditions).

3) Location of navigation aids (i.e. the critical area surrounding a NAVAID — existing or proposed — in relation to possible holding bay locations).

There is insufficient economic justification for construction of a holding bay to accommodate fewer than two aircraft. Also provision for more than four aircraft is not usually justified. If the traffic density is such that more than four holding positions appear necessary, investigation will generally disclose that another solution to the problem is in order.

6.4. TYPICAL PHASED DEVELOPMENT PLAN

Figure 6-2 shows a typical phased development plan for an airport that may be obtained by the use of the concepts and methodology presented in this section. A cross reference, locating the type of development with the applicable criteria, is also presented on this diagram.

References

"Planning and Design of Airports", Third Edition, Robert Horonjeff and Francis X. McKelvey, 1983 — McGraw-Hill Book Company.

"Airport capacity and delay", U.S. Federal Aviation Administration, AC 150/5060-5, 1983.

Annex 14 — *Aerodromes.*

Aerodrome Design Manual (Doc 9157).

Chapter 7. APRONS

7.1 ABOUT THIS CHAPTER

An apron is defined as an airside area on an airport intended to accommodate aircraft for purposes of loading or unloading passengers, mail or cargo, fuelling, parking, or maintenance. Aprons can be classified according to their main purpose and function. This chapter describes characteristics of various types of aprons and aspects related to their planning. Not all of the apron types presented here are required for every airport but the need for them and their size should be estimated based on the type and volume of forecast traffic at the airport. Besides aircraft stands, the associated apron taxiways, apron service roads and parking for ground service equipment should all be included as a part of an apron system. Further guidance related to aprons is given in 9.8 and 10.6, since aprons are only a part of the over-all terminal complex. Other useful references are listed at the end of this chapter.

7.2 PLANNING PARAMETERS

Apron Siting

7.2.1 Aprons are interrelated with the terminal complex, and should be planned in connexion with terminal buildings to achieve an optimum solution; the following are general objectives to be considered in siting aprons in the master plan:

a) provide minimum taxiing distances between runways and aircraft stands (savings in fuel, time and maintenance);

b) allow for freedom of aircraft movement to avoid unnecessary delay (punctuality of scheduled flights);

c) reserve sufficient area for future expansion and change of technology;

d) achieve maximum efficiency, operational safety and user convenience of each apron complex and the airport as a total system; and

e) minimize adverse effects such as engine blast, noise, air pollution, etc. on the apron and the surrounding environment.

Apron Sizing

7.2.2 The planning of a particular apron depends on its purpose and function. However, basic parameters to be considered are as follows:

a) number of aircraft stands required at present and in the future;

b) aircraft mix, both present and future;

c) aircraft dimensions and manoeuvring capabilities*;

d) aircraft parking configuration including shape of terminal and the surrounding area available for development*;

e) clearance requirements between aircraft and aircraft, buildings or other fixed objects*;

f) method of aircraft guidance onto the aircraft stand*;

g) aircraft ground servicing requirements (vehicles versus fixed servicing installations, etc.)*; and

h) taxiways and service roads*.

Aircraft Parking Configuration

7.2.3 This subject is related to the method by which the aircraft will enter and leave the aircraft stand, e.g. either under its own power (self-manoeuvring) or taxies in and is pushed out (tractor assisted). The different aircraft parking configurations are shown in Figure 7-1 and the main advantages and disadvantages of each configuration are given in Table 7-1. As a general rule, nose-in parking configurations are common at high traffic airports where the tractor cost is justified by more efficient use of limited apron area. Other parking configurations are employed at

* Details are provided in the *Aerodrome Design Manual,* Part 2.

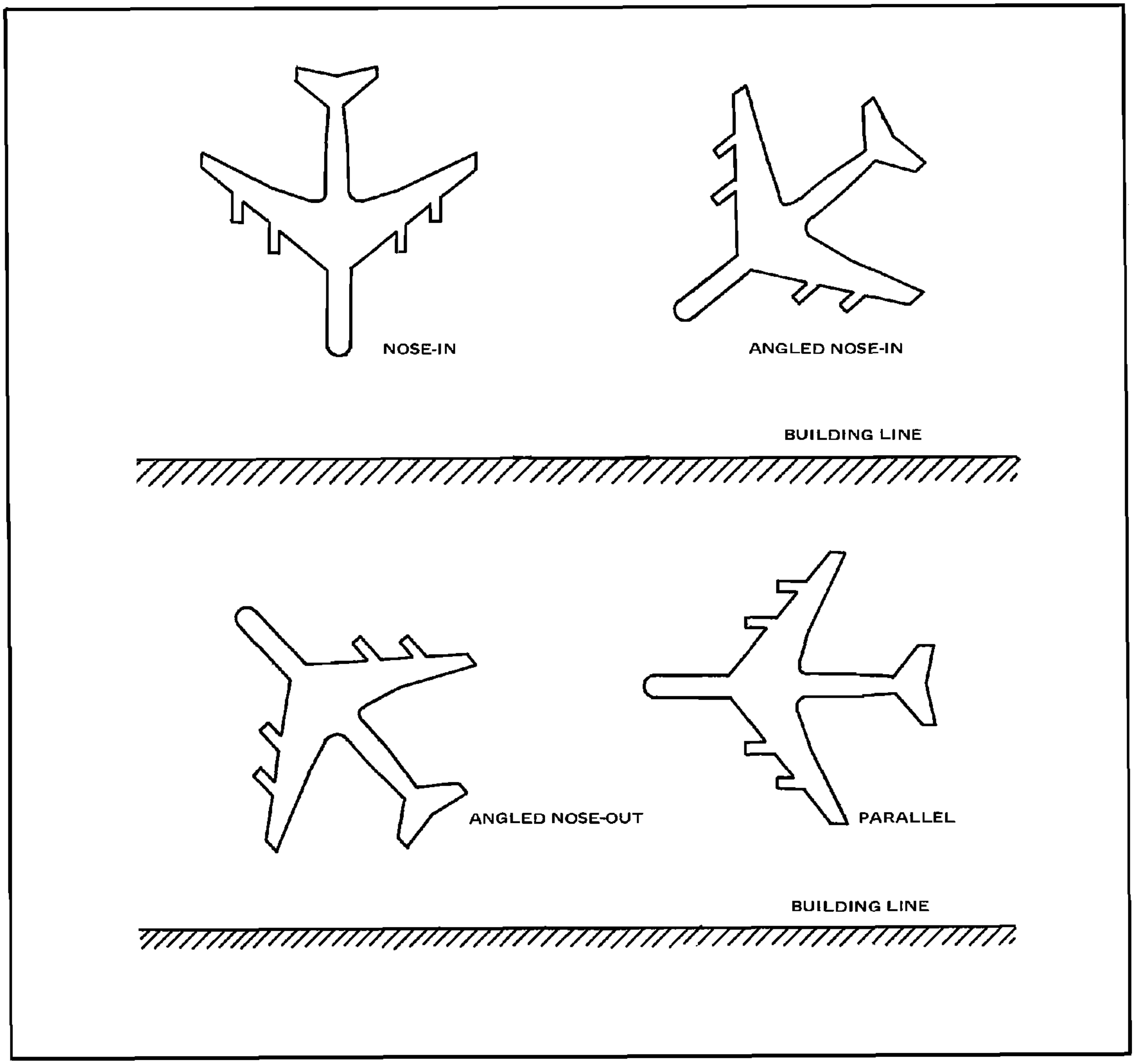


Figure 7-1. Parking configurations

Table 7-1. Comparison of different aircraft configuration

	Nose-in (taxi in and push out)	*Angled nose-in (in/out by own power)*	*Angled nose-out (in/out by own power)*	*Parallel (in/out by own power*
Advantages	Requires smallest stand area for given aircraft The effects of jet blast on equipment, personnel and terminal are substantially less Reduces aircraft service time as ground equipment can be positioned prior to aircraft arrival and fewer removal requirements at aircraft departure Easy to employ passenger loading bridge	No requirement for tractor	No requirement for tractor	Easiest manoeuvring for aircraft to taxi in/out No requirement for tractor
Disadvantages	Requires tractor for push-out operation Push-out operation requires time and skilled operator	Requires larger apron area than nose-in configuration Relatively severe engine blast and noise is directed at terminal	Requires larger apron area than angled nose-in configuration Breakaway engine blast and noise are directed at terminal	Requires largest apron area for given aircraft Limits aircraft servicing activity at neighbouring stand when aircraft taxi in and out

low traffic airports where it is difficult to offset the tractor operation cost by savings in apron size. As the amount of apron area required for a particular aircraft varies largely with the parking configuration, and passenger/cargo handling concepts are greatly interrelated with aircraft parking configuration, the issue of preferred aircraft parking configuration must be resolved at an early stage.

7.2.4 Particularly for a passenger terminal apron, a nose-in parking configuration coupled with passenger loading bridges affords advantages as follows:

a) less apron area required;

b) less aircraft ground time due to:

— efficient passenger handling;

— more efficiently positioned ground servicing equipment;

c) service road can be sited so as to reduce requirements to drive on apron;

d) better passenger handling in terms of safety, convenience and comfort since passengers are free from apron walking, climbing up/down stairs and adverse weather effects such as rain, snow, wind, heat, etc.;

e) substantially less adverse effects of jet blast noise and fumes of engines on ground equipment, personnel and terminal facilities; and

f) greater security control of passengers on air side.

On the other hand, it involves additional costs for purchasing and operating tractors and passenger loading bridges.

The world trend is towards nose-in/push-out configuration with passenger loading bridges at high traffic volume airports. Although many of the advantages are difficult to quantify in terms of money, first consideration should be given to adopting the nose-in/push-out configuration if the anticipated annual passenger volume is greater than two to three million.

7.3 PASSENGER TERMINAL APRON

Required Number of Aircraft Stands

7.3.1 The number of aircraft stands at a passenger terminal apron depends on passenger aircraft movements by aircraft type during the peak hour and their gate occupancy time. As the number of stands dictates apron size and very often the terminal configuration, it is one of the most important aspects of master planning. The required number of aircraft stands should be estimated for the short, medium and long term and an orderly and timely development scheme prepared. Staged expansion of the apron should be planned when appropriate but such requirements may vary. For example, in planning medium-term requirements, it may happen that despite an increased volume of passengers the estimated number of required aircraft stands may remain the same due to the introduction of larger aircraft. In such a case, it may be wise to construct a larger apron during the initial stage.

7.3.2 The peak hour passenger aircraft movements by aircraft type may be estimated by the two procedures shown in Figure 7-2. The ratios of aircraft peak day/hour movements should be derived from past records as well as by taking into consideration factors particular to local conditions. It may be useful to consider separately the requirements for domestic and international passenger traffic, or for national and foreign carriers. Special consideration may be needed for seasonal peaks by tourists or pilgrims (scheduled versus non-scheduled flights). Another important aspect of this ratio is that the greater the traffic volume the smaller the peak ratio in general. Thus it may be useful to study other airports with similar traffic characteristics.

7.3.3 Forecasting the future aircraft mix is a difficult task and should be done by studying world trends and consulting airport user airlines to arrive at the best estimate.

7.3.4 The gate occupancy time is the time for an aircraft to manoeuvre in and out of an aircraft stand, load and unload passengers, baggage and cargo, refuel, perform cabin cleaning, and receive various routine services and minor repairs. The gate occupancy time varies depending on aircraft size, flight type such as domestic or international, and station type such as originating/terminating, through, or transfer/transit stations (see 9.2.21 to 9.2.31). One typical example of the gate occupancy time is shown in Table 7-2.

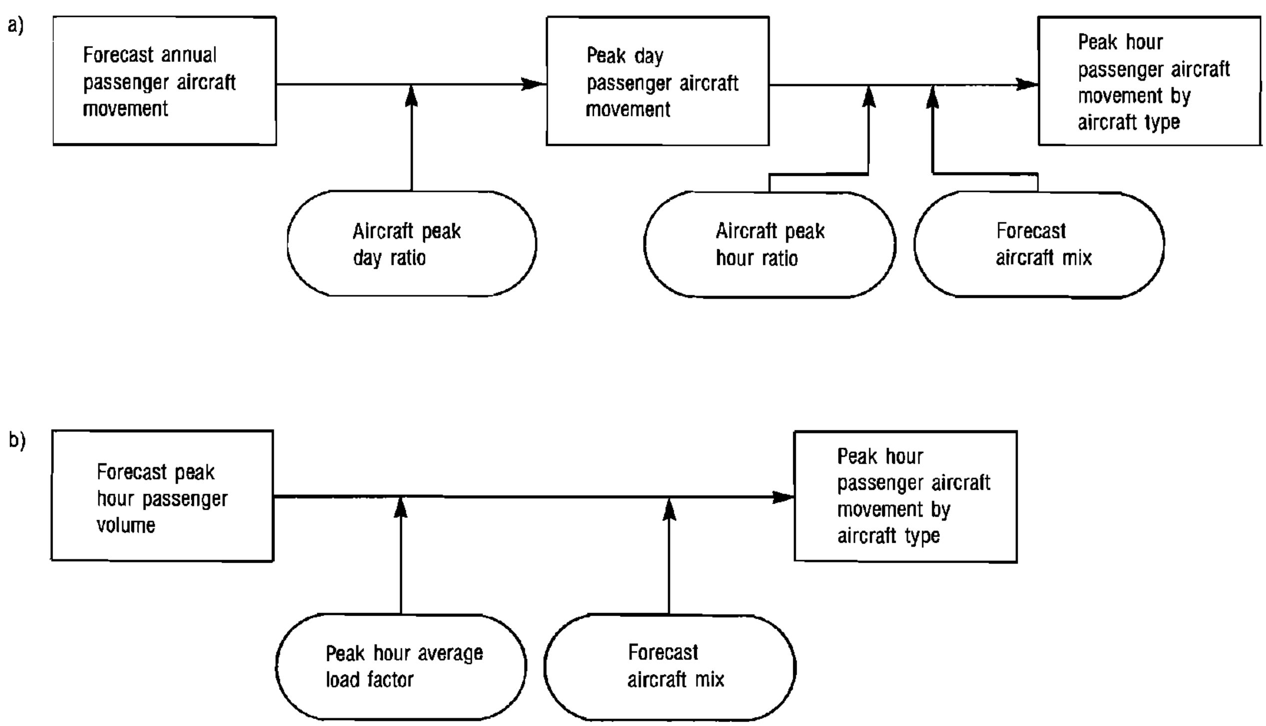


Figure 7-2. Peak hour passenger aircraft movements

7.3.5 The next step is to categorize present and future aircraft serving at the airport into groups according to their required stand size. Since the purpose of categorization is to enable common use of a particular stand by different aircraft types, consideration should also be given to the common use of the fixed apron facilities such as passenger loading bridges, hydrant systems, etc. An example of categorization is given in Table 7-3.

7.3.6 The required number of aircraft stands at a passenger terminal may be estimated by the following formula:

$$S = \Sigma\left(\frac{T_i}{60} \times N_i\right) + \alpha$$

where S = required number of aircraft stands

T_i = gate occupancy time in minutes of aircraft group i

N_i = number of arriving aircraft group i during peak hour

α = number of extra aircraft stands as spare.

7.3.7 The number of arriving aircraft can be obtained either by simply dividing the previously calculated passenger aircraft movement by two or by applying a heavy direction factor particular to the airport, which may be in the order of 0.6 to 0.7. This value of 0.6 to 0.7 means that arriving aircraft represent 60 to 70 per cent of the total peak hour arriving and departing aircraft movements.

Table 7-2. Typical gate occupancy time (in minutes)

	Domestic		*International*
Aircraft	*Through flight*	*Turnaround flight*	*Turnaround flight*
B-737, DC-9, F-28	25	45	—
B-707, B-757	45	50	60
A300, DC-10, L-1011	45-60	60	120
B-747	—	60	120-180

Table 7-3. Example of aircraft categorization

Group	*Aircraft*
S	F-28, B-737
M	B-707-320, A-300, L-1011, DC-10
L	B-747 SP, B-747
LL	B-747 II (future aircraft)

When the airport is planned to have different passenger terminals dedicated exclusively for domestic, national flag carrier international and foreign carriers, the above-mentioned formula should be applied individually for each case.

Apron/Terminal Relationships

7.3.8 As previously mentioned, apron arrangements are directly interrelated with the passenger terminal concept. Details of various passenger terminal concepts are described in 9.2.37. This section presents various concepts pictorially in Figure 7-3 and briefly describes the characteristics of each concept from the viewpoint of the apron.

a) *Simple concept.* To be applied at low traffic volume airport. Aircraft are normally parked either angled nose-in or nose-out for self taxi-in or taxi-out. Consideration should be given to providing adequate clearance between apron edge and terminal frontage facing air side to reduce the adverse effects of jet engine blast. Where this is not done, jet engine blast fences should be provided. Apron expansion can be done incrementally in accordance with demands, causing little disruption of airport operation.

b) *Linear concept.* This concept may be regarded as one of the advanced stages of a simple concept. Aircraft can be parked in an angled or parallel parking configuration. However, nose-in/push-out parking configuration with minimum clearance between apron edge and terminal becomes more common in this concept for more efficient utilization of apron space and handling of aircraft and passengers. Nose-in parking affords relatively easy and simple manoeuvring for aircraft taxiing in to gate position. Push-out operations cause little disruption of apron activities in neighbouring gate positions. However, towing tractors and skilled operators are required. At busy traffic airports, it may become necessary to provide double apron taxiways to lessen the blocking of the taxiway by push-out operations. The corridor between the apron edge and terminal frontage can be used for circulation of apron traffic and the area around the nose of the parked aircraft can be used for ground service equipment parking slots. When apron depth is planned from the outset to cater to the longest fuselage length, the linear concept has as much flexibility and expansibility as the simple concept and almost as much as the open apron concept.

c) *Pier (finger) concept.* As seen in Figure 7-3, there are several variations of this concept, according to the shape of the pier. Aircraft can be parked at gate positions on both sides of the piers, either angled, parallel or perpendicular (nose-in). Where there is only a single pier, most advantages of the linear concept would apply for air side activities except for a limited incremental expansion capability. When there are two or more piers, care must be taken to provide proper space between them. If each pier serves a large number of gates, it may be necessary to provide double taxiways between piers to avoid conflicts between aircraft entering and leaving the gate positions.

d) *Satellite concept.* The satellite concept consists of a satellite unit, surrounded by aircraft gate positions, separated from the terminal. The passenger access to a satellite from the terminal is normally via an underground or elevated corridor to best utilize the apron space, but it could be on the surface. Depending on the shape of the satellite, the aircraft are parked in radial, parallel or some other configuration around the satellite. When aircraft are parked radially, which used to be common, push-back operation is easy but requires larger apron space. If a wedge-shaped aircraft parking configuration is adopted, it not only requires unfavourable sharp turns taxiing to some of the gate positions but also creates traffic congestion of ground service equipment around the satellite.

e) *Transporter concept.* This concept may be referred to as an open or remote apron concept. As aprons may be ideally located for aircraft close to the runway and remote from other structures, it would provide advantages for aircraft handling such as shorter over-all taxiing distance, simple self-manoeuvring, ample flexibility and expansibility of aprons, etc. However, as it requires transporting passengers, baggage and cargo for relatively longer distances by transporters (mobile lounges/buses) and carts to and from the terminal, it can create traffic congestion problems on the air side.

f) *Hybrid concept.* The hybrid concept means the combining of more than one of the above-mentioned concepts. It is fairly common to combine the transporter concept with one of the other concepts to cater to peak traffic. Aircraft stands located at remote areas from the terminal are often referred to as remote aprons or remote stands.

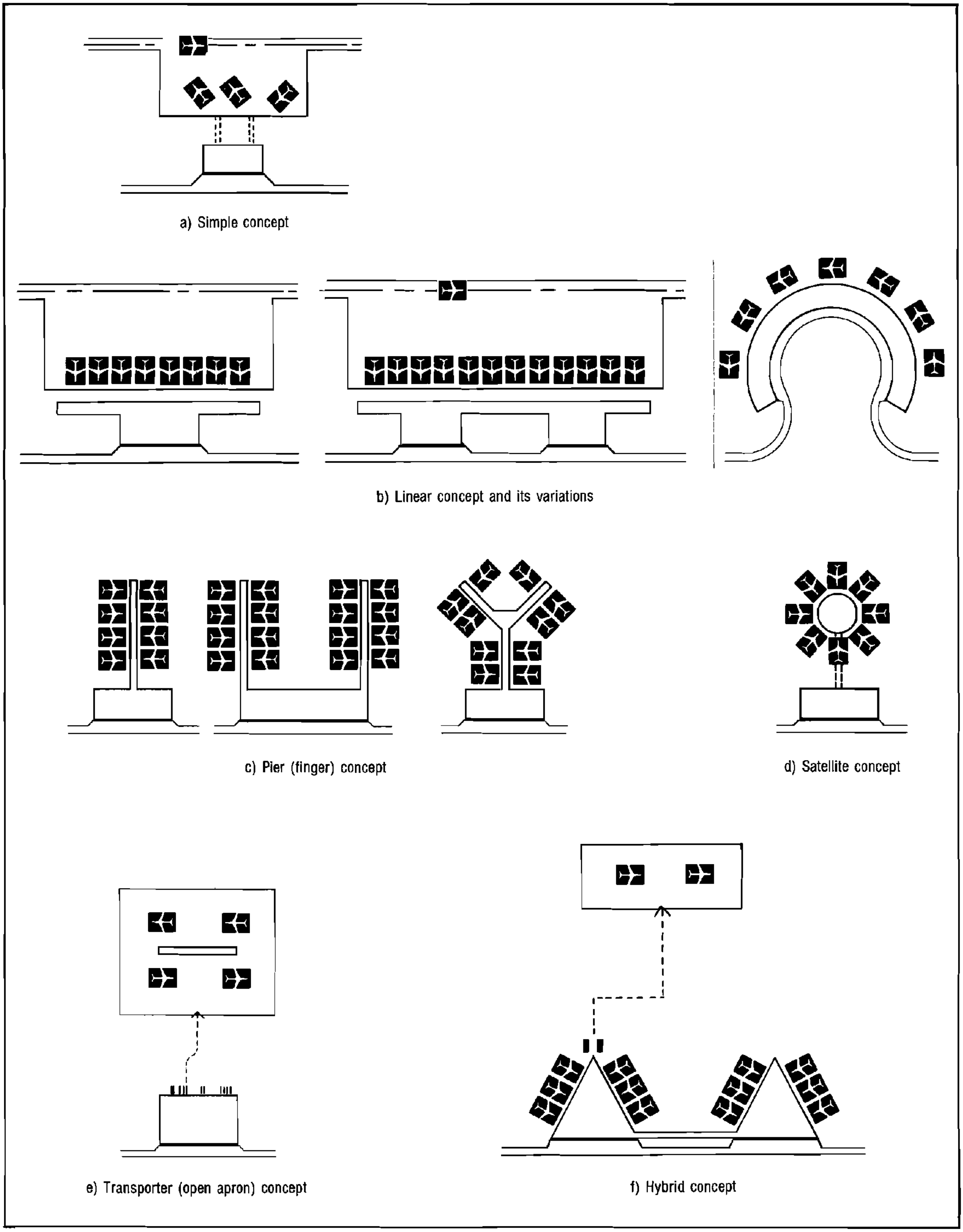


Figure 7-3. Passenger terminal concepts

7.4 CARGO TERMINAL APRON

7.4.1 At airports where the amount of air cargo is relatively small and mostly carried by passenger aircraft, there is no need to construct a cargo terminal apron exclusively for freight aircraft, and the cargo terminal building is best located close to the passenger terminal apron to minimize the travel distance, with due consideration given to the future expansion of both areas.

7.4.2 In recent years, air cargo has expanded and all-cargo aircraft operate into many airports. The planner should examine the need for a cargo apron based on air cargo forecasts. The all-cargo aircraft are normally parked either parallel or nose-in, but parking configurations depend mainly on the forecast volume and type of cargo handling system to be employed. See Chapter 10 for details of cargo terminal planning.

7.5 MAINTENANCE TERMINAL APRON

7.5.1 Maintenance of aircraft is an important pre-flight activity for safe and punctual operations. It is often categorized as follows:

a) line maintenance;

b) airframe maintenance;

c) power plant maintenance; and

d) component maintenance.

The type and interval of maintenance are normally predetermined for each type of aircraft. Line maintenance can be carried out on a passenger apron and the airlines can schedule aircraft so that other types of maintenance are completed at their home base. Thus not all airports need to have a major maintenance terminal area and apron.

7.5.2 For an airport which serves as the base for an airline, a maintenance terminal including hangar, workshop, storage and apron will probably be required. As the scale of the maintenance area depends on the fleet size and maintenance policy of the airline, the planner should consult user airlines at an early stage of planning. In addition to the maintenance apron, it may be necessary to provide an engine test-run area with facilities to reduce engine blast and noise.

7.5.3 As maintenance may be carried out during the night, it is preferable to locate the maintenance terminal area close to the parking apron (see 7.6) located adjacent to the passenger terminal apron. Care should be exercised, however, to reserve future expansion areas for both passenger and maintenance terminals including their aprons. It is generally recommended that maintenance terminal aprons be located at a fairly remote area from the passenger apron.

7.6 PARKING APRON

7.6.1 Where aircraft are obliged to be grounded for a long period, for example, six to eight hours, or to remain overnight at the airport, a parking apron may be justified. If such occurrences are few or do not conflict with the peak hour periods of the airport, it may be possible for such aircraft to remain at the terminal. However, as the number of such aircraft increases, it is more economical to remove them from the passenger terminal apron and some airports may thus require a separate parking apron. The number of the required stands at a parking apron should be estimated based on future aircraft fleet size and operating patterns at the airport. The parking apron should be located as close as is practical to the passenger terminal.

7.6.2 It is also common that the maximum number of aircraft gate positions be required only for short periods of the day or on a limited seasonal basis. Thus it may be difficult to justify the construction of a new terminal unit to accommodate these extreme peak demands by fixed gates. In such cases an economical solution may be the introduction of transporters combined with off-terminal parking positions. As these parking positions are often located at an area remote from the passenger terminal buildings, they are often referred to as remote parking aprons.

7.7 HOLDING BAYS

7.7.1 If aircraft proceeding for take-off were always to receive clearance in the order of their arrival at the ends of a runway, they could be held in single file on a taxiway. In practice, it is necessary to be able to bypass these aircraft so that aircraft can be cleared in the sequence desired to expedite movements. In addition, piston-engined aircraft require space to carry out checks and run-ups facing into wind prior to take-off.

7.7.2 Consequently, for runways to be used for take-off, holding bays (or bypass taxiways) should be planned to permit aircraft to be held or bypassed. They should be located so that:

a) satisfactory clearances are available from the runway and from aircraft using the taxiway;

b) propeller wash and jet blast are not directed at other aircraft;

c) interference with the operation of approach and landing aids is not caused; and

d) aircraft on a bay cannot be subjected to illegal interference from a public area.

See also the *Aerodrome Design Manual,* Part 2.

7.8 GENERAL AVIATION APRON

When an airport is also intended to serve general aviation aircraft, a general aviation terminal including a separate apron and other related facilities may be required. The general aviation terminal and its apron, however, should be located so as to minimize conflict with the scheduled aircraft operations.

7.9 HELICOPTER APRON

When an airport is also intended to serve extensive helicopter operations it may be necessary to plan for a helicopter terminal and apron. The location for such a terminal may depend on the type of helicopter traffic, e.g. public passenger service. See the *Heliport Manual* for detailed information on planning a helicopter apron.

7.10 APRON SECURITY

In planning the location and design of aprons, the need to maintain security of operations from possible sabotage or armed aggression should be considered in areas where this may be a problem. This will require control of public access to the apron, such as through doors in the passenger buildings, and includes the design of the building and any other barriers preventing the public from having ready access to the apron. For a further discussion of airport security, refer to Chapter 14.

7.11 FIXED FACILITIES

Aircraft Guidance

7.11.1 A proper guidance system on aircraft stands is necessary for safe manoeuvring of aircraft on the stand and positioning of aircraft. Apron markings are a widely used means to provide guidance; however, some airports have inset pavement lights in addition to painted guidelines to assist pilots in the dark and poor visibility conditions.

7.11.2 With the adoption of the nose-in parking configuration and the use of passenger loading bridges, precise positioning of aircraft is important. There are several types of visual docking guidance systems currently in use but not all of them meet agreed operational requirements. Reference should be made to the *Aerodrome Design Manual,* Part 4, for further information on suitable systems.

Aircraft Servicing

7.11.3 Fixed aircraft servicing installations reduce apron congestion and permit shorter servicing times. Possible installations include:

a) hydrant fuelling;

b) fixed ground power;

c) potable/non-potable water supply;

d) compressed air; and

e) air conditioning.

7.11.4 A fixed water supply is usually economically justifiable, whereas a large volume of traffic is usually required before a hydrant fuelling system can be justified (for details of hydrant system, refer to Chapter 13). Aircraft with auxiliary power units (APU) can provide ground power and air conditioning of the cabin. However, the noise created by APUs often is a nuisance to crew working on the apron and to neighbouring communities, particularly at night. Thus a decision to install any fixed servicing system requires both economic and environmental justification.

7.12 APRON TAXIWAYS AND AIRCRAFT STAND TAXI LANES

A sufficient number of apron taxiways or aircraft stand taxi lanes should be provided to prevent conflicts. As the number differs depending on the terminal concept, the number of total gate positions and the peak hour traffic, it may be worthwhile to simulate the future peak to analyse planned apron taxiway and aircraft stand taxi lane configurations. Care should also be taken to provide sufficient clearances between aircraft and other aircraft or fixed/moving objects. See the *Aerodrome Design Manual,* Part 2, for details of apron taxiway and aircraft stand taxi lanes.

7.13 APRON SERVICE ROADS AND GROUND EQUIPMENT PARKING AREAS

7.13.1 Provision and layout of service roads on aprons is of great importance for efficient airport operation and safety. Service roads should provide direct and convenient access between the apron and other service areas of the airport with minimum interference with manoeuvring aircraft and terminal functions. On passenger terminal aprons, service roads may be located at either the rear or in front of parked aircraft in nose-in configuration. For aircraft parked in parallel configuration, service roads may be placed along the outside wing tip. Where service roads pass under passenger loading bridges, sufficient vertical clearances must be provided so that ground service equipment (e.g. catering trucks) may pass underneath.

7.13.2 In addition to service roads on the apron, staging and parking areas should be provided for ground service equipment. ("Staging" means to set ground service equipment in position prior to the aircraft's arrival in order to expedite ground servicing.)

7.13.3 Some of the staging area near the aircraft stand may be used for long-term parking. However, it will be necessary to allocate specific areas for the parking and storage of equipment. The area for parking and storage of equipment, and possibly for the repair shop and fuel station for such equipment, may be located at a remote area from the passenger terminal apron to avoid conflicts in the future expansion of the airport central zone.

References

Annex 14 — *Aerodromes.*

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Chapter 8. AIR AND GROUND NAVIGATION AND TRAFFIC CONTROL AIDS AT AIRPORTS

8.1 ABOUT THIS CHAPTER

Planning of airports must include provision for facilities which will support the air traffic control system, for navigation aids for aircraft approaching the airport and, finally, for control of aircraft and vehicles on the surface of the airport. The purpose of this chapter is to describe the requirements for such control aids as pertain to airport master planning. Specific information on performance of equipment and on siting of navigation and control aids, among others, may be found in Annex 10, Annex 14 and the *Aerodrome Design Manual,* Part 4.

8.2 VISUAL AIDS

8.2.1 The selection of the visual aids to be provided at an airport will depend primarily on the visibility conditions under which it is intended operations be conducted and on the type of aircraft to be operated at the airport. The specifications in Annex 14 indicate for each visual aid the operating conditions under which it should be provided. In general, approach and runway lighting aids are related to the type of runway which is planned, that is non-instrument, instrument approach or precision approach Category I, II or III, and this must be resolved before any planning for visual aids is done.

8.2.2 The type of visual aids to be planned both initially and in the future should be determined during the initial planning of the airport, as requirements for approach lighting may require the purchase of additional land for installation, or the clearance of obstacles in the approach area to ensure visibility to pilots approaching to land. The future development of lighting systems may also have an effect in other areas, which might best be prevented by making provision for it in the initial construction phase. An example of this would be duct capacity underneath paved areas. Installation of ducts after pavements have been constructed, besides being costly, requires closure of the area involved and, unless carefully constructed, results in unsatisfactory pavement surface conditions. It is therefore prudent to install more than adequate duct capacity during initial construction. Similarly, if in the near future it is planned to upgrade a runway to precision approach Category II or III, involving in-pavement lights, then it may be found more economical and convenient to include ducts for these lights in the initial pavement construction.

8.3 RADIO NAVIGATION AIDS

8.3.1 Most modern airports are likely to have all or some of the following navigation aids:

a) instrument landing system (ILS)*/microwave landing system (MLS);

b) VHF omnidirectional radio ranges (VOR);

c) distance measuring equipment facilities (DME) (generally collocated with VOR or ILS or MLS);

d) collocated tactical air navigation systems and VOR (VORTAC);

e) radars — approach, secondary and surveillance type.

8.3.2 When the types of navigation aids needed at the airport have been decided, the site selection should be carried out with the assistance of the individual expert associated with the aid. Unless the proposed site happens to be flat with few obstructions, some preliminary site clearing and grading would be necessary, depending on the nature of the site, the quality and nature of the navigational facility required and the associated costs. All preliminary grading and site preparation is usually

* ILS will cease to be an ICAO standard system on 1 January 1998. However, on the basis of Regional Agreement, the ILS can remain in service at international airports until 1 January 2000, after which it ceases to be an ICAO Standard system.

included in the airport construction contract. Subsequently, each site should be flight checked using portable equipment, if this is not too difficult to obtain. Unless the selected sites happen to be ideal, the best choice of variables to arrive at the most economical configuration of the required navigation aid can be determined only by means of a flight check.

8.3.3 It is very difficult to specify exact sizes for the buildings for the sites, because the choices and the combinations of the navigation aids are quite numerous. The rapid developments and advances in electronic technology and the consequential miniaturization of equipment may offer radically different concepts, so far as the installation of navigation aids at the airport of tomorrow is concerned. Up-to-date information should be obtained from experts in each field to allocate appropriate areas for the required facilities. However, some general guidance is provided in the following paragraphs.

8.3.4 Parts of the instrument landing system (i.e. markers and non-directional beacons) are not usually located on the airport; however, the control for all facilities and power for the middle and inner markers are usually provided from the airport. The required power supply can be provided more economically from the airport than by separate individual power sources at each of the facilities, with the exception of outer markers and non-directional beacons.

8.3.5 The number of instrument landing systems at an airport would depend on the precision approach runways required. Usually the ILS/MLS is planned to serve the prevailing bad weather wind direction, but since the fair weather use of ILS/MLS is becoming more common for safer operation, especially for large aircraft, some runways are planned to have instrument landing systems at both ends. Since the integrity of the radio signals in space depends on the reflecting properties of the terrain surrounding the antennas, minimal roughness and slope with adequate drainage and soil stability is highly desirable. The roughness of localizer course and glide path depends on the number of unwanted signal reflections received by the aircraft. The number and magnitude of unwanted reflections depend on the number, size and material of objects (e.g. buildings, hangars, vehicles, etc.) and distance of the objects illuminated by the antennas. At those sites where the number of significant objects is unavoidably large, the signal quality can be improved with the help of directional antennas, which are usually more costly and much larger than the standard type of antennas.

8.3.6 Most of the site grading work, construction of access roads and provision of ducts under the runways for the power supply and control of navigation aids should be included in the airport construction contract.

8.4 BUILDINGS FOR RADIO NAVIGATION AIDS

When planning buildings for radio navigation aids, the following points should be taken into consideration:

a) *Size.* Particular attention should be paid to the future needs and possible extension or modification of the facilities. In the case of localizers and glide paths, provision of space for dual installations should be considered, from the point of view of both the future construction at the airport and the upgrading of performance to accommodate faster and larger aircraft. Additional space should be allocated for standby powerplants or air conditioning equipment where called for by virtue of equipment design or local climatic conditions.

b) *Power supply.* At those sites where an independent self-contained unit power station cannot be provided, the power supply transformers and associated accessories have to be installed inside the building. Appropriate isolation and ventilation of the radio equipment is necessary to dissipate the additional heat generated by the power equipment. Where standby plants are employed, diesel engine noise is also a factor which should be considered.

c) *Drainage.* Provision should be made to drain the site adequately. Poor drainage, particularly at the glide path sites, can cause appreciable changes to the signal in space and accumulated water in the vicinity of the building could even cause equipment shutdown. Drainage ditches in the vicinity of the glide path antenna must be of such dimension that they do not adversely affect the signals in space.

d) *Access roads.* Restoration of a facility to normal operation depends a great deal on fast and easy access to the building. For those facilities which are located on the airport, access via the runways could cause considerable delays if the traffic is heavy and separate access roads should therefore be considered. If proper planning precedes the choice of the building sites, the cost of construction and maintenance of the access road could be reduced considerably.

8.5 DEMARCATION OF CRITICAL AREAS

The areas immediately surrounding the localizer and glide path antennas form a part of the "critical areas" within which obstacles or any sort of vehicle movement is prohibited. These areas are designated as "critical" because presence of reflecting objects can cause intolerable distortion of the signals in space. Particular attention should be paid to the critical areas, so far as demarcation of boundaries and restriction of other airport activities is concerned. The critical areas associated with ILS/MLS are described in Attachment C to Part I of Annex 10, Volume I.

8.6 AIR TRAFFIC SERVICES

8.6.1 The requirements for accommodation of air traffic services units and associated equipment on an airport will vary according to the plans developed by the appropriate air traffic services authority for the air traffic services organization. The minimum requirement for all airports is for an airport control tower to accommodate a unit providing airport control service and for accommodation of an air traffic services reporting office. This latter office, however, may not necessarily be a separate unit. At airports planned to be equipped with aids for instrument approach and departure there may be an additional requirement for an approach control office, but in many cases the equipment and staff for such an office are located in the control tower room. At some airports there may also be a need to accommodate an area control centre or a flight information centre. It is important that these requirements be determined at an early stage in consultation with the appropriate air traffic services authorities and that the planning of buildings on the airport take these requirements fully into account. It is also important that flexibility in the arrangements of air traffic services units and adequate expansion possibilities be reflected in the planning.

Airport Control Tower

8.6.2 The effective provision of airport control service requires a clear and unobstructed view of the entire movement area of an airport and of air traffic in the vicinity of the airport. The airport control tower should therefore be so located and be of such a height that aprons, taxiways, runways and the airspace surrounding the airport, particularly approach and departure areas, are clearly visible from the control room and that future developments of the manoeuvring area or future construction of buildings would not restrict this view. In determining the location of the control tower, the need to avoid sun glare is also an important consideration. The cable requirements associated with the need for remote control or monitoring of the operation of approach and landing aids, and airport lighting and the provision radar and communication facilities should be taken into account. Another important factor is the security of the control tower, and it may be preferable to locate the tower away from public areas avoiding places such as tops of passenger terminal buildings. The control room should be large enough to accommodate control desks, associated devices and operating personnel and provision should be made for equipment rooms, office space and rest facilities immediately underneath the control room. Requirements for special lighting, noise protection, air conditioning and special accommodation of sensitive equipment should be taken into account.

Approach Control Office

8.6.3 The approach control office, where required as a separate entity, should be located conveniently close to the airport control tower room. The office should be large enough to accommodate control desks, associated devices and operating personnel, and provision should be made for equipment rooms, office space and rest facilities near by. Requirements for special lighting, noise protection, air conditioning and special accommodation of sensitive equipment such as radar should be taken into account.

Area Control Centre/Flight Information Centre

8.6.4 The area control centre or flight information centre, where required, should preferably be located conveniently close to the airport control tower room and the approach control office. The centre should be large enough to accommodate control desks, associated devices and operating personnel, and provision should be made for equipment rooms, office space and rest facilities near by. Requirements for special lighting, noise protection, air conditioning and special accommodation of sensitive equipment such as radar and computer equipment should be taken into account.

Air Traffic Services Reporting Office

8.6.5 If required to be established as a separate unit, rather than as a part of another air traffic services unit or aeronautical information service unit, the air traffic services reporting office should be located in close proximity to other briefing and reporting offices, e.g. meteorological briefing office, aeronautical information services unit, etc. The office should be easily accessible to flight crews of departing and arriving aircraft and to flight operations officers of airlines. It should be sufficiently large to accommodate necessary staff and equipment and to enable flight crews and other personnel to prepare flight plans and reports. Additional information relating to briefing offices may be found in the *Aeronautical Information Services Manual.*

8.7 SEARCH AND RESCUE SERVICES

At some airports there may be a need to accommodate a rescue co-ordination centre collocated with or conveniently close to the area control or flight information centre or a rescue sub-centre collocated with or conveniently close to an appropriate air traffic services unit. For information on the accommodation of rescue co-ordination centres and rescue sub-centres see Part I of the *Search and Rescue Manual.*

8.8 APRON MANAGEMENT SERVICE

The number and complexity of aircraft and vehicle movements on an apron may create a need for an apron management service and thus separate accommodation for the staff, with clear sight to all parts of the apron in their charge. Requirements for special lighting, noise protection, air conditioning and communications should be taken into account.

8.9 COMMUNICATIONS

Aeronautical Fixed Services

8.9.1 Telecommunications are required to many parts of an airport and, in many cases, to more distant remotely controlled transmitter and receiver stations. Because of the complexity of equipment and connexions to the points to be served (usually by means of cables for which underground conduits and conduits within buildings must be provided), the communications centre installation is relatively inflexible once it is established. It should, therefore, be allotted sufficient space to serve the ultimate point-to-point communications needs of the airport without requiring relocations, and should be sited to avoid restricting the expansion of other facilities. Where point-to-point AFTN or direct ATS speech circuits are operated by radio, remote transmitter and receiver buildings are, in most cases, required. In siting such buildings, several factors should be taken into consideration, such as radio interference, adequate and appropriate space for antennas, accessibility, reasonable distance from the central installation in the communications centre (usually accommodated in or near the passenger building), availability and reliability of power sources, etc.

8.9.2 The size of the transmitter and receiver buildings should be adequate to accommodate the ultimate point-to-point (and possibly aeromobile) radio equipment, workshop, stores, offices, emergency power plant, and other facilities required for efficient operation. In many cases, it may not be possible to site the transmitter and receiver buildings within the airport boundaries, but they should nevertheless be considered as part of the airport installation as far as control and operational aspects are concerned.

Aeronautical Mobile Services

8.9.3 Air-ground communications for airport traffic control, surface movement control and approach control are operated by the corresponding air traffic services, and the associated terminal equipment should be suitably sited in relation to these services. If air-ground communications for en-route air traffic control or other services are to be provided, the associated terminal equipment should be suitably sited in relation to the corresponding area control centre/flight information centre or other services concerned. The relative inflexibility of these installations, once established, is comparable to that of the aeronautical fixed services, and similar planning provisions should be made. The radio transmitters and receivers associated with the aeronautical mobile service are frequently located at the remote transmitter and receiver buildings mentioned under the aeronautical fixed services heading.

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SECTION THREE — LAND SIDE DEVELOPMENT

INTRODUCTORY NOTES

Land side refers to that area of an airport from a point where the passenger loading device connects with the passenger building, through and including the passenger building and through and including cargo facilities, to and including the ground access system.

The major elements comprising the land side of an airport may be identified as: the passenger building, cargo facilities, and ground transport and vehicle parking.

Land side development includes all areas of the airport and buildings to which the non-travelling public has free access as well as the non-public portions containing airline operations and cargo facilities, airport administration, and government facilities.

Chapter 9. PASSENGER BUILDING

9.1 ABOUT THIS CHAPTER

This chapter deals with planning for facilities to accommodate those activities associated with the transfer of passengers and their baggage from the point of interchange between ground transportation and the passenger building to the point of connexion with the aircraft, and with the transfer of connecting and in-transit passengers and their baggage between flights. Planning principles, factors affecting the type and scale, and specific planning details of various passenger building functions are presented in this chapter.

9.2 GENERAL CONSIDERATIONS

9.2.1 In passenger building planning it is necessary to provide the means for passengers to enter and leave their cars or public transport vehicles, parking for cars and public transport vehicles, buildings in which aircraft operators can undertake passenger processing and where government control authorities can undertake their inspections and in which all necessary facilities for passengers' comfort and assistance can be provided.

9.2.2 Aircraft operations will be less costly and more efficient if the passenger building is as close as possible to the runways. This reduces taxiing distances, and hence fuel consumption, and helps to avoid congestion by reducing the time spent by aircraft in ground movement. Care must be exercised, however, to ensure that expansibility and flexibility are not compromised. Therefore, the location of passenger facilities is inseparably associated with the planning of the over-all runway layout and the total airport plan.

9.2.3 The type and size of the passenger building and the various components within the building will evolve from land-use requirements activity forecasts (Chapter 3, 3.2 to 3.4), and site evaluations (Chapter 5, 5.2).

9.2.4 For many airports to which this manual is directed, passenger building facilities will be contiguous, with one general location on the airport. However, in certain circumstances, particular functions such as aircraft maintenance may be situated at locations remote from the main passenger building.

9.2.5 In keeping with the objectives of airport master planning, the development of passenger building plans should be limited to conceptual studies and drawings. Such drawings should not be so detailed as to preclude adjustments which evolve later in the detailed planning phase. Such changes frequently occur as an airport development project moves beyond the master planning phase to final design and construction.

9.2.6 One of the most important objectives in the development of the passenger building is provision for all of the necessary passenger services at an optimum cost, while recognizing the need for flexibility and expansibility, as well as economy of any future passenger building expansion.

Planning Principles

9.2.7 The passenger building's function — interchange between transport modes — combines with passengers' physical and psychological characteristics to make the passenger area a most sensitive part of the whole air transport system. In considering the planning of these facilities any preconceptions about the result should be eliminated, except that the facilities should provide comfortable, convenient and speedy movement of passengers and baggage between air and ground transport at the lowest effective cost and should be able to accommodate expanding traffic without extensive modification.

Characteristics of passenger areas

9.2.8 Well-designed passenger buildings are usually the result of close co-operation between all the members of the planning team concerned, both those whose task it is to lay down the requirements and those, particularly architects and engineers, who have to translate the requirements into detailed designs. Although each group has its own primary responsibility, it can also help the other in many ways. In what follows there is no attempt to lay down principles of design but only to set out some planning principles that are likely to influence design.

a) For general layout, passengers should be thought of as forming a homogeneous flow, whether constant or intermittent.

b) The majority of passengers are content to form part of the main flow and require clear indications of what they are expected to do and the flow routes they should follow.

c) Passengers have individual needs, preferences and (sometimes) disabilities. Some of these requirements involve the airport in extra expense (e.g. facilities for invalids, disabled and elderly persons); others can bring in revenue (e.g. concessions).

d) A system that attracts passengers to the routes required by the flow pattern will often give better results than one that appears to offer no alternative, particularly if it also gives some freedom for individual requirements.

Separation of functions

9.2.9 The key to achieving the planning objectives is simplicity. In the context of passenger planning it means simple, obvious flow routes. Complex flow routes usually arise from complex plans and buildings. Complex buildings are usually costly, inflexible and not readily expansible as a logical extension of the plan and operating system. The facilities may still be costly if so desired, but this will not be an unavoidable consequence of the plan and operating concept. Separation of functions is the principal aid to achievement of simplicity. If other facilities, such as multi-storey office blocks, car parks, control towers, etc., are incorporated with passenger buildings, not only does the flow plan tend to be distorted but flexibility is seriously compromised by the presence of these facilities, and also by the structural features they impose on the building. Figure 9-1 illustrates each of the important functions of a passenger building and gives an approximation of various passenger and baggage processing interrelationships. Planning requirements for each of these components are described, in turn, in subsequent sections of this chapter.

Size of passenger buildings

9.2.10 For passenger convenience, a large area in the passenger building should be broken down into units or modules, since it is difficult to construct a single building which can accommodate aircraft parking positions for high runway capacities and still maintain passenger walking distances within reasonable limits. A walking distance of about 300 m from the centre of the air side of the passenger building to the farthest aircraft parking position has been generally accepted as the reasonable limit. However, even this can result in passengers having to walk long distances to make connexions between one aircraft, although judicious allocation of stands can reduce such cases to a minimum. The size of the modular passenger unit is very important and should be the best compromise responding to the physical limitations of passengers and the economics of construction and operation of the passenger building and apron. Further discussion on factors affecting passenger terminal size may be found in 9.2.32 through 9.2.39.

Layout of passenger buildings

9.2.11 Passenger buildings should be associated with car parks and aprons, etc., of the necessary capacity. When the passenger movement rate exceeds the capacity of the optimum size building, additional buildings should be provided, each complete with its own associated full complement of facilities. The layout of these modular passenger units within the passenger building plan should include the necessary apron space, car parking and road circulation space in the most compact arrangement to minimize transfer distances between the passenger buildings, and between the associated facilities within each modular unit.

9.2.12 These units should be arranged in the simplest manner possible to provide an easily comprehensible environment to facilitate free flow of vehicles and people, and to provide a flexible and expansible layout capable of adaptation to future possible requirements. Transfer routes will be required for passengers and baggage on the air side, within customs bond, and land side. The nature of these transport systems should be considered in conjunction with town centre/airport public transport systems to which all the passenger buildings should be conveniently linked.

Flow principles

9.2.13 The following flow principles should be considered, to the extent it is practical, and evaluated against local circumstances. Particular regard should be paid to the separation of functions. The passenger flow plan should be the first to be considered. Baggage movement is of equal importance since it should be integrated with the passenger flow but, because baggage is inanimate, it is easier to make the baggage flow compatible with the best passenger flow. In practice the flow plans should be tested against one another at all stages.

9.2.14 Flow principles to consider with respect to passengers include:

a) Routes should be short, direct and self-evident. They should not, as far as is practicable, conflict with nor cross the flow routes of other passenger, baggage or vehicular traffic.

b) Changes in level of pedestrian routes should be avoided as far as is practicable.

c) Passengers should be able to proceed through a building without the need to rely on guidance or instruction from staff. The flow system should be for "trickle flow" rather than controlled movement in groups.

d) In heavy traffic conditions, mass flows can only be achieved by the use of trunk routes. Particular categories of passengers should be diverted from the main flow route to pass through specific controls only at the last point on the main flow route where the character of the traffic changes.

e) Departing passengers should have an opportunity to check their baggage at the earliest possible point.

f) Each flow route should, as far as is practicable, be in one direction only. Where a reverse flow has to be provided it should be via a self-contained and separate route. Flow routes and milling spaces (areas of random movement) are necessarily complementary to each other but are separate functions. Therefore, milling spaces should be adjacent to but not part of the flow routes.

g) Free flow through all parts of the routes between air and ground transport should be interrupted as little as possible. While government control authorities and aircraft operators determine their own procedures, the plan should provide for them in the best manner to achieve passenger convenience, maximum security, optimum utilization of staff and minimum cost for aircraft operators and control authorities.

   Every control point in the flow system has a potential to delay and also to irritate and confuse passengers. The delay is caused not only by the time needed for officials to carry out their procedures but also the reaction time of passengers. This reaction time consists of the time taken to realize that a control has to be passed, to understand its nature and to find the necessary documents. This time will be increased for some passengers by lack of understanding of foreign languages, illiteracy, or confusion. These effects can be reduced minimizing controls and concentrating them at the fewest number of points. This can also improve utilization of staff by permitting great flexibility.

h) Passengers should not have to pass through the same type of control more than once. Thus, if procedures or controls are established in more than one place the flow routes should be planned to permit passengers to bypass all subsequent controls of the same type.

i) The last control which passenger should pass through is security. Any controls established at an airport for screening of passengers and their hand baggage should be sufficiently remote from the boarding gate as to provide maximum restriction of unauthorized access to aircraft. Moreover, provision should be made for a "sterile" buffer area between the security control point and the aircraft. See Doc 8973 and Annex 9 for further information.

j) Flow routes should be planned to give visual continuity to the maximum possible extent. As a minimum it is essential that there should be visual continuity from one functional stage of the flow route to the next, e.g. from baggage claim to customs or from check-in to immigration. Such continuity assists passengers' understanding of the flow system and draws them on in a steady flow through each successive stage. A visual blockage, such as exists where each function or authority is contained in a separate room, is confusing and creates the need for signs, broadcast instructions or staff supervision of passengers.

k) Features which cause hesitancy, such as ambiguous terminology on signs, flow routes which appear to lead in the wrong direction, and multi-directional junctions should be avoided.

l) The speed of flow and capacity of the passenger routes should be matched to that of other systems, such as baggage flow and aircraft turnaround time, and to the over-all capacity of the airport. The fastest possible passenger flow or highest possible capacity, far from being an advantage, will create frustration, delay, congestion and criticism if it is not balanced by all parts of the airport system.

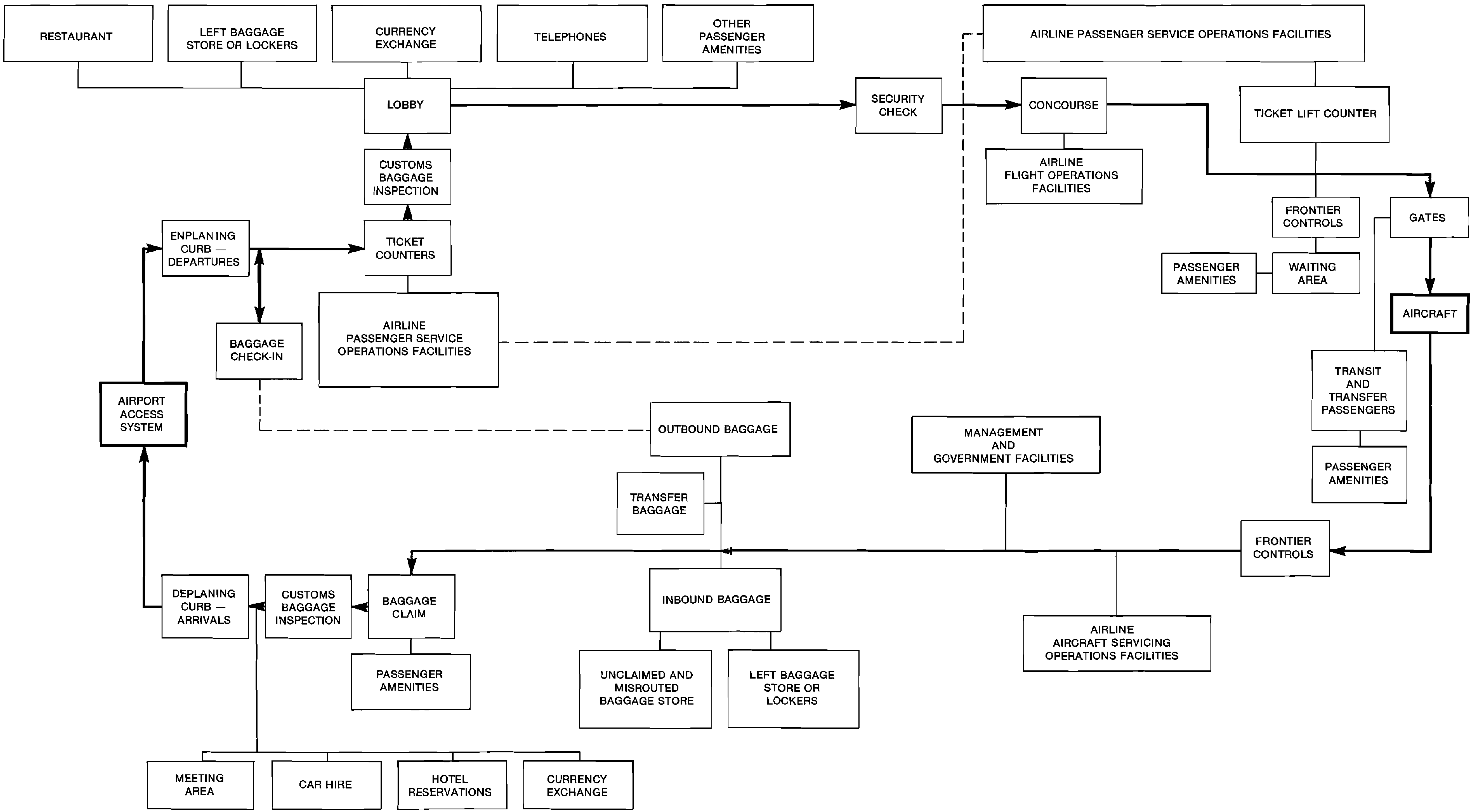
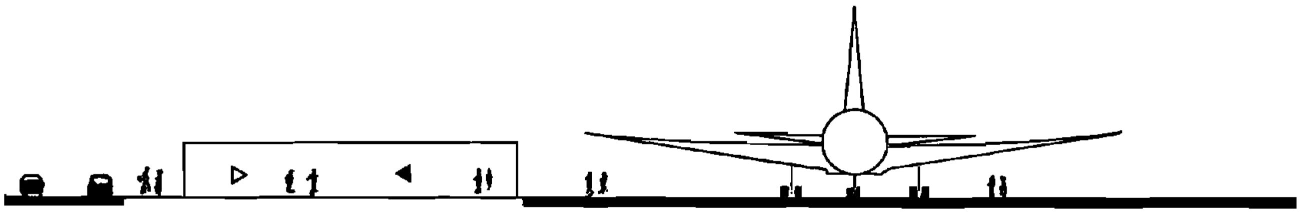
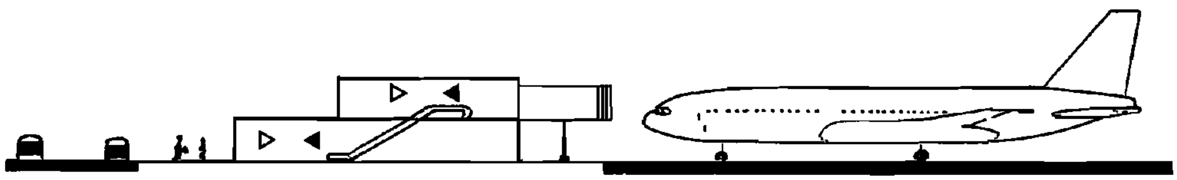


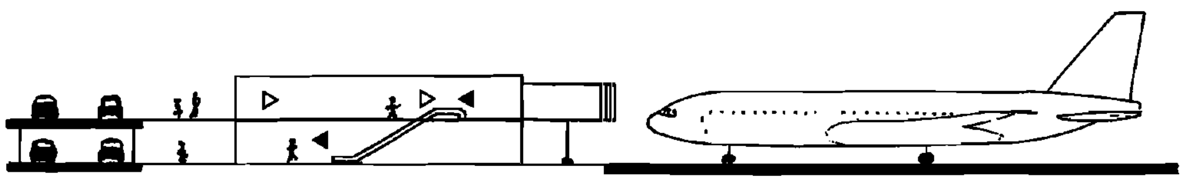
Figure 9-1. Passenger building functional relationships



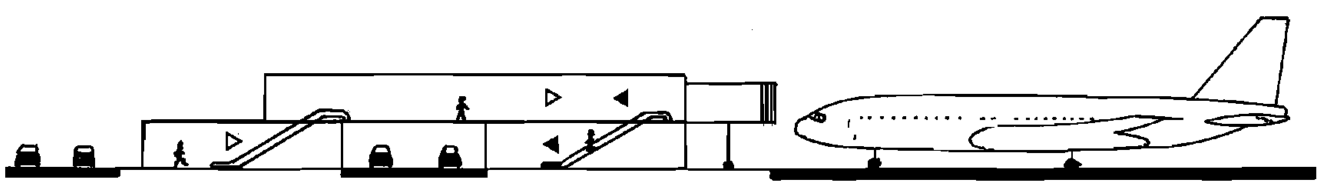
a) single level road/single level terminal



b) single level road/double level terminal



c) double level road/double level terminal



d) single level roads/double level terminal

▷ Departing passengers
◀ Arriving passengers

Figure 9-2. Typical arrangements by processing levels

9.2.15 For those parts of the passenger flow routes where baggage accompanies passengers, the passenger flow principles also apply to baggage. Baggage flow routes are those parts of the system which are specifically for baggage handling when it is separated from passengers. The general planning principles also apply to baggage systems planning. Passenger considerations have to be noted at those points where the passenger and baggage flows come together, and they can consequently influence aspects of the whole baggage system.

Signing considerations

9.2.16 In order to realize the full capacity potential of the passenger building, an orderly flow of both passengers and baggage must be achieved to assure this orderly flow. Prudent use of the system of international signs is necessary in order to assist air travellers in locating various facilities and services (See Doc 9430).

Airport Passenger and Service Characteristics

Passenger characteristics

9.2.17 The two main categories of passengers are those who travel for business purposes and those who travel for tourism, personal, or religious reasons. The business passenger is usually more experienced and will often use the full range of passenger building services available to the public, time permitting. Other types of passengers include a high percentage who are less experienced and familiar with airline procedures and the available passenger building services and concessions.

9.2.18 Significant variations in the characteristics and ratio of these passenger types can influence passenger building space requirements and staffing. One example relates to small or medium airports serving vacation centres, pilgrimage centres, and resort areas with relatively short seasons. This type of airport will require different passenger building facilities than airports handling similar peak volumes of predominantly business travellers. Nearby military installations may warrant additional or different processing facilities and services. Also, those airports having a significant number of non-travelling visitors must provide adequate space in the passenger building so as not to impede the orderly flow of passengers.

9.2.19 Additional primary characteristics of passengers are thus:

a) *International.* Passengers travelling between countries and subject to inspection by government frontier control agencies.

b) *Domestic.* Passengers travelling on routes which begin and end within the boundaries of a single State and not subject to government control inspection. For planning purposes this category also includes all passengers on routes which are exempted from government control inspection. This includes traffic within a customs union, economic community of free trade area, in which the national governments have agreed on the free passage of people and goods. Depending on the details of such agreements traffic may be domestic in one direction and international in the other. Thus, the classification between domestic and international applies to the aircraft route and not the origins and destinations of individual passengers as indicated below under "Service Characteristics."

9.2.20 There are further distinctive categories which apply to both aircraft and passengers but which only impose special requirements in respect of passengers. These are:

a) *Departures.* Passengers using an airport for the purpose of departing from it by air.

b) *Arrivals.* Passengers arriving by aircraft at an airport and not departing by a continuing or connecting flight.

c) *Transit.* Passengers who arrive and leave again on the same aircraft. These passengers may remain on the aircraft, in which case they do not create any requirements which planning need take into account. On the other hand, it may be necessary to accommodate them in the passenger building for the duration of the aircraft's stay at the airport, for example to permit the aircraft cabin to be cleaned, and to provide reasonable comfort and facilities for them.

   Some transit passengers may also be subject to frontier controls. This applies where part of an aircraft's route is domestic and another part international. Passengers arriving from an international section may be destined for an airport at which frontier control facilities are not provided and will, therefore, have to pass the controls at the transit airport.

d) *Transfer*. Some passengers arriving at an airport by air may do so simply to connect with a flight for another destination. For most planning purposes these passengers can be considered as transit passengers except that their baggage needs to be transferred to another aircraft. Some ticketing facilities are required specifically for their use, and planning should therefore take account of this type of traffic.

e) *General aviation and air taxis*. There may be a demand for general aviation and a careful cost-benefit analysis should be made to determine whether to intermix this traffic with commercial aviation or to keep it separate. While air taxis may be a problem at large airports, this is not usually the case at small- or medium-sized airports.

Service characteristics — scheduled airlines

9.2.21 Airline service characteristics are directly related to the route certificates, bilateral agreements, and structure of each scheduled airline's system. They can generally be categorized into three basic types: originating/terminating station, through station, and transfer/transit station. An airport may be identified as one type for the airline industry in general and at the same time serve as a different type for an individual airline. The characteristics of a particular airport may change as an airline is awarded new routes and develops different connecting patterns and as the results of new bilateral route negotiations are instituted.

9.2.22 An "originating/terminating station" airport is usually characterized by a high percentage of originating passengers (over 70 per cent of total enplanements) and a preponderance of turnaround flights with ground times ranging from 45 to 90 minutes or more. Another characteristic is in the primary flow of passengers between aircraft and ground transportation vehicles, generating a relatively high requirement for ticket counter, curb length and parking spaces per enplaned passenger as compared with transfer/transit or through stations. Passengers will usually require maximum baggage-handling services for checking and claiming baggage. Typical domestic peak conditions will show hourly aircraft movements per gate averaging about 0.9 to 1.1.

9.2.23 A "through station" airport has a relatively high percentage of originating passengers combined with a low percentage of originating flights, resulting in shorter aircraft ground times than either originating/terminating stations or transfer/transit stations. Another characteristic is that boarding load factors may be lower than those for originating/terminating stations, thereby reducing departure lounge space requirements. Typical domestic peak conditions will show hourly aircraft movements per gate averaging 1.5 to 2.0. Experience in planning for these characteristics indicates the importance of identifying originating passengers separately from total enplanements.

9.2.24 A "transfer/transit station" airport has a significant proportion of passengers transferring from arriving flights to departing flights or arriving and departing on the same aircraft (at least 30 per cent of total enplanements, including online and offline transfers). Aircraft ground servicing times will average 30 to 60 minutes, depending upon connecting patterns and operating policies. By determining the relative proportion of online and offline transfers for each carrier, adjacency of carriers with a high proportion of interchange may help reduce over-all in-terminal circulation requirements and between-flight connecting times. Typical domestic peak conditions will show hourly aircraft movements per gate averaging 1.3 to 1.5.

9.2.25 Compared to the same volume of enplanements at an originating/terminating station airport, the transfer/transit station airport will have:

- less ground transportation activity and a lower requirement for curb frontage;
- less need for airline counter positions serving normal ticketing and baggage check-in, although more positions may be required for flight information and ticket changes;
- less requirement for baggage claim area, but more space needs for baggage transfer (online and/or interline baggage);
- increased requirements for concessions and public services because of passengers remaining in the terminal while waiting for connecting flights. This is generally related to aircraft ground servicing times; and
- increased need for centralized security control locations to assist passengers transferring to other flights.

Service characteristics — non-scheduled airlines

9.2.26 In addition to their scheduled operations, many airlines operate charter flights, group tour flights, and other types of non-scheduled passenger service. Additionally, there are a number of certificated supplemental carriers which operate similar types of non-scheduled service. The certificated supplemental carriers generally operate aircraft similar to those of major international flag carriers, although seating capacities may be higher. Since the supplementals do not lease facilities at most airports, their operations are often handled by a certificated carrier or by a fixed base operator (FBO), who may be located outside the passenger building complex.

9.2.27 Air-taxi operators constitute another class of non-scheduled/charter service using aircraft that are generally smaller than those operated by other airlines. At many airports, air-taxi service is provided outside the passenger building complex.

9.2.28 Airline facility planning for non-scheduled operations involves consideration of the following:

— *Frequency/volumes.* Collectively these usually suggest facilities that are more modest and utilitarian than those for scheduled operations.

— *Group processing.* May permit "batch loading" and bypassing otherwise congested elements of the passenger building apron-terminal. Buses can transport passengers and baggage directly between off-airport locations (hotels) and aircraft remote from the passenger terminal.

— *Processing times.* May differ substantially from scheduled service. Some charter/group-tour procedures call for passengers to arrive at the airport two to three hours prior to departure, which increases the number of people in the passenger building well beyond that for scheduled operations. The early arrival requirement is sometimes related to airline staffing and fewer counter positions, thereby producing longer queues and more congestion in the ticketing lobbies.

— *Operational reliability.* For many reasons, charter/group tour departures and arrivals tend to be delayed more than scheduled flights. This usually increases the number of persons in the terminal or departure lounge areas beyond the norms and patterns typical of scheduled operations.

9.2.29 Consideration of the above factors may suggest facilities different from those normally provided for scheduled operations. At some airports, a relatively high volume of airline charter operations may warrant consideration of separate and modest passenger building facilities for supplemental carriers. In a few cases, one or more scheduled carriers may want aircraft stands and buildings to service charter operations when seasonal peaks or recurring operation patterns exceed the capabilities of facilities leased for their own scheduled operations. Any such proposal should be evaluated thoroughly with the airlines involved, since a separate charter facility may involve considerable inefficiencies in logistics, staffing, ground equipment utilization, and other costs.

Service characteristics — international airlines

9.2.30 Depending upon the geographic locations involved, one characteristic of international service is a tendency toward higher scheduled peaks due to heavy dependence on schedules for city pairs related to time zone crossing. Another characteristic is that of relatively long ground service times (two to three hours for turnarounds, and one hour for through flights) required for long-range aircraft servicing.

9.2.31 Governmental control and clearance (or pre-clearance) requirements are major planning considerations, particularly those for the frontier controls and customs baggage facilities. The techniques and procedures used in implementing governmental regulations vary from one location to another and may change periodically.

Factors Affecting Scale of Facilities to be Provided

9.2.32 The final stage of passenger building planning involves assessment of the size of the facilities and their arrangement in the optimum relationship to each other and in accordance with the flow principles. The facilities required will vary according to the number of aircraft operators to be accommodated, their proportionate shares of the traffic, the type of aircraft operated and the nature of the operations.

Number of aircraft operators

9.2.33 For a given volume of traffic the minimum facilities would be required if only one aircraft operator had to be accommodated. The scale and variety of facilities required increases where there are a number of operators. In these circumstances continuity of utilization of facilities tends to decrease.

Allocation of facilities

9.2.34 Aircraft operators often have differing views on the best passenger processing methods. These views, coupled with commercial competition and the consequent wish for separate public identity, often lead aircraft operators to seek allocation of specific parts of passenger areas or buildings to their individual use. While aircraft operators do need fairly localized areas of operation in order to be able to concentrate staff and equipment, separation of operators can lead to an over-all reduction in utilization of facilities and a consequent increase in their total size and cost.

9.2.35 Minimum cost for the airport will be achieved by the most continuous and homogeneous use of facilities, and passenger convenience will be enhanced by reduction of interchange between various sections of the passenger area or buildings. But certainty of the location of their chosen aircraft operator is also a passenger requirement. So between the partly conflicting interests of the airport authority, aircraft operators and passengers, a compromise is necessary to determine the optimum allocation of facilities.

Developing criteria for the passenger building plan

9.2.36 Specific planning criteria, related to demand and capacity cited below, should be developed for the above factors and for those major passenger building components affecting the scale of facilities to be provided. Information for determining passenger building requirements should be obtained from all present or potential users of the facilities including, *inter alia*, the airlines, general aviation interests, concessionaires, airport management, and special technical committees which may be organized to act as advisors to the airport planners. The criteria should be analysed and agreed upon by all parties involved before being incorporated into the master plan.

Determination of passenger building concepts

9.2.37 The selection of a passenger building concept must be made jointly with the selection of the aircraft parking system discussed in 7.3.8. Through careful study and analysis, the planner should reduce the possibilities to those few concepts which will be most compatible with the planned airport configuration. These most desirable concepts should then be presented to airport management, airline and general aviation interests, and airport concessionaires for their consideration and appraisal. It is essential that co-ordination with airport interests and users be effected before the final selection of a passenger building concept is made. If this is not done, the plan may well be rejected at the time of its official presentation. The following concepts should be considered in the development of the passenger building plan.

a) *Simple concept.* The simple building concept consists of a single common waiting and ticketing area with several exits into a small parking apron. It is adaptable to airports with low airline activity and is also adaptable to general aviation operations whether it is located as a separate entity on a large airline-served airport or is the operational centre for an airport used exclusively by general aviation. Where the simple building serves airline operations, it will usually have an apron which provides close-in parking for a few commercial transport aircraft; however, due consideration should be given for jet blast effects against the building when a nose-in or nose-out parking configuration is adopted for jet transport aircraft. Where the simple building serves general aviation only, it should be within convenient walking distance of aircraft parking areas and should be adjacent to an aircraft service apron. The simple building concept will normally consist of a single-level structure where access to aircraft is by walking across the apron. The layout of the simple building should take into account the possibility of linear extension for future expansion.

b) *Linear concept.* The linear building concept may be regarded as an extension of the simple building concept, that is, the simple building is repeated in a linear extension to provide additional apron frontage, more gates and more space within the building for passenger processing. Passenger and baggage processing can take place in a central area of a terminal (centralization), but when the terminal becomes larger with increased number of aircraft gate positions the problem of long walking distances arises. This problem can be solved by installation of mechanical devices, such as people movers, or by decentralization of some passenger and baggage processing facilities. Complete decentralization would allow passenger and baggage check-in and baggage claim at the individual gate and thus afford very short walking distance between curb-side and aircraft, but construction and operation become costly. The degree of decentralization of processing facilities must be determined after careful study of volume and type of traffic, and of construction and operation costs.

   The linear configuration lends itself to the development of adequate close-in public parking. Ample curb frontage for loading and unloading ground transportation vehicles can be provided with each extension of the linear building. Linear buildings can be expanded with almost no interference to passenger processing or aircraft operations. Expansion may be accomplished by linear extension of the existing structure's air-side corridor or by developing two or more linear building units connected by an air-side corridor. The loading of aircraft may be accomplished by nose-in/push-out operations with or without passenger loading bridges.

c) *Pier (finger) concept.* The finger or pier concept evolved in the 1950s when gate concourses were added to simple central buildings. Since then, very sophisticated forms of the concept have been developed with the addition of hold rooms at gates, passenger loading bridges, and vertical separation of the ticketing check-in function from the baggage claim function. However, the basic concept has not changed in that the main central passenger building is used to process passengers and baggage (a centralized system, although waiting lounges in most cases are dispersed at each gate position along piers) while the pier provides a means of enclosed access from the central building to aircraft gate. Aircraft are parked at gates along the pier as opposed to the satellite concept where they are parked in a cluster at the end of a concourse (see Figure 7-3).

   Walking distances through pier buildings tend to become long. Curb space must be carefully planned since it depends on the length of the central building and is not related to the total number of gates afforded by piers. This is particularly true of deplaning curbs near centralized baggage claim facilities. Although the pier concept has afforded one of the most economical means of adding gate positions to existing buildings, its use for expansion should be limited. Existing piers should not be extended at the expense of taxiway manoeuvrability nor should new piers be added without providing adequate space for passenger processing in the main building. Most successful additions are effected by extending the main building and then increasing the number of piers.

d) *Satellite concept.* The primary feature of the satellite concept is the provision of a single centralized terminal with all ticketing, baggage processing, and ancillary services except waiting lounges, which is connected by concourses to one or more satellite structures. The features of the satellite concept are very similar to those of the pier concept except that aircraft gates are located at the end of a long concourse rather than being spaced at even intervals along it. Satellite gates are served either by common or by separate hold rooms. The concourse can be elevated or located underground, thereby providing space for ground service equipment and aircraft taxi operations between the main building and the satellite.

   Because the distance from the main building to a satellite is usually well above the average distance to gates found with the pier concept, a people-mover system or some other mechanical devices are often used to reduce walking distances between terminal and satellite. There is no direct relationship between the number of gates and curb space so that special care should be taken in the planning of enplaning and deplaning roadways serving the central building to prevent curb overloads.

   Buildings developed under the satellite concept are difficult to expand without reducing apron frontage or disrupting airport operations. Increases in building capacity are therefore usually effected by the addition of new units rather than expansion of an existing unit.

e) *Other concepts.* Other passenger terminal concepts include the transporter concept (also known as the remote aircraft parking concept) and the unit terminal concept. The former involves the vehicular transport of departing and arriving passengers discussed in Chapter 7, and may be combined with other concepts to cater for peak hour demands. The latter is one where the individual compact module units are built around a system of interconnecting access and service roads. The buildings are spaced some distance apart under this concept, with each building providing complete passenger processing and aircraft parking facilities. Consideration of the unit terminal concept is usually feasible only for the larger airports.

9.2.38 Passenger building concepts can also be considered by the level(s) on which passenger arrival, processing and departure takes place. Four typical configurations are as follows (see also Figure 9-2):

a) *Single-level road/single-level terminal.* Arrival and departure processing in the terminal is done at same level but is separated horizontally. Passenger boarding to aircraft is by means of stairs.

b) *Single-level road/double-level terminal.* Arrival and departure processing in the terminal is normally at grade (road level) with departure lounges on a higher level, permitting the use of passenger loading bridges or of transporters with level change capabilities.

c) *Double-level road/double-level terminal.* Access roads and curb-side are on different levels, to allow vertical separation of arrival and departure processing in the terminal (usually, the upper level is for departure and the lower level for arrival).

d) *Single-level roads/double level terminal.* This is a variation of c), with access road and curb-side for arrival and departure separated horizontally (laterally) but not vertically.

9.2.39 In the process of developing a terminal concept, planners must also pay attention to the desired degree of centralization or decentralization of the passenger and baggage processing facilities (passenger/baggage check-in, government and security control, baggage sorting and make-up, departing passenger holding, and baggage claim facilities) within a terminal. A centralized design means that all passenger and baggage processing facilities are centralized for common use by all gate positions at a terminal. (There are variations and exceptions to this, such as the pier concept which is basically centralized yet normally provides passenger holding lounges for exclusive use by each gate position.) In contrast, each of the processing facilities in a decentralized design is dispersed over a number of centres within a terminal. In a completely decentralized concept, all of the processing facilities are available at each gate position for its exclusive use. Complete decentralization affords advantages such as shorter walking distances, efficient passenger and baggage flow, less chances of mishandled baggage, etc., but it may turn out to be uneconomical due to under-utilization of personnel, equipment and terminal space. Thus the planner should analyse the efficiency of the processing system as a whole, its economy in terms of total requirements of floor area, equipment and personnel, and passenger convenience to achieve optimum degree of centralization or decentralization of the passenger and baggage processing facilities.

Capacity and Demand

9.2.40 In planning, the aim should be to ensure that capacity satisfies demand within practical economic limits and to provide capability for increased capacity as demand increases with traffic growth. Because of the time required to construct additional facilities, it is normal practice to plan capacity which will be in excess of demand during the initial life of the facility. Statistical forecasts to be used for planning are discussed in Chapter 3.

Movement rate

9.2.41 For planning purposes, the capacity of a passenger building or of its segments is usually expressed in terms of achievable movement rates or, in some cases, of actual populations for a given area. Although there are different criteria used to describe movement rate, the basic concept is one of a number of movements (of passengers, bags or vehicles) per unit of time, the appropriate unit of time depending upon the particular application. In some cases it may be desirable to plan capacity to satisfy an estimated peak demand, but normally a figure somewhat below this will be more realistic due to costs involved and space required. What is important is to match the capacities of different segments in the processing, because inadequate capacity in one operation will restrict the overall flow.

9.2.42 The capacity of the public corridor in passenger buildings is a function of walking speed, the width occupancy expressed as a lateral distance per person (passenger or visitor), and headway distance between persons in the direction of flow. While variations in speed, width and distance are bound to occur, averages can be selected in order to arrive at an average flow of persons per unit of time per unit of width of public corridor, using the following equation:

$$CC = \frac{WS}{WO \times HD}$$

where:

CC = corridor capacity (number of persons per minute, per one metre width);
WS = walking speed (normally 75 m per minute);
WO = width occupancy (0.6 $\sim$ 0.8 m per person);
HD = headway distance between persons (1 $\sim$ 2 m).

9.2.43 In order to determine the width of a facility such as a pier, the total flow rate per unit of time must be known. Arriving aircraft create a much greater concentration of passengers in a relatively short period of time than do departing aircraft, a problem which is compounded when large capacity aircraft use the airport. The size of this surge will depend primarily on the size of aircraft, their arrival schedules, and the number of exits that are used. Therefore, in the planning of space for a pier facility, a flow rate of passengers per hour is not appropriate; a much shorter time period, such as five to ten minutes, may have to be used. The appropriate time period for all parts of the passenger building will not be the same and must be assessed individually depending on function.

Capacity to be provided

9.2.44 Airport authorities may be faced with a number of alternatives in deciding the capacity for which passenger facilities should be planned. The introduction of new very high-capacity aircraft made it much more important to consider these alternatives, because their passenger capacity may represent a very large proportion of the hourly capacity of many passenger buildings, accentuating the concentration of passenger flow. Four alternatives are outlined below; all four have disadvantages and the choice should be made by progressive elimination of the least desirable.

First alternative: estimate the building area required for the maximum passenger capacity of the runways (that is, assume that all runways will be used to their maximum capacity and that all aircraft will be the largest type forecast to use the airport). In actual practice, the forecasts of passenger demand and probable aircraft mixture will usually produce a passenger flow rate below this maximum passenger capacity, allowing a downward adjustment of the building area required.

Second alternative: allow delays and congestion caused by surges in the flow to rectify themselves within one hour, as provided for by the standard busy rate which assumes that peaks of up to 20 per cent will occur for short periods. As traffic increases at busy periods, however, and with high capacity aircraft, it may be expected that congestion in any one hour would spread to succeeding hours and it would soon be necessary to restrict the traffic demand. Acceptance of such excessive delays is most undesirable.

Third alternative: spread the traffic evenly throughout the hour by specifying a capacity for a shorter period, for example 15 minutes. This would restrict aircraft scheduling so that the passenger flow is evened out over the hour. This is practised by some airport authorities and has the advantages of spreading the airport's utilization and permitting more efficient and economic use of facilities and staff. It may not be favoured by some aircraft operators because it limits the use of any preferred departure and arrival times. However, every airport and passenger building has a finite capacity which, when reached, requires schedules to be spread. The disadvantage of this procedure is that it cannot be applied to arrivals traffic. Conditions en-route, such as winds and delays at other airports, can introduce a considerable element of irregularity in arrival times and small variations can accentuate surges and have a large impact on the passenger flow.

Fourth alternative: plan the passenger facilities on the flow rate indicated by the size, duration and frequency of the passenger surges. This would produce an hourly capacity significantly higher than the capacity necessary for an even distribution of traffic throughout the hour. The cost of providing capacity for the passenger surges within the hour should be considered and the capacity to be provided should be determined by the over-all cost-benefit analyses. If provision of passenger capacity for the forecast flow conditions cannot be economically justified, e.g. because of the infrequency of occurrence or very high cost, it may be necessary to combine some degree of limitation of aircraft operators' schedules with some passenger congestion of a limited duration.

Processing rates

9.2.45 The appropriate measurement of capacity may not be the same for all individual facilities. The rate at which passengers flow to a facility is determined by the rate at which they flow through the previous part of the route. For example, the rate at which passengers leave an aircraft is determined largely by the number and size of the aircraft doors used. The rate at which they flow into the passenger building depends upon the method used to transport them to the building. Passengers flowing through a pier will spread out according to their walking speeds and will arrive in a stream at the first control point, i.e. port health or immigration for international passengers and baggage reclaim for domestic passengers. Passengers conveyed to the passenger building in a vehicle, either from the aircraft or population centre, will arrive at the frontier controls or check-in position in groups.

9.2.46 The average time required to process one passenger at any specific facility depends upon the nature of the procedures; these vary, both in content and method, between States. The processing time for each facility and control on the flow routes can be determined by observation. It is not possible to define standard processing times for all airports, although the times achieved at other airports are often a good guide to the flow rate which can be achieved. For example, at some airports immigration officials undertake health document inspection or preliminary customs control. At others each of the controls is carried out by different officials at separate locations. Sometimes customs controls are established for clearance of passengers and baggage separately. At others both are cleared at the same point. Similarly, some aircraft operators check in passengers and their baggage at one point, others check in baggage at one point and passengers at another. These are only examples of the wide differences in existing passenger control procedures and a comparison of processing times is invalid without analysis of the methods and procedures used.

9.2.47 The nature of the control also determines the period of delay or degree of congestion which is acceptable at that point for the efficient operation of the passenger building. The standard busy rate, being less than the peak rate, assumes that it is exceeded for a small proportion of the time, which can lead to some short-term delays or congestion. For many facilities, such delays or congestion constitute only temporary reductions in convenience, which is reasonable and acceptable in over-all economic terms. However, in some parts of the flow route such delays could lead to major and intolerable inconvenience. These are the points where certain procedures have to be completed by a specific time to allow other procedures to be undertaken. For example, check-in usually has to be completed by a specific period before flight departure time to permit aircraft operators to complete aircraft documentation and load balance, etc. Thus, if check-in desk capacity is computed at the standard busy rate, the temporary delay or congestion which may arise when that rate is exceeded could prevent some passengers from checking in by the latest specified time and either delay the aircraft or cause the passengers to miss their flights.

9.2.48 Each procedural control on the flow routes should, therefore, be analysed to determine the acceptable delay factor applicable to it. The capacity required for each facility is thus determined by the rate of flow to it, the average passenger processing time and the acceptable delay factor.

9.3 PASSENGER BUILDING CONNEXION WITH ACCESS SYSTEM

Land Side Entrances and Exits and Passenger Building Curb

9.3.1 Passenger building entrances, exits and curb area are important parts of the total airport system. The principal components are:

a) vehicular traffic lanes, through lanes, bypass lanes, curb/manoeuvring lanes;

b) sidewalk platform;

c) signs, for both direction and identification;

d) curb side baggage check-in points, located on the sidewalk platform;

e) building openings, entrances and exits;

f) pedestrian roadway crossings.

The necessary curb lengths and the vehicular traffic lanes will greatly influence the passenger building configuration. The vehicular curb areas at the passenger building are required for the efficient off-loading of departing passengers and their baggage, and for the efficient on-loading of arriving passengers and their baggage.

Signs

9.3.2 At this initial point of connexion of the passenger with the passenger building, directional and identification are most necessary to facilitate on orderly flow of passengers to their desired locations. The Council of ICAO recognized this need when they decided that a set of uniform signs should be developed for use at international airports throughout the world. This action was taken to facilitate air travellers in locating various facilities and services such as telephones, check-in counters, baggage reclaim areas, post offices, toilets and banks. The ICAO publication *International Signs to Provide Guidance to Persons at Airports* contains such a set of signs.

Curb-side layout

9.3.3 The shape of ground vehicles and the numbers to be accommodated make the provision of sufficient space of a suitable shape for vehicle unloading one of the most difficult elements of passenger building planning. For the shortest flow route the unloading points should be as close as possible to the first processing positions in the passenger building. For straight and direct flows it should be possible to enter the building directly from the unloading points at any point along its frontage. The unloading area should be on the same level as the passenger departure floor and its depth should be the minimum possible consistent with other requirements. The capacity of the unloading area can be increased by introducing a two-level road system. If it is necessary to consider the alternative merits of increased depth or more levels, the choice should depend on the horizontal and vertical length of the passenger route.

9.3.4 The passenger building entrances and exits, with their signs, can be considered points for potential vehicular traffic accumulation. The planner needs to establish the relationship between the possible number and location of terminal openings, the terminal functions with which they connect, and the total required curb length.

9.3.5 Ticket lobby length is usually determined by the length of the ticket counter. The number and spacing of building openings are functions of the layout of the ticket lobby. The effective terminal curb length available relates directly to the arrangement of the building openings.

Similarly, the baggage reclaim lobby dimensions, predominantly the reclaim device arrangement, will determine the number and spacing of building openings and the effective passenger building frontage available. Building concepts providing curb areas greatly in excess of the building length or providing an excess of building entrances and exits with little direct relationship to either ticket counter or baggage reclaim should be analysed for their economics, efficiency, and passenger convenience.

9.3.6 The curb-side baggage check-in system was once considered to be ideal for departing passengers as they could drop their baggage at a designated area of the enplaning curb frontage for an airline agency to check-in, thus becoming free of their baggage prior to checking in for their seats. However, for security reasons this system is no longer considered practical for international flights. In this regard it is worth noting that ICAO Annex 17 calls for a State to establish measures to ensure that operators providing service to or from that State do not place or keep the baggage of passengers who have registered, but who have not reported for embarkation, on board the aircraft, without subjecting it to security control.

Capacity and curb space utilization

9.3.7 The curb length required is affected by the numbers, average size and characteristics of vehicles. The use of cars by passengers may be influenced by any public transport systems which are provided, particularly an exclusive town centre/airport system. The distribution of passengers by travel modes and the numbers and types of vehicles to be accommodated can be obtained from the operational and economic forecasts. The minimum time necessary to unload passengers and baggage depends upon the average number of passengers per vehicle and the average number of pieces of baggage per passenger. Occupancy time should be limited to ensure that there is always space to unload passengers and baggage without congestion or delay. This limitation will depend upon the rate of arrival of vehicles and the total number of spaces available — many airport authorities have found that a waiting period of three minutes for cars is sufficient for unloading and is consistent with provision of a number of car spaces which is economically reasonable and compatible with the passenger flow principles.

9.3.8 An analysis of curb space utilization by the various types of vehicles should be performed. It is assumed that curb areas for buses, limousines and courtesy cars will be designated areas and, as a consequence, can be completely controlled. Similarly, queue lines for taxis will be designated and controlled. Pick-up of passengers by taxis at the deplaning road sections can be controlled by dispatching from a designated queue line.

9.3.9 The loading and unloading of passengers by private vehicles and unloading by taxis cannot be tightly controlled. Orderly performance therefore depends on the arrangement and organization of the curb lanes, building openings and signs.

9.3.10 Vehicular curb manoeuvring lanes are provided for the purpose of loading and unloading passengers with bags. The dimensions in length and width need to be such that traffic volumes generated for the design year during peak periods will be processed without undue delays. The curb manoeuvring lane width should be approximately 1.6 of a regular traffic lane, to permit manoeuvring to take place without interfering with the flow of traffic.

9.3.11 The curb manoeuvring lane should be used only for loading and unloading, and not as a waiting area for vehicles. Each vehicle should occupy a curb space only for the time it takes to load or unload passengers and baggage, and to manoeuvre into and out of the space. This total time is identified as the "dwell time/vehicle." Strict policing, as done at many high-volume airports to minimize dwell time, will promote an efficient traffic flow.

9.3.12 The number of building entrances and exits signs, and sign programme both for public information and airline identification should be arranged in such a manner that the effective curb length thus formed will closely approximate the required curb length.

9.3.13 The required curb length can be calculated as follows:

a) Determine design hour passengers enplaning and deplaning. Identify the design period for deplaning passengers within the peak-hour — peak 10 or 20 minutes (a 20-minute peak can be equivalent to 50 per cent of the peak-hour traffic).

b) Determine the percentage of transfer passengers of the total, and deduct from the total design hour requirement to find the number of passengers entering the airport using the road system.

c) Determine the modal preference by vehicular type.

d) Determine the percentage of passengers that go directly to the parking facility and do not use the curb system.

e) Determine the visitor ratio of passengers to visitors, and apply to the percentage of passengers using private vehicles.

f) Determine occupants per vehicle and the average curb dwell time for that type of vehicle.

Relationship of curb to passenger building layout

9.3.14 The total calculated curb lengths need to be related to actual terminal layouts for both enplaning and deplaning. The total length of the facade of the ticket lobby and the baggage claim area must be arranged in relationship to the required curb lengths.

9.4 PASSENGER PROCESSING

Check-in Concourse

9.4.1 The area between the passenger building entrance and the check-in positions is the check-in concourse (note that facilities for check-in may also be provided at the aircraft gates). The primary flow is that of passengers holding flight tickets and proceeding directly to check-in; separation of functions is most important in this area to ensure that this primary flow is not compromised (see Figure 9-3).

9.4.2 The airline ticket counter is the first objective for originating passengers once they have entered the passenger building. To ensure that the passenger reaches this first objective with a minimum of confusion, the check-in concourse should be designed so that counters and individual airline or flight locations are clearly visible immediately upon entering the passenger building. Circulation patterns should allow the option of bypassing counters with a minimum of interference. Provision for seating in this area of the building should be minimal to avoid congestion as well as to facilitate exposure to concessions and other services.

9.4.3 Until passengers have checked in, they have no assurance of being able to travel and cannot proceed through any subsequent controls. Passenger and baggage check-in has to be completed some time before flight departure to provide sufficient time for subsequent procedures such as aircraft operators' documentation and aircraft load computation, loading baggage into the aircraft, clearing passengers through government controls where required and boarding of the aircraft by passengers.

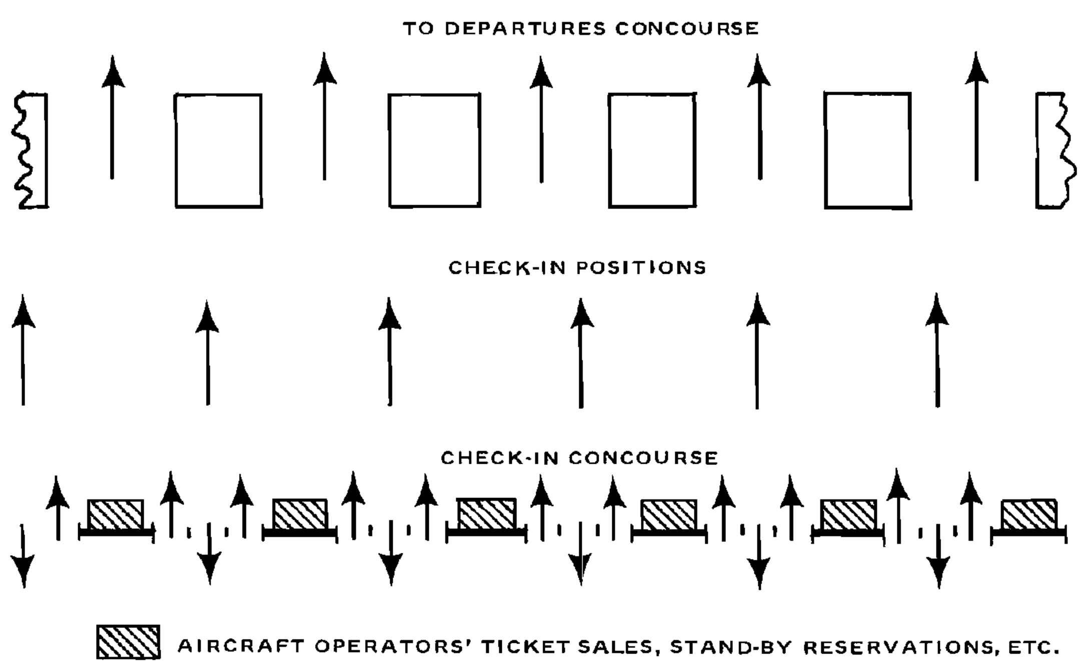


Figure 9-3. Passenger check-in flow

Aircraft operators' documentation and baggage handling are usually the limiting factors which determine the time by which checking in must be completed.

9.4.4 The space between the land side entrances and check-in positions should be sufficient to provide free access to check-in and other facilities. Check-in concourse sizing is a function of total length of airline ticket counter frontage, queuing at counters, and allowance for lateral circulation without undue congestion. For small- and medium-sized airports, a depth of approximately 10 m should be adequate for the check-in concourse. However, airports having a high visitor/passenger ratio may require additional depth.

9.4.5 Although check-in is the primary activity in this area, a number of allied functional facilities, i.e. aircraft operators' ticket sales, stand-by passenger registration, aircraft operators' information and currency exchange facilities may also have to be accommodated.

Aircraft operators' ticket sales, stand-by registration and information

9.4.6 Passengers purchasing tickets or making stand-by registrations must do so before they can check in. Similarly, passengers may require information from aircraft operators before purchasing tickets or making reservations. To ensure unobstructed flow to the check-in positions these facilities should be located clear of the primary flow streams.

Currency exchange

9.4.7 Passengers making payments for ticket purchase or airport tax may need to cash cheques or change currency, and a bank or currency exchange facility is, therefore, required in the check-in concourse. In choosing the location, care should be taken to ensure that passengers using this facility do not interfere with the free flow of passengers through the building.

Airport tax or passenger service charge

9.4.8 Where airport taxes or service charges are imposed on departing passengers, methods should be developed whereby passengers may pay them when purchasing tickets. When this cannot be done, arrangements should be made for payment of these charges in the vicinity of check-in counters. The fullest advance warning should be given to ensure that passengers are aware of any payment to be made before they arrive at the point of collection or pass the currency exchange.

Check-in

Capacity

9.4.9 The number of check-in positions required is a function of the time required to process one passenger and the rate of flow to the check-in positions. Average check-in process times vary according to the route and category of traffic and should be determined in consultation with aircraft operators. Based on the process time, a sustainable check-in rate can be defined and the capacity for each position required can be defined. Surges within the hour occur on the same basis as for the land side vehicle unloading positions and the unit period for rate of flow measurement should similarly be obtained by research measurement. It is necessary to ensure that passengers arriving just before the designated final check-in time can be processed without delay.

9.4.10 The type and number of counter positions required are usually determined by the airport authority in consultation with each airline or handling agency according to its staffing criteria and company standards for processing passengers and baggage. Individual airport variables that influence the number of positions include one or more of the following:

a) *Design hour enplanements.* These are usually derived from projections of peak hour/average day of peak month enplanements plus consideration of the number of gate positions, the seating capacity of aircraft that those gate positions can accommodate, and boarding load factors considered representative for the airport.

b) *Contact ratio.* This ratio is usually projected from historical data and shows the relationship between the number of passengers who contact counter agents and the total number of enplanements or originating passengers. Separate contact ratios can be determined for each type of counter position: ticketing, baggage check-in, multipurpose, information, and future ticketing.

c) *Passenger arrival distribution patterns.* This is the rate at which enplaning passengers arrive at check-in counters for processing, sometimes presented in tables showing the percentage of passengers arriving in 5- or 10-minute increments during a period up to 120 or 150 minutes prior to departure. Two different patterns may be applicable at some airports where the passenger arrivals for early morning flights occur during a shorter time span than do passenger arrivals during other times of the day. Figure 9-4, which

Line	Minutes Prior to Departure																								
	120	115	110	105	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5	0
A		1	1	2	2	2	3	3	4	4	5	5	6	6	8	8	8	8	7	6	5	4	3	2	0
B							0	1	1	1	2	3	4	5	6	8	9	11	10	10	9	8	6	4	2

Line A — Percentage distribution of passengers arriving for flights departing between 1000 and 0400.

Line B — Percentage distribution of passengers arriving for flights departing between 0405 and 0955.

Figure 9-4. Passenger arrival distribution

illustrates these points, can be derived for individual airports by time-coding passenger tickets at contact with the agent and then relating this time to the scheduled departure time of the passenger's flight.

d) *Average process time for each type of counter activity.*

e) *Service goals of an individual airline for specific types of counter positions.* These are generally expressed as the percentage of passenger contacts who will wait for service "x" minutes or less.

The combination of enplanements, contract ratios and arrival patterns describes the passenger flow to a given type of counter. Passenger flow, process time and airlines' service goals are used to determine the number of agent positions required.

9.4.11 Late check-in can be effected at the aircraft gate in circumstances where passengers would otherwise miss their flights. This places on passengers the burden of transporting their baggage to the gate, but the system is permissive and it is for the passengers to decide whether to accept the burden or miss the flight. This arrangement should, however, only be used to supplement the provision of appropriate check-in facilities in the check-in concourse. If the terminal is designed following a completely decentralized concept (gate check-in concept), late check-in can be easily accommodated. However, consideration shall be given to the economic aspect since personnel and facilities tend to be underused when decentralized.

9.4.12 Further considerations influencing check-in capacity are the number of aircraft operators, their shares of the traffic and frequency of operation, the allocation of check-in positions and operating system adopted. The minimum facilities will be required when all are used homogeneously and any passenger can check-in at any position for any flight. Utilization of the facilities, and hence the total capacity required, will depend on whether particular positions are designated for specific purposes (for example, specific check-in positions for domestic as opposed to international services, or separate positions for each operator or flight). The check-in capacity to be provided is a matter for both aircraft operators' and airport authorities' judgement.

9.4.13 Use of the land side vehicle unloading positions and entrances to the passenger building has also to be related to any allocation of check-in positions for specific purposes. Homogeneous use of all check-in positions provides the greatest passenger convenience and ensures highest utilization of land side vehicle unloading positions and check-in facilities and, therefore, requires minimum provision of these facilities and building space. The more that facilities are allocated to specific uses the more difficult it becomes to provide balanced capacity over all parts of each flow stream, with passenger routes becoming less straight and cross-flows developing along the length of the building. The optimum balance is often difficult to define but it will be achieved by close adherence to the flow principles and cost-benefit assessment.

Check-in systems

9.4.14 The check-in system used by airlines or handling agencies can exert a major influence on planning. The conventional check-in system of manual ticket control and baggage weighing and labelling is still in use, but only at small airports. Many operators find it economically justifiable to install computer check-in systems, and already computerized departure control systems with inputs from check-in desks at airports and elsewhere are being widely used. Airport planners should be aware of common use terminal equipment (CUTE) which is a generic airline industry term for a facility which allows individual airlines to access their host computer(s), and to share passenger terminal handling facilities. Full details in respect of CUTE systems are contained in IATA Recommended Practice 1797 which is available from Senior Manager, Passenger Services, IATA, 2000 Peel Street, Montreal, Quebec, Canada, H3A 2R4. A concurrent development is the elimination of baggage weighing and thus the need for scales. This already applies on many domestic routes, where the passenger baggage entitlement is fixed as a specified number of pieces of defined size.

9.4.15 These new operational systems can affect passenger building planning by imposing different space requirements for the check-in positions. They may also reduce the passenger service time so that the capacity (flow rate) of the check-in positions would be very considerably increased. The capacity of any particular section of the passenger flow routes should be matched by a corresponding capacity in the other sections. Failure to do so merely causes congestion and consequent delay in the subsequent lower-capacity sections of the route, or under-utilization of the high-capacity section, because passengers cannot flow to it fast enough.

9.4.16 Changes in check-in systems can also affect their utilization and the systems of allocation. The extent to which new high capacity check-in systems can, or need to be adopted, will vary among aircraft operators and the routes and types of traffic which an airport serves. The appropriate balance between numbers for each type of system and the appropriate system of allocation should be determined by the airport authority in consultation with operators, in the light of local circumstances.

Check-in counters

9.4.17 The passenger terminal layout is largely influenced by the check-in concept and the ticket counter configuration employed by airlines and handling agencies. Consequently, it is essential that airlines and handling agencies are consulted at an early stage of the planning.

9.4.18 The check-in system may be divided into the following three concepts:

a) *Centralized check-in concept.* Passengers and baggage are processed at check-in counters located in a common central area, usually the departure concourse of the terminal. The counters may be of different configurations and may be divided into sections specially designated for individual airlines (airline base) or flights (flight base) or alternatively passengers may be free to check-in at any counter positions (common base).

b) *Split check-in concept.* The check-in function is split between two or more locations within the terminal complex, e.g. baggage may be accepted at check-in counters on the lower level and seat assignment takes place at the waiting lounge on the upper level of the terminal.

c) *Gate check-in concept.* Gate check-in is normally directly related to the decentralized passenger terminal concept. By this system passengers and baggage are processed at check-in counters located very close to an aircraft gate position (or a few positions in case of semi-decentralized passenger terminal concept) and its waiting lounge. This concept can afford advantages such as short distances, simple check-in handling for both passengers and baggage, etc. However, economic aspects should be well taken into consideration, since the facilities and personnel tend to be under utilized during off-peak hours.

9.4.19 The check-in counters, on the other hand, may be divided into three types of configuration:

a) *Linear counter.* This is the most frequently used ticket counter configuration. At low-volume airports multipurpose positions are common where an agent can perform any ticket transaction, check in baggage, and provide such other service as an airline may deem appropriate to its operation. Multipurpose positions reduce the number of servicing stops for some passengers and afford flexibility in staffing, especially during non-peak periods.

   During peak periods, some airlines utilize multipurpose positions for a single function to expedite processing of passengers who need only one type of service (e.g. ticketing, baggage check-in, ticketing for future flights, etc.). At high-volume airports, single function positions become more common and airline servicing procedures may justify some special-purpose positions in addition to those single function positions. Special-purpose positions provide general information and passenger assistance, including paging service, gate assignments, information regarding delayed or cancelled flights and weather. Some of these services may also be required in departure lounges.

b) *Flow-through counters.* This concept is in use at some airports, although experience indicates that future applications may be limited to relatively few airports. This concept appears to be most successful when specialized for baggage check-in, where passengers queue along the baggage input, complete their transactions with the agent, and walk through to a lobby or circulation area beyond. The principal advantages are reducing cross-circulation and increasing baggage take-away capability, by providing one input for one or two positions at linear counters. This increased capability can be beneficial at high-volume stations having a relatively high percentage of "baggage-only" transactions.

One difference between linear and flow-through counters is the additional floor space required for the latter — usually 4.6 to 6.5 square metres more for each bag check-in position, including space for queuing. Another characteristic is that out-bound baggage systems become more complicated with flow-through counters because of the greater number of individual inputs and the difficulty of merging multiple inputs into a single transport conveyor or sorting device, thereby increasing investment and maintenance costs for baggage systems.

c) *The island counter.* This concept combines some features of both the flow-through and linear arrangements. The agent positions form a "U" around a single conveyor belt (or pair of belts), providing interchangeability between multipurpose or specialized functions.

Layout

9.4.20 Check-in facilities should be located so as to enable passengers to check in at the earliest possible moment, thus reducing the effect of delays at earlier stages of the flow route and permitting the latest possible arrival at the airport before flight departure. This also enables passengers to be relieved of their baggage at the earliest opportunity.

9.4.21 Check-in positions should be immediately obvious on entering the building. Passengers flow to the check-in positions in a number of parallel streams formed by the layout of the land side vehicle unloading positions, and the passenger building land side entrances. The layout of the check-in facilities is influenced by two considerations — preservation of the straightness of the parallel flows across the check-in concourse through to the air side, and minimum distance to the air side. Examples of check-in layouts are shown in Figures 9-5, 9-6 and 9-7. For straight, direct flows passengers should pass between the check-in positions as through a comb, as depicted in Figures 9-5 and 9-7; long continuous lines of check-in positions at right angles to the flow can conflict with the flow principles.

9.4.22 The check-in positions should be grouped into units of sufficient size to maintain acceptable staff costs and utilization compatible with efficient passenger flow. Too many positions in each group would compromise the flow principles to an unacceptable extent, and the flow rate would be reduced by congestion and confusion. The larger the number of positions the more the passenger flow is distorted.

Offices

9.4.23 Aircraft operators often require staff offices at the check-in positions. These should be arranged to ensure that visual continuity is preserved from the check-in concourse through and beyond the check-in positions. Passengers are drawn on through the building when they can see self-evident and continuous flow routes ahead of them. The more that offices are sited in the flow routes the more difficult it becomes to provide visual continuity and the longer the routes become because of the space required for the offices. Therefore, only the minimum offices which are essential for the operation of check-in facilities should be provided in this area. They should form the rear of each of the groups of check-in positions with the passenger streams passing between them.

Flight information

9.4.24 Passengers have to be informed when their aircraft is ready for boarding and when delays occur. This has generally been done by loud speaker annoucements, but at busy airports such arrangements can cause problems: due to the constant flow of annoucements passengers tend to miss those applying to their particular flight and the high ambient noise level in buildings containing a lot of people necessitates a high volume for the loudspeaker annoucements which can cause severe discomfort for staff working in the building.

9.4.25 Visual presentation of flight information should, therefore, be considered. Flight information display systems should be considered at the same time as the check-in concourse and waiting areas are being planned. They should be located so that flight information is visible from all principal parts of these areas, and also to ensure that they do not create visual obstruction or cause passengers to obstruct the primary flow routes. In large buildings, the size of indicators necessary for viewing from all parts of the check-in and waiting areas may be incompatible with these considerations and more than one indicator at each location may be necessary (refer to the ICAO publication *Dynamic Flight-related Public Information Displays).*

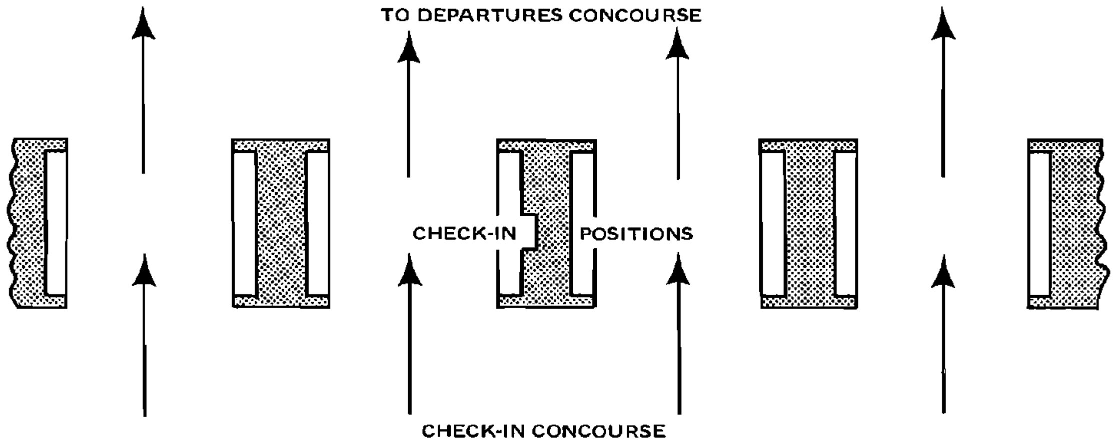


Figure 9-5. Passenger check-in layout

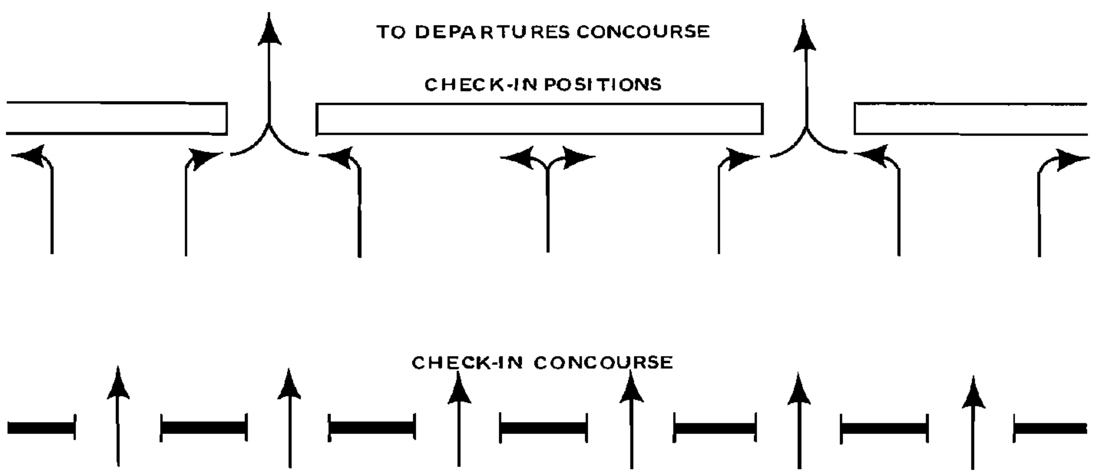


Figure 9-6. Passenger check-in positions and check-in concourse

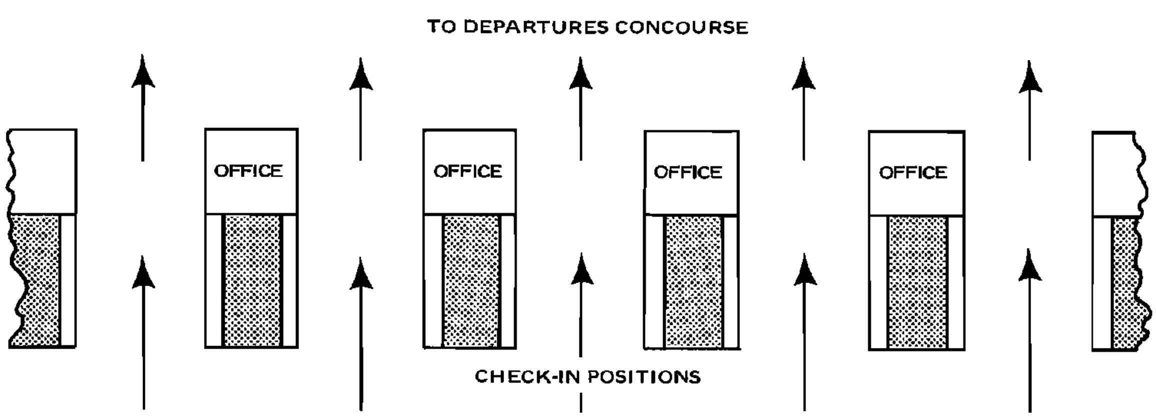


Figure 9-7. Passenger check-in positions

9.5 BAGGAGE PROCESSING

Baggage Processing Concept

9.5.1 For those parts of the passenger flow routes where baggage accompanies passengers, the passenger flow principles also apply to baggage. The term "baggage flow" refers to those parts of the system which are specifically for baggage handling when it is separated from passengers. General planning principles apply to baggage systems planning, while passenger considerations have to be noted at those points where the passenger and baggage flows come together. Factors to be taken into account include:

a) baggage and passenger flow should be matched in speed and capacity;

b) flow routes should not conflict with passenger or vehicular flows;

c) flow routes should be accessible so that baggage can be recovered at various stages;

d) the flow system should involve a minimum number of individual handling operations, e.g. transfers between different types of vehicles, etc., and the flow should be steady and uninterrupted;

e) passengers should have an opportunity to check their baggage at the earliest possible point;

f) baggage claim systems should provide continuous presentation to passengers and permit them to recover their baggage personally;

g) flow routes may be influenced by the type of handling system adopted, e.g. manually or mechanically propelled trucks, conveyor belts, etc.; and

h) palletized systems should be compatible with aircraft baggage holds and loading systems.

9.5.2 Although it is not normally necessary, security checks of baggage may be required for specific flights or at certain locations; the type of checks may vary, depending upon the circumstances surrounding the particular threat and the method for inspection adopted. Security checks of baggage should be performed prior to flight check-in. Regardless of the system adopted, the baggage flow should be designed so that all baggage boarding an aircraft, including transfer baggage, is subject to the same inspection.

9.5.3 Figure 9-8 illustrates passenger and baggage flow systems which include the whole range of possible procedures which may require consideration.

9.5.4 Departures customs inspection is contrary to the International Standards and Recommended Practices of ICAO Annex 9 — *Facilitation*. States still retaining this control should conduct it prior to flight check-in.

9.5.5 Pre-clearance of baggage under bilateral agreements between States which provide for arrivals inspections to be carried out at the airport of departure is another possibility which should be taken into consideration in the early planning stage.

Baggage Check-in Remote from the Airport

9.5.6 Maximum convenience is achieved if passengers can be relieved of their baggage at the earliest possible stage of their journey. In the past some airports provided baggage check-in facilities at off-airport buildings such as specially arranged terminals in the city. For security reasons, however, this system is no longer recommended since it would create passenger/baggage matching problems at the airport prior to the passengers boarding the aircraft.

Departures Baggage Flow

9.5.7 Baggage facilities should be analysed as a flow plan and all systems should have maximum flexibility. Similarly, all baggage areas should be planned to provide the maximum clear, unobstructed space to facilitate adaptation to new systems and procedures.

9.5.8 After being checked in, baggage must be sorted into flight groups, then further sorted into sub-groups (such as destination airports, transfer baggage, and/or the particular aircraft holds in which it is to be carried). After sorting it may have to be stored for a period prior to delivery to aircraft. Where such controls exist, baggage may have to be submitted to customs inspection. The baggage system is, therefore, required to provide facilities for each of these functions. Except for the smallest airports this is best achieved by baggage handling being done on a separate floor below the passenger departure floor.

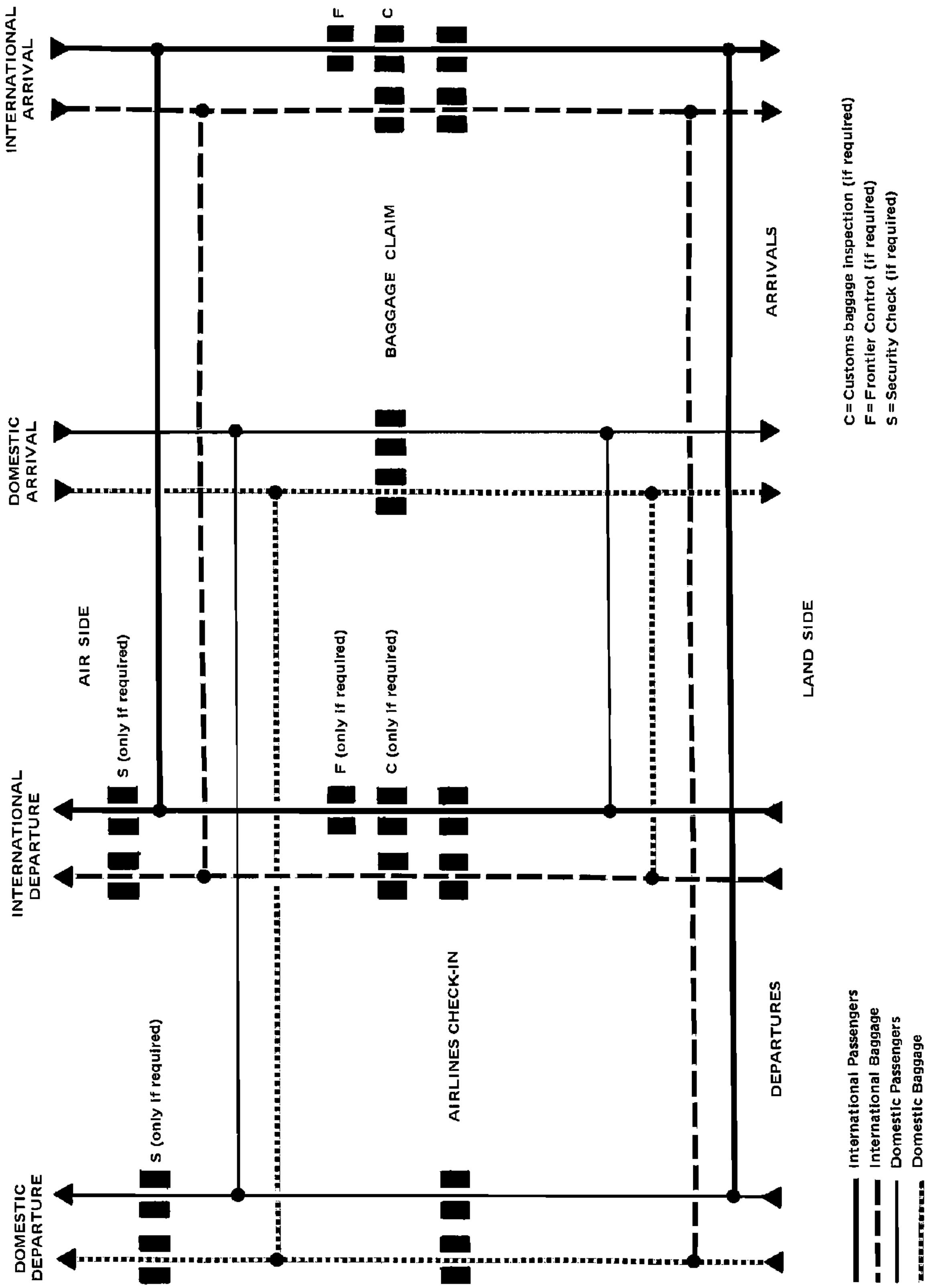


Figure 9-8. Diagram of passengers/baggage flow

Systems

9.5.9 The choice of baggage handling systems will depend upon the size and nature of the traffic and local considerations such as the cost and availability of manual labour and the skills of local labour for the operation and maintenance of mechanical equipment. The rate of traffic movement and quantity of baggage can quickly exceed the capacity of manual systems and mechanical and/or automatic sorting systems are often required. These may have the advantage of requiring less space than manual systems.

9.5.10 The sorting system can be fundamentally influenced by the check-in system and some systems completely integrate the two procedures. Even where the two systems are functionally separate the allocation of check-in positions can determine the form of the baggage sorting system. Thus the management policy to be adopted for check-in should be defined at the earliest stage and in conjunction with consideration of the baggage system. Shared baggage sorting systems which serve all check-in positions and all aircraft operators have considerable cost and space advantages and are compatible with aircraft operators' individual loading and transport of baggage to aircraft.

Security baggage inspection

9.5.11 The technique for security baggage inspection are extremely varied, and include hand inspection or inspection by detection devices. Usually inspection of checked baggage for security purposes will only be implemented when a potentially dangerous situation is believed to exist. All baggage will, therefore, not be required to be subject to inspection. It is important, however, when security measures are being invoked for a particular flight, that all baggage and cargo, mail, etc., intended for that flight be subject to the same checks. See Chapter 14 for additional information.

9.5.12 The baggage flow system should be designed so that persons not connected with processing of baggage or operation of the airport will be denied access to the baggage. Under certain circumstances, however, it may be necessary for passengers personally to identify, open and search their own baggage prior to loading, in order to ensure that nothing has been placed surreptitiously in the baggage. Facility for this may need to be included in the design of the airport.

Layout

9.5.13 No single layout offers such overwhelming advantages that it can be recommended for use for all baggage areas. The main factors to be considered are the handling time, which is usually a direct function of the distance which the baggage has to travel, and the provision of sufficient positions at the air side of the building for the delivery of baggage to aircraft.

9.5.14 Apron vehicles provide the cheapest and most flexible system for the transport of baggage between passenger buildings and aircraft. The size and shape of the vehicle loading positions in the baggage area depends upon the type of vehicles, e.g. conventional road vehicles or special trolleys formed into trains and towed by prime movers.

9.5.15 Most large aircraft are equipped for the carriage of baggage in containers which are loaded and emptied in the passenger building. This system is likely to be increasingly adopted and may influence the type of apron vehicles used. The types of containers, however, vary between aircraft and aircraft operators have differing methods of handling them; baggage storage and loading areas should therefore provide for loading of a variety of container types as well as uncontainerized baggage. Adjacent space may also be necessary for storage of a number of containers according to aircraft operators' requirements.

Departure customs baggage inspection

9.5.16 If, in spite of the provisions of Annex 9, departure customs baggage inspection facility is still required, the appropriate position is indicated on Figure 9-1. Customs baggage control should be located to avoid the need for repeated handling of baggage by aircraft operators and the consequent longer ground handling times and higher costs.

9.5.17 Government regulations may require inspection of registered baggage, i.e. baggage checked in for carriage in the aircraft hold and/or passengers' hand baggage. Hand baggage moves with the passengers and is, therefore, available for inspection at any point (see 9.7). But registered baggage is given up at check-in and dispatched to the air side for loading. Government regulations may require alternative procedures, depending on whether checks are random or continuous and the method by which they are imposed.

9.5.18 If all baggage is subject to inspection, the control positions should be sited at the point where the baggage and passenger flow routes separate — i.e. immediately before check-in. If random or selective checks of individual passengers' baggage are required, including pre-clearance under bilateral arrangements which provide for arrivals customs baggage inspection to be carried out at the foreign airport of departure, the control should be similarly sited. If customs inspection is carried out at check-in, the service time is considerably increased and the flow through the check-in facilities correspondingly reduced, making additional check-in facilities necessary. Because passenger convenience and flow speeds would be compromised by the longer flow routes arising, the functions should be separated.

Customs accommodation

9.5.19 In association with the baggage inspection control, customs may require offices for their administrative procedures, as well as for interview or search rooms for passengers found in contravention of regulations. The same considerations apply to the siting and form of these offices as to the airline check-in offices described previously. Office accommodation for customs in this area should be restricted to the absolute minimum necessary for application of baggage inspection; supporting administrative offices, rest rooms, etc., should be provided elsewhere in the building.

Baggage Claim
(see Figure 9-9)

9.5.20 A variety of mechanical and semi-automatic baggage claim systems are available and in use throughout the world. The main consideration in choosing a manual or mechanical claim system should be to reduce the amount of "milling" (random movement) of passengers.

9.5.21 Where the numbers of baggage or passengers in the claim area at any one time are fairly small, simple manual systems which rely on passengers moving to their bags are satisfactory. However, this can lead to confusion when too many passengers claim their baggage simultaneously. As passenger flow rates and aircraft sizes increase, baggage claim systems should be arranged to eliminate milling; this can only be achieved by having passengers remain in the principal flow streams and presenting their baggage to them, on equipment arranged in a "comb" across the line of the flow. For high flow rates, reduction in milling can be realized by presenting

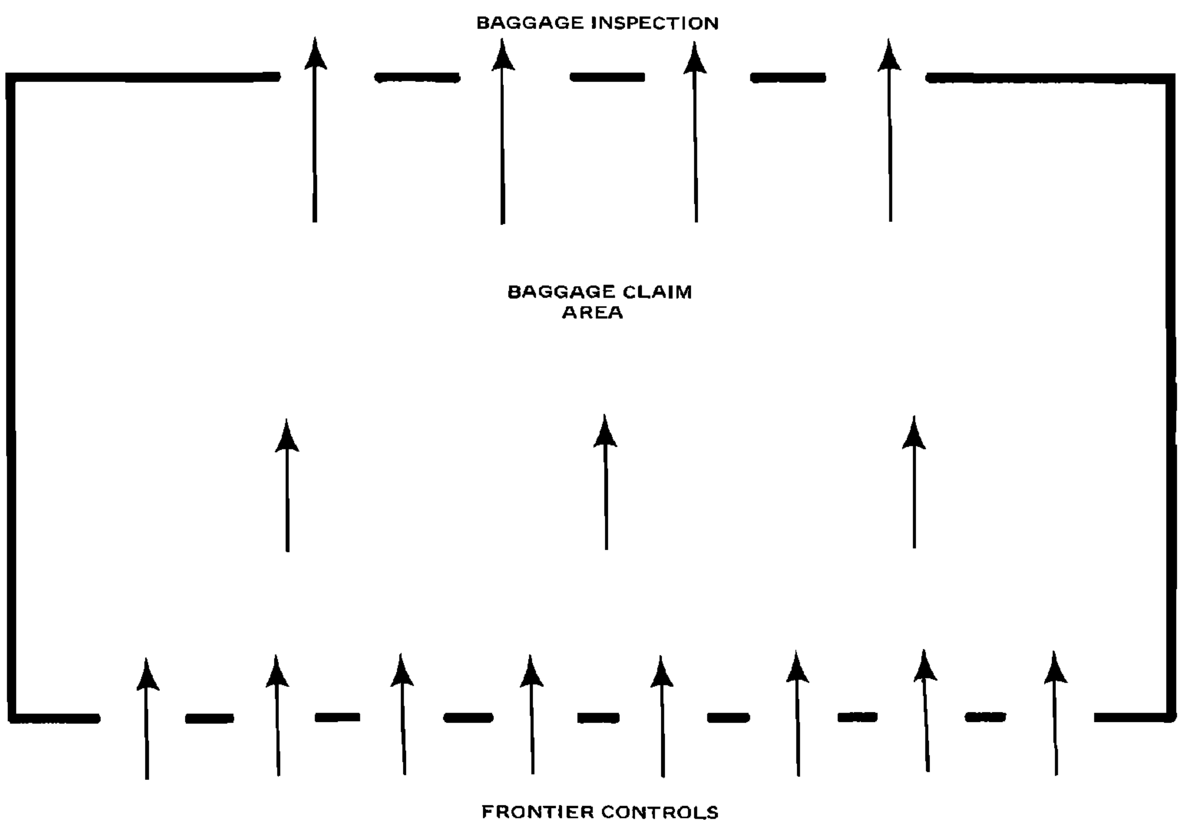


Figure 9-9. Baggage claim flow

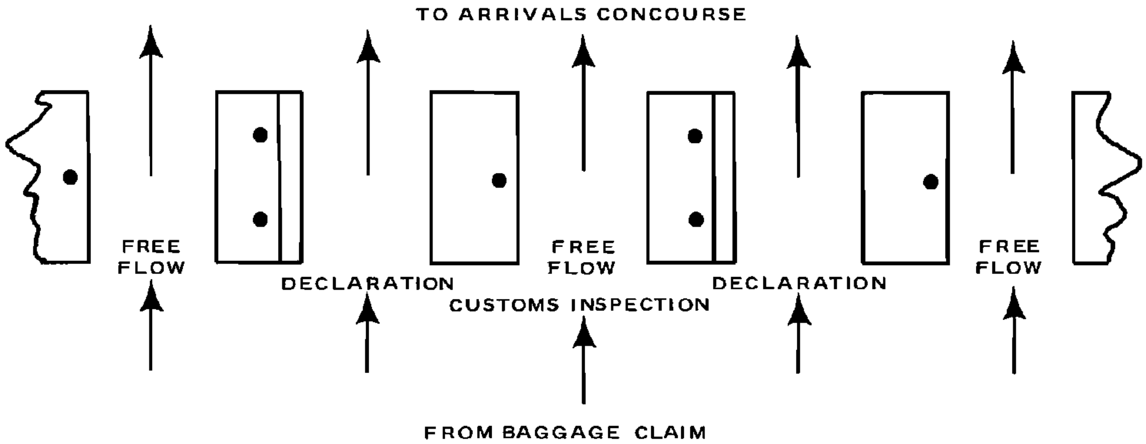


Figure 9-10. Customs inspection

baggage on a moving display, such as a revolving turntable or belt, which passes in front of the passengers.

9.5.22 Space should be provided, behind the frontier controls and in front of the baggage claim, in which passengers can wait if baggage delivery from aircraft is delayed. Facilities should also be provided in the claim area for the storage of baggage belonging to passengers who are delayed by health or passport controls. Misrouted or unclaimed baggage should be stored in facilities provided adjacent to the passenger processing areas, rather than in the claim area.

Customs Inspection
(see Figure 9-10)

9.5.23 At international airports, passengers flow from baggage claim to customs baggage inspection. Various inspection systems are possible, with the choice usually being dictated by the statutory regulations to be enforced. As for all passenger control, the customs inspection should be arranged as a "comb." Flow streams through the control should be arranged so that passengers with goods to declare do not hold up passengers without dutiable goods to declare. Annex 9 recommends that States introduce, at their major international airports, in close co-operation with the airport operators and other agencies concerned, a dual-channel system for the clearance inwards of passengers and their baggage. The system shall allow the passengers to choose between two types of channels:

a) one channel (green) for passengers having with them no goods or only goods which can be admitted free of import duties and taxes and which are not subject to import prohibitions or restrictions; and

b) the other channel (red) for other passengers.

It is possible to apply random or selective checks to these streams as may be required without interrupting the normal fast, unimpeded flow. The streams in the second category should flow past customs officers in the normal way.

9.5.24 Once "red" and "green" channels are adopted, the number of streams can easily be altered in accordance with the specific need at the time, as long as the total number of streams has been properly determined based on local conditions.

Arrivals Baggage Flow

9.5.25 The considerations to be taken into account in respect of the containers and vehicles onto which baggage is loaded and transported between aircraft and passenger building are the same as described in the departures section in 9.5.7 through 9.5.15. After arrival at the passenger building, baggage has to be unloaded from vehicles and containers and delivered to the baggage claim system or transferred to the departures area in the case of transit and transfer passengers. Sufficient space and height for easy manoeuvring of vehicles is required and also for storage and removal of empty containers. Sufficient space is also required adjacent to each baggage delivery facility to enable simultaneous use of several or all such facilities.

Convenient connexion with outwards baggage sorting area and wide storage areas for either empty containers or baggage should be provided. A one-way vehicle flow is desirable to provide unobstructed access for vehicles arriving from aircraft. Delays in baggage handling often occur at this point and delivery of baggage to the claim area at a rate comparable with the passenger flow is one of the most important elements of airport operation.

Transfer baggage

9.5.26 Passengers transferring between international flights should not have to claim their baggage until they reach their final destination. The baggage of all such passengers should be identified in the baggage vehicle unloading area and transferred directly to the departures baggage sorting area for integration with all other departures baggage. The route and system of transfer should be as direct and fast as possible to enable baggage to connect between flights with the least possible delay. Passengers transferring from international to domestic flights are usually subject to customs inspection and their baggage is, therefore, treated as normal arrivals baggage and delivered to the baggage claim area. This also applies to transit passengers on flights changing category.

9.6 PASSENGER WAITING

9.6.1 For certain passenger processing systems, waiting areas at or close to the aircraft gates may be required; the form and use of such areas depend on the systems used for connecting the passenger building to aircraft. Where waiting areas are provided at forward positions they may affect the form and use of the main waiting area in the passenger building. The waiting area can be the appropriate location for certain passenger amenities. It is, however, of the utmost importance to separate functions and preserve clear, unobstructed routes for the primary flows.

Capacity

9.6.2 The capacity of the waiting area should be defined by the number of passengers to be accommodated at any one time. The average time spent in the area is in part a reflection of the passenger processing system; a survey can be used to determine the proportion of the total passenger flow which proceeds almost immediately to the aircraft and the average time which the remainder of passengers spend in the area. The space required will vary according to the levels of comfort considered appropriate, and should take into account the average time spent in the area, climate and local custom.

9.6.3 The capacity required is a function of the passenger rate of flow, the average period spent in the waiting area and the functions carried on there. The capacity should be sufficient to absorb the difference in flow rates between check-in and aircraft boarding. The flow rate out of the waiting area is determined by aircraft apron movement rates and aircraft operators' procedures. The flow into the area may reflect influences from land side ground transport systems. Each should be separately assessed where either of these influences is dominant.

Layout

9.6.4 To maintain the straightest possible flow routes, the waiting area should be of the same general length as the departures concourse. Entrances should be provided for each main flow stream (where frontier controls are applied see also 9.7). For passengers proceeding directly to their aircraft, straight, clear routes, unobstructed by any other flows or functions, should lead directly from the entrance to the air side exits.

9.6.5 Passengers not proceeding immediately to board their aircraft will pass to the waiting areas, which should normally be sited to the side, and clear of, the direct flow to aircraft. The concept of flow planning still applies even for the time during which passengers are waiting; the general planning principle should be to site waiting areas and amenities so as to keep passengers with the longest waiting periods clear of the exit routes to the gate. Passenger circulation within the waiting area, i.e. to and from seating, amenities, toilets, etc., is random and adequate space is required.

9.6.6 Passengers often wish to board their aircraft as soon as it is possible to do so; this leads to surges in the flow out of the waiting areas. When flights have been delayed and complete passenger loads are waiting, surges in the flow can be large and will be accentuated with the introduction of very high capacity aircraft. Thus routes to the exits are required which will ensure the speediest and easiest flow from the waiting areas to the aircraft. To enable passengers to leave the area as directly and quickly as possible there should be routes to the exits along the whole air side frontage as shown in Figure 9-11. Any procedures or controls which aircraft operators apply, such as boarding pass inspection, etc., should be carried out at a point outside the waiting area. (A number of the points raised above will not apply if forward waiting areas are provided at the gate.)

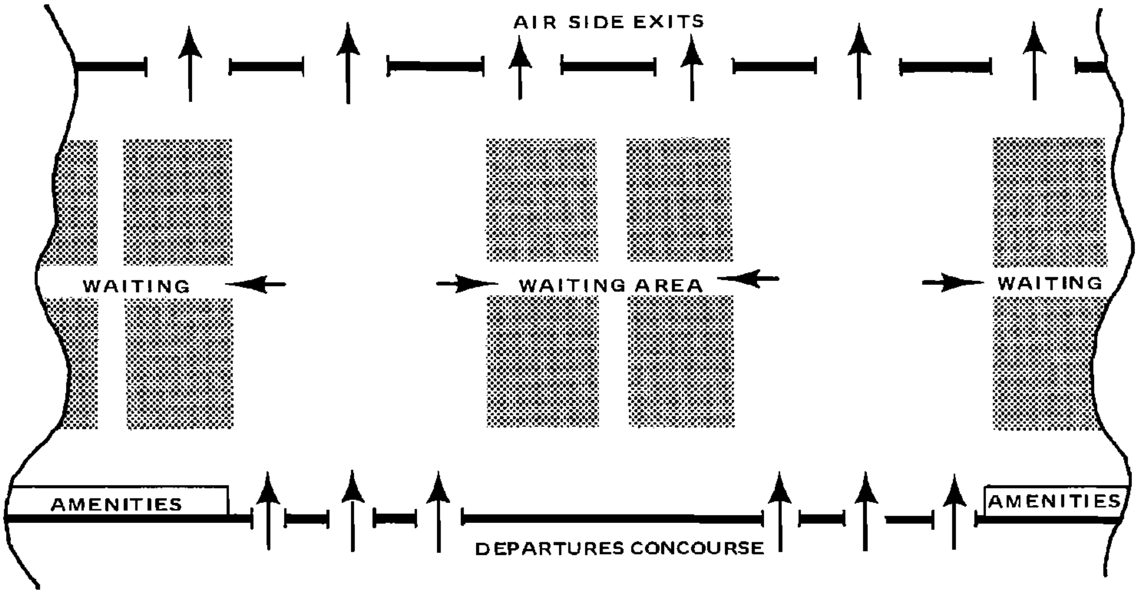


Figure 9-11. Waiting areas

9.6.7 Problems arise in planning when an area is very large. Passengers are attracted to positions from which there is a view of the apron and aircraft, and visual continuity is difficult to achieve when distances become too great. Thus, if the distance from land side to air side is too great, the land side of the area will tend to be underused while the air side will be overcrowded and the exit flow obstructed. For large passenger buildings, it is particularly difficult to achieve a satisfactory compromise because the space necessary for the number of passengers to be accommodated may make the distance from land side to air side greater than desirable. In such circumstances, one solution which might be considered is the provision of a balcony above the main waiting area.

9.7 GOVERNMENT FRONTIER CONTROLS

9.7.1 Departures frontier controls are contrary to the International Standards and Recommended Practices of Annex 9. For States which still find it necessary to retain them, these controls should be executed at locations between the departure concourse and the air side waiting lounges. This section also includes preclearance under bilateral agreements between States which provide for arrivals inspections to be carried out at the airport of departure.

Location

9.7.2 The location of frontier controls and the stage in the passenger processing system at which they are applied are important in maintaining free and continuous passenger flow (see Figure 9-12). Controls should be located between the departures concourse and the air side waiting area, as this is the point where the rate of flow is most regular. Controls located at the exit from the air side waiting area would be subject to large surges and would delay passenger flow to aircraft.

9.7.3 After passing controls, passengers may not re-enter the land side areas and are segregated from all persons, other than staff authorized to enter the air side areas. The controls should be grouped together at one location and should form the entry control to the air side waiting area, thereby avoiding any additional control positions which would be an irritation to passengers and a hindrance to flow and involve additional space and staff costs.

9.7.4 The most frequently applied government exit controls are immigration and police, but some States also impose customs inspection of passengers or their hand baggage. Such customs inspection should be before check-in, for baggage handling reasons.

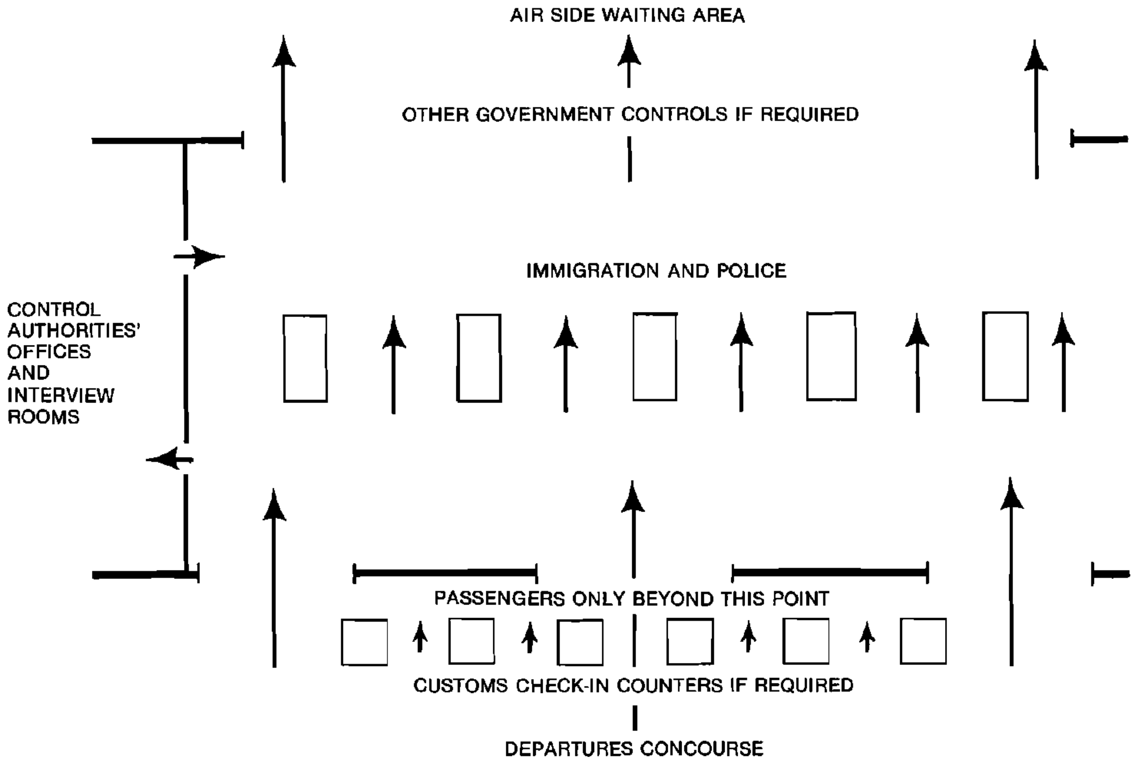


Figure 9-12. Government frontier controls

9.7.5 Specific considerations for the location of frontier controls are:

a) Passenger flow from aircraft to the frontier control facilities should be as short and direct as possible, and unimpeded by obstructions.

b) Passenger circulation should be designed so that there is no cross-circulation between international passengers and domestic passengers. Where appropriate, an area for exclusive use of international transit passengers should be provided.

c) The design of frontier controls should be such that there is no possibility for passengers to bypass the facilities, thereby avoiding inspection.

d) Physical contact between international passengers and visitors to the aerodrome should not be permitted once they have cleared controls.

Capacity

9.7.6 The capacity required for each authority and procedure is a function of the service time, passenger flow rate and proportion of passengers inspected. It is important to achieve a high rate of passenger clearance by reducing frontier controls service time and reducing cross and reverse flows of passengers seeking to complete and/or obtain the required documents. Although some passengers may always require longer than average service time because of particular problems, it will not be possible to handle increased rates of passenger flow, including surges in average flow rates, unless those passengers whose documentation is complete can bypass such problem cases and thus maintain the average service time and flow rate.

Health Control

9.7.7 Unless epidemiological conditions require sanitary measures, it is now normal practice to integrate health control with immigration control. However, it may happen that the State requires personal medical inspection of certain passengers. The facilities required should be defined by the medical authorities concerned and may include X-ray rooms. The medical facilities should be restricted to those required for passenger control and should not be a general first aid or medical centre for the airport. The location of passenger medical inspection facilities should be immediately adjacent to, but at the side of, the frontier control. A circulation route between the passport control and medical facilities should be provided which is compatible with the main arrival flow.

Immigration and Police

9.7.8 Passport clearance often includes, or is associated with, police inspection. Opening passports and other documents, and searching for visas and entry stamps represents a considerable proportion of the total service time. It is, therefore, a help in maintaining rapid passenger flow to reduce the number of occasions on which this has to be done, for instance by immigration and police officials inspecting documents together. Where immigration and police control cannot be operated with simultaneous inspection, the controls should be arranged consecutively on the line of the air side/land side flow route. If the service rates are different it is preferable for the inspection requiring the longest time to be placed first. Thus delays at the second control will not cause obstruction at the first control, and minimum distance may be provided between the two controls.

9.7.9 The straightest flow routes are obtained when the inspection positions are entirely homogeneous and any position can be used by any passenger. However, some States require varying degrees of inspection of documents, depending on the category of traffic and nationality of passengers. A faster over-all flow and some economy in the number of positions can be achieved if some positions are allocated for the use only of those categories of passengers who are subject to minimal inspection. The capacity of these positions would as a result be very high, allowing more positions to be allocated exclusively to the categories of passengers subject to more detailed inspection and which, therefore, have a slower rate of flow. Where such arrangements are applied it is important that the positions for each category are proportionately related to, and evenly dispersed among, the parallel flow streams.

Control Authorities' Accommodation

9.7.10 The control authorities usually require offices and search and interview rooms in conjunction with the frontier control inspection points. These should be restricted to those essential for passenger processing and should be arranged on the flanks of the control position to maintain the widest unobstructed area for the controls. This ensures flexibility for future rearrangement and operational changes and the clearest, unobstructed flow routes. Search and interview rooms will probably need to ensure absolute privacy of both sound and vision; in providing this it is most important that visual continuity through the passenger flow route is not obstructed. General administration, etc., should be located elsewhere in the building (see Figures 9-13 and 9-14).

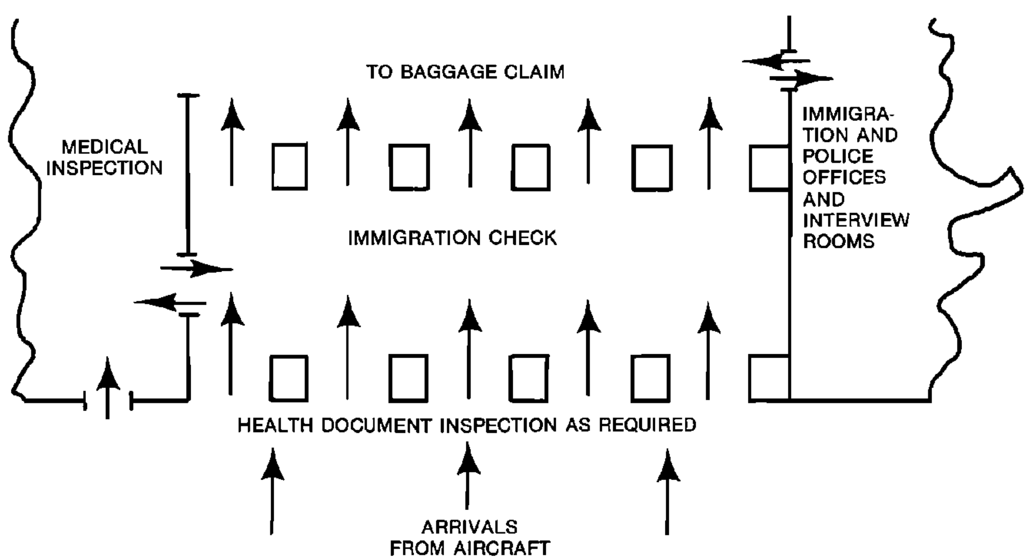


Figure 9-13. Control authorities' accommodation

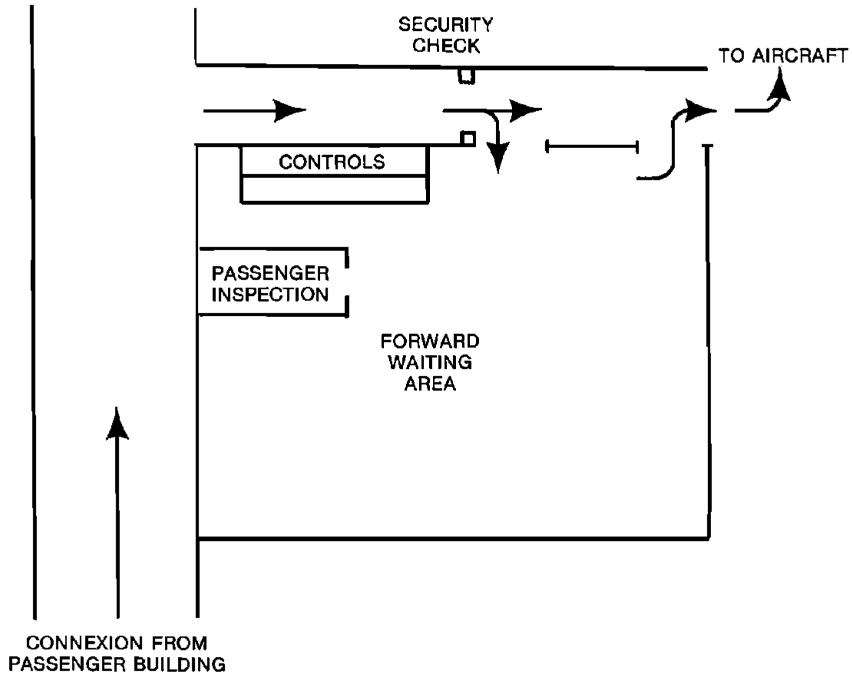


Figure 9-14. Layout of passenger security check and forward waiting area

9.8 PASSENGER CONNEXION WITH AIRCRAFT

Air Side Exits

9.8.1 While the type of connexion between the passenger building and aircraft may determine the precise form of the exits, they should be arranged to form the passenger flows into a linear pattern on a narrow front compatible with the size of the aircraft or apron passenger vehicle doors. Some form of control is necessary to ensure that only authorized persons and bona fide passengers are allowed to pass to the air side and board the aircraft. Such control is usually carried out by aircraft operators at the exits from the building or at the aircraft gates, and positions may be required for this control to be undertaken, arranged so that passengers can flow freely and easily out of the air side waiting area and past the control without obstructing other passengers or forming queues in the waiting area. The form and location of controls also depends upon the form of the connexion between the passenger building and aircraft and is considered in conjunction with the following section.

Aircraft Gates

9.8.2 Passenger processing and aircraft handling systems influence the form of the gates. The gates may be no more than doorways giving access to the aircraft stand, but they can also appropriately accommodate a number of departures facilities including gate check-in. The precise form should be determined by the nature of the passenger traffic, the flow rate and the processing system adopted for the passenger building.

9.8.3 The fullest implementation of the trickle flow principle should be the basis of planning. Trickle flow can be implemented over any section of a passenger route, with some form of group or controlled flow over the other sections if necessary. The full benefits of the system are achieved when passengers can flow freely, at their own speed, through all parts of the route. Ideally, this should include, in the case of departures, a flow directly into aircraft. However, it is not always possible to admit passengers to aircraft as soon as they arrive at the gate because of aircraft delays or incomplete cabin servicing, etc., making a waiting area necessary. For quick aircraft turnaround it is necessary for passengers to be at the gate ready to board the aircraft immediately it is available. A waiting area is necessary, therefore, for this purpose also.

Forward waiting areas

9.8.4 Provision of waiting areas at the gates reduces the requirement for the waiting area in the passenger building. The space required at each location is determined by the passenger processing system but space provided at the gates does not permit an equivalent reduction in the passenger building waiting area because some passengers will linger in the building to use the passenger amenities.

9.8.5 The size and layout of waiting areas depend upon the functions to be performed. With the increasingly rapid introduction of larger aircraft it is essential that the plan should provide maximum expansibility without need for rearrangement or reconstruction of the basic areas. If aircraft operators' controls are undertaken in the forward waiting area they may be applied, either as passengers enter the area or as they exit from it to board the aircraft. Climate can also affect the size and location of waiting areas. In cases where aircraft are subject to protracted delays because of weather conditions, passengers may wish to return to the waiting area in the passenger building to use the amenities. In such cases, due account should therefore be taken of this factor in planning the size of the main waiting area in the passenger building.

9.8.6 Forward waiting areas generally serve three purposes, namely, the provision of passenger lounge, passenger processing area, and passenger deplaning area.

a) *Passenger lounge area.* The lounge comprises seating, processing and circulation areas. The area required is a function of the number of passengers anticipated to be in the lounge 15 to 30 minutes prior to boarding the aircraft. This number can be determined by applying the forecast aircraft and its load factor for boarding that is typically experienced at the airport. A space standard is applied to the number of passengers and visitors (if appropriate). The space standard assumes that not all passengers will have seats in the lounge, as a certain percentage of the passengers will want standing area, and this should be considered in the development of the standard. Based on experience, aircraft arrivals and departures are distributed over time so that the full passenger population is never experienced at one time. Where it is possible, therefore, to combine the lounge area for a number of aircraft gate positions, the total area can be reduced by 20 to 30 per cent, based on four to six gates.

b) *Passenger processing area.* The number of agent positions is normally determined by the airport authority in consultation with the user airlines and is based on a standard of service that specifies minimum waiting and processing times for the passenger. Probably the greatest queue buildup occurs when the first agents appear at the desk to commence processing. Additional agents may then be furnished to reduce the queue and maintain a minimum length. The average depth of lounge area generally considered to be reasonable is 7.5 to 9 m. The number of agent positions used, however, is based on the standard of service with a queue length not less than 3 m at larger airports. Public telephones, garment bag hangars, waste baskets, etc., are amenities that may be considered necessary. A means of delivering late baggage to the apron area (such as chute, conveyor or dumbwaiter) may be required, although in most cases the baggage can be delivered via the loading bridge door or the departure lounge door (if at ground level).

c) *Deplaning area.* The deplaning area is a corridor for deplaning passengers leading from the building entrance door (from the apron, loading bridge, or transporter) to the public corridor without interfering with the passengers waiting in the departure lounge. To allow for two passengers and baggage side by side or one passenger and baggage with passing room, an acceptable width is 1.5 to 1.8 m. The length is a function of the depth of the departure lounge itself and may include a transition area for the meeter/visitor.

Passenger security check

9.8.7 The location of the passenger security check is dependent upon traffic characteristics and the terminal concept. The security check can be centralized, partly decentralized or completely decentralized. A centralized security check can be located at the point in the terminal where passengers are separated from the general public (i.e. after immigration control). In case of a fully decentralized system, the security check will be made at the entrance to the waiting lounge. Should the initial passenger check reveal any abnormality, a closer examination of the passenger may be necessary and a private area where this may be carried out, should be provided. For further information see Chapter 14.

Connexion between Passenger Building and Aircraft

9.8.8 The system for moving passengers between the passenger building and the aircraft is an integral element in the choice of the aircraft parking system and apron plan.

The most appropriate system will depend on the traffic for which the individual airport is provided and other local conditions. The most important consideration is to maintain free movement of aircraft, vehicles and passengers while avoiding conflict between them.

9.8.9 A number of different systems can be used to connect the passenger building to the aircraft. These include having passengers walk up boarding stairs or along a passenger loading bridge, or conveying them in a transporter. The routes may be over the open apron, through enclosed routes at or below apron level, or at passenger building and aircraft floor levels. Any specifically defined route over which passengers walk, other than over an apron, is a "pier". Thus a pier can be at, above or below apron level.

9.8.10 For closest compatibility with the flow principles, the choice should be determined in consideration of the passenger building floor levels: for multi-level passenger buildings the connexion between building and aircraft should keep to a minimum any changes in level, but because of the variety of aircraft floor heights it is impossible to define a single suitable level.

Aircraft boarding stairs

9.8.11 Integral aircraft stairs are used with aircraft in the 50-120 seat capacity range, such as B727, B737, DC-9, BAC111, CV580, and YS11B.

9.8.12 In the case of stairs, whether integral or mobile, the width and relative density in terms of persons per square metre serve as the limiting constraint for calculating capacity. Ascending or descending rates will not be significantly different in handbook references. Flow will be in one direction, enplaning or deplaning.

9.8.13 Passenger flow rate for aircraft in the 40-210 seat capacity range is approximately 20 to 22 persons per minute, and 25 persons per minute for the 220-420 seat capacity aircraft. In the latter case, the rate of boarding or disembarking can be increased by the use of more than one door, but this may create traffic conflicts on the apron with the ground service equipment operation.

Passenger loading bridges

9.8.14 Passenger loading bridges can provide quicker, more even passenger flow between aircraft and passenger buildings and protect passengers from weather, noise and fumes. The installation of passenger loading bridges, however, should be economically justified by traffic volumes and other considerations (refer to 7.2). The primary factors to be taken into account in planning passenger loading bridges are aircraft door sill heights (which range from 2 to 5 m) and door positions. The size and form of passenger loading bridges should be chosen to provide sufficient flexibility to serve different types of aircraft other than those indicated in the operational forecast, and for resiting at new gate positions in accordance with changes in apron plans.

9.8.15 The capacity of the passenger loading bridge is determined by using the same density and width criteria applied to aircraft stairs. For the best passenger flow the interior width of passenger loading bridges should be sufficient for at least two people to walk side by side so that children and the aged or infirm can be suitably assisted. Floor slopes should generally not exceed one in ten.

9.8.16 The width of the loading bridge does not usually constrain the flow as much as does that of the aircraft door, which generally ranges from 84 to 107 cm. As with aircraft doors, another constraint on the flow rate could be the point where the passenger loading bridge joins the building. For example, a 90 cm wide doorway will allow a flow rate of 37 passengers per minute. Another constraint on the flow rate of the passenger loading bridge is the aisle width of the aircraft cabin. Studies in the United States support the flow rate of 30 passengers per minute identified in Boeing document D6A 10305-1, "SST Ground Services Time and Motion Study".

9.8.17 The passenger flow rate may be reduced slightly if stairs rather than ramps must be negotiated. Stairs result in a 20 to 22 passenger per minute rate, similar to that of a mobile passenger stair. The stair or ramp may be provided with an enclosure for weather protection when a single-level connector is provided.

9.8.18 The passenger route should be clear and unambiguous and, if possible, should avoid multi-directional functions where the passenger loading bridge joins the building. The passenger loading bridges should be arranged to lead arriving passengers, who may not be familiar with the route, directly to the main flow routes into the passenger building.

9.8.19 The type of passenger loading bridge — fixed pedestal, apron drive, or suspended — and its length are functions of variables including apron dimensions, wing span, door locations, fixed aircraft services, adjacent aircraft positions, and economics. For example, a certain ramp drive bridge may extend up to 35 m from the face of the building, and may be capable of serving five or six different types of aircraft. In a practical application of the passenger loading bridge, only two or three aircraft may use the bridge because of fixed service locations and positions of adjacent aircraft. A pedestal-type bridge could be more appropriate in that case, particularly in view of its lower capital, operating and maintenance costs.

9.8.20 A ramp drive bridge, when in a stowed position, will allow a taxi-out operation where the pedestal or suspended types are limited to pushout operations. Judgements as to which passenger loading bridge design to apply to each case will be based on the specific characteristics of the aircraft mix and airline operating requirements.

9.8.21 Normally only one passenger loading bridge is required to serve any one aircraft up to and including the B-747. This may, however, be affected by the airport involved and the type of traffic using that airport (i.e. originating/ terminating or transit). For very high density routes or at airports where airlines require fast turnaround, as well as for maintenance of approved standards for business and first class passengers, installation of two passenger loading bridges may be preferable. If two passenger loading bridges are to be used, there should be a separate tunnel to the terminal for each bridge or, alternatively, a double width corridor from the junction of the two bridges to the terminal building. The minimum width for this double corridor should be 3.2 m.

Transporters

9.8.22 Transporter vehicles may be used when aircraft are parked remote from the terminal. Transporter types range from a bus in combination with stairs to a specifically designed vehicle with an elevating capability.

9.8.23 When buses are to be used to transport passengers between remote stands and the terminal, consideration should be given to specially designed airport passenger buses. These vehicles should have a low floor height (preferably one step above the ground), wide doors, and minimum seating around the sides of the cabin. The capacity and dimensions of the bus should be in accordance with the conditions prevailing at each airport where it will be used. IATA has developed a functional specification (AHM 950) on airport passenger buses, which is also included in IATA's "Airport Handling Manual".

9.8.24 When a specifically designed vehicle with elevating capability is used, special attention should be paid to their relatively slow speeds, lack of easy manoeuvrability and the potential hazard they may be to aircraft operations. These vehicles have high capital, operating and maintenance costs and require highly skilled drivers.

9.8.25 In general, although transporters afford almost ideal flexibility from the apron planning point of view, they tend not to be compatible with the passenger flow principles. They may, however, be useful as a supplementary system to handle peak hour demands only or to serve aircraft which differ from the general types of aircraft for which the airport is planned.

Transporter loading and unloading positions

9.8.26 The specific form of transporter loading positions depends upon the type of transporters to be accommodated. Generally, the positions should be considered as aircraft gates and the same planning considerations applied, except that transporters will generally occupy the loading gates for a much shorter period than aircraft occupy the stands. Therefore, the possible degree of trickle flow to the transporter loading positions may be much less, and the time spent in the waiting area may be correspondingly short.

9.8.27 Loading positions should be as close as possible to the passenger building air side waiting area, to reduce the walking distance and hence the time required for passengers to get from the waiting area to the aircraft. The specific location of the loading positions will usually be determined by the air side vehicle traffic circulation and the need to provide unobstructed access between the loading positions and the apron roads. The number of positions required depends upon the utilization of aircraft stands, size of aircraft, etc.

9.8.28 As with aircraft gates, it is possible to use the transporter gate positions for both departures and arrivals, but because the vehicle movement rate is higher than that of aircraft at the aircraft stands and thus the movement rate of passengers is also higher, it is advisable to separate the departures and arrivals flows and provide separate transporter positions for each. This separation also permits the unloading positions to be located as close as possible to the arrivals flow routes in the passenger building, thus reducing walking distances.

Air Side Entrances

9.8.29 From piers or transporter unloading positions passengers flow into the passenger building. Although two-way flow of departures and arrivals passengers is unavoidable and tolerable in piers, in no circumstances should arrivals flow routes pass through departures areas in the passenger building. The air side entrances should, therefore, give access directly to the arrivals areas of the building. These may be on a lower floor in multi-level buildings or by the side of the departures areas in single level buildings. In multi-level buildings the descent should be direct, obvious and easy.

9.8.30 Passengers entering the building include transit and transfer passengers as well as passengers ending their air journey. The air side entrances should be arranged to separate passengers into the appropriate flow streams (see Figure 9-15). The entrances for each category should be arranged consecutively along the flow route so that passengers do not have to choose from more than two alternatives at any time. Confusion will arise if special categories are not segregated from the main flow before the first control point. Thus all arrivals passengers should flow through a common route as far as possible; when transfer and transit passengers are not subject to controls, they should be diverted before the main route reaches the frontier controls.

9.9 TRANSIT AND TRANSFER PASSENGERS

Transit Passengers

9.9.1 Transit passengers stay at the airport only for the duration of the aircraft turnaround, and have no requirements beyond those of arrivals and departures passengers. Usually they should follow the main arrivals route, until being diverted directly into the departures air side waiting area or into a sterile "in-transit" waiting lounge. However, some transit flights change category and in these circumstances transit passengers may be subject to frontier controls. Their requirements are then the same as transfer passengers and the same facilities can be used for both. Transit passengers who arrive and depart on international flights should never be subjected to frontier controls and should remain in the air side area, where all amenities which they may require are provided. On departure of their flight, they follow the normal routes and procedures of departure passengers, including security check, if required.

Transfer Passengers

9.9.2 The flow route for transfer passengers depends on whether the transfer is between flights of the same or different categories, i.e. domestic to domestic, international to international, or between international and domestic. When the traffic is between international and domestic, transfer passengers are subject to the normal arrivals controls and should follow the main arrivals route to the land side, where they then pass through the main departures flow route and follow the normal departures procedures.

9.9.3 When traffic is entirely domestic or international, transfer passengers should not pass through arrival controls. They should be segregated from the main arrivals flow and pass directly to the departures air side waiting area, usually following the same route as transit passengers (see Figure 9-16). Unlike transit passengers who leave the airport on the same flight on which they arrive, however, transfer passengers change flights, and it may be necessary for them to check in for the connecting flight.

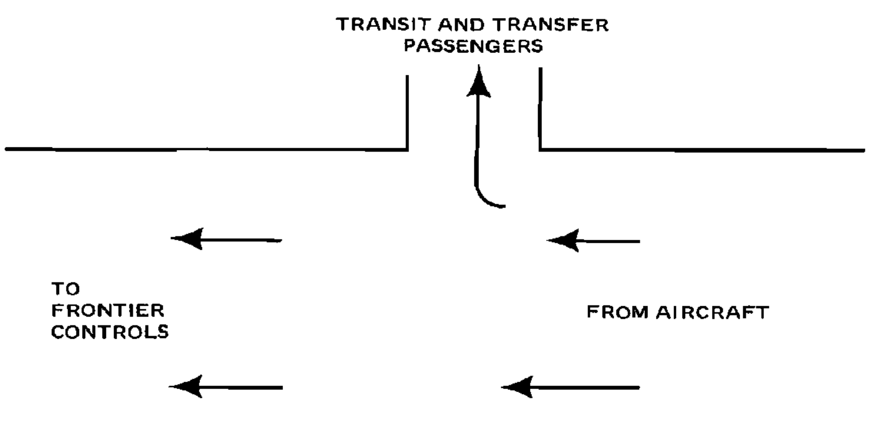


Figure 9-15. Air side entrances

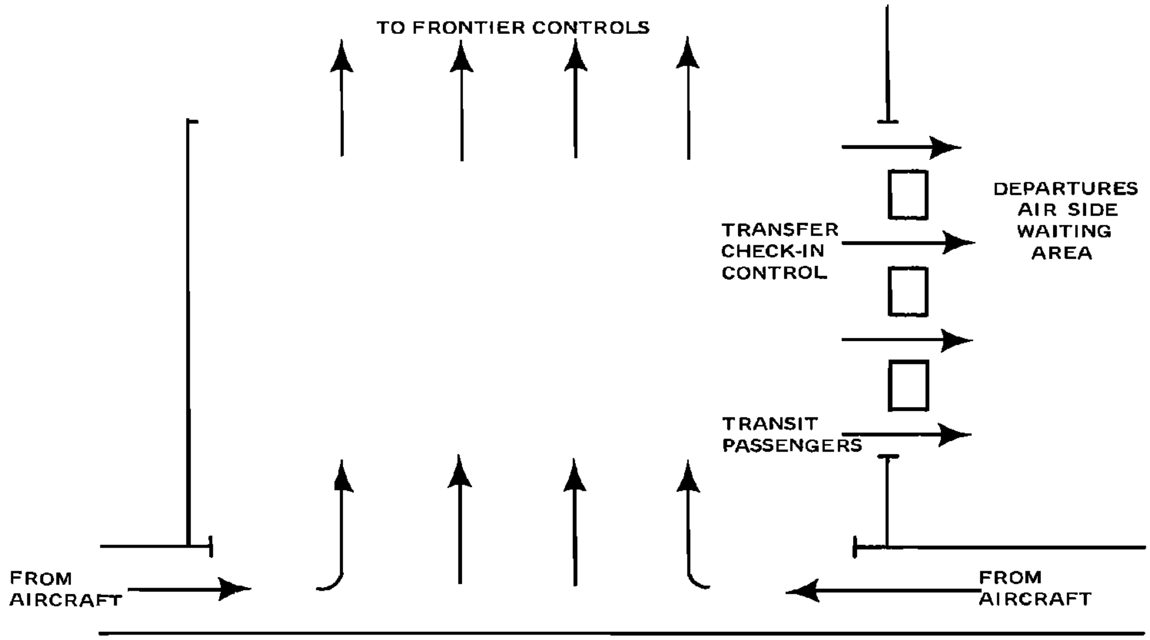


Figure 9-16. Transfer passengers

This can be undertaken either at the gate, if such facilities are provided, or preferably on the route to the departures waiting area. At airports serving a number of airlines, some form of shared use of transfer check-in positions is necessary to avoid the provision of facilities which are excessive and thus uneconomical, and which distort the building plan. Nowadays many airlines provide boarding passes for on-line transfer at the originating station, so that transfer passengers do not need to check in for the connecting flight at the transfer station.

9.9.4 For international flights at airports where there is more than one international passenger building, a passenger transfer system that operates on the air side is desirable for the transfer of passengers and baggage between international flights. Requirements for the vehicle unloading and loading positions are the same as for other transporters, and the same positions can be used for both.

9.10 PASSENGER AMENITIES AND OTHER PASSENGER BUILDING SERVICES

9.10.1 Airport master planning also includes consideration of passenger amenities, concessions, and other services usually located in the passenger building.

Passenger Amenities

9.10.2 Amenities should be sited to ensure that passengers using them do not interfere with the primary flow streams and they should not obstruct visual continuity throughout the area. The location of amenities can affect the rate of flow through the building, and the appropriate siting of the amenities relative to each other and the flow routes can be of considerable assistance in distributing passengers throughout the whole of the waiting area and in reducing circulation within the area. The nature of each amenity provides a general indication of the degree and type of use it will receive. For example, duty-free goods and liquor shops can with advantage be adjacent to the main flow routes for easiest access by a large number of passengers and to provide fast service.

9.10.3 Depending upon the size of the passenger building and the category of traffic, the departures concourse can be the appropriate location for some passenger amenities. If they are also provided in the air side waiting area there may be a reduction in the time passengers remain in the departures concourse and, therefore, in the space required.

9.10.4 The greatest use of other amenities is generally made by passengers with the longest waiting periods.

Passengers whose aircraft boarding is imminent tend to gravitate to those parts of the waiting areas nearest the exits. It is important, therefore, to site amenities so that the passengers who are likely to remain in the area for the longest period are attracted away from the busiest areas nearest the flow routes. These areas of least activity, which are the appropriate sites for passenger amenities, are between the main flow routes and adjacent to the land side boundary of the waiting areas.

9.10.5 The siting should also be related to service accesses for supplying goods, and storage areas. To preserve flexibility and economy in the use of space, all main storage areas should be located elsewhere in the building and only sufficient for immediate purposes should be provided in the waiting areas.

9.10.6 At some airports, planning efforts have suffered because of conflicting views on priorities for the location and size of revenue-producing services in relation to basic airline services for passengers. One example involves inbound baggage or claim facilities that are constrained by the location of concessions or another ancillary functions. The resultant delays in baggage delivery and display end up inconveniencing passengers, and the by-product of such delays can often be congestion, not only in the baggage claim area, but also in the adjacent circulation elements and at the curb.

9.10.7 Concessionaires, airport authorities, and airlines share common concerns regarding customer satisfaction and economic productivity, and ultimately suffer by inconveniencing passengers upon whose patronage all three groups are highly dependent. Accordingly, the following suggestions are offered:

— The location and accessibility of passenger building services should provide the optimum exposure and convenience for patrons without impeding basic patterns of pedestrian traffic between aircraft and various forms of ground transportation.

— The location and sizing of passenger building services should not constrain basic airline functions to the extent that passengers cannot be serviced efficiently.

Food and beverage services

9.10.8 Food and beverage services include snack bars, coffee shops, restaurants and bar-lounges, and warrant discussion as a distinct sub-element of the passenger building because the quantitative aspects involve more than a simple relationship to annual enplanements or daily passenger averages.

9.10.9 The basic service offered at the small airports is a coffee shop, although a separate restaurant can be successful, depending on the surrounding community. Only very large airports can justify several locations for snack bars, coffee shops, bar-lounges and restaurants. Requirements for more than one of each type are greatly influenced by the building concept involved, particularly for linear terminals at very large airports.

9.10.10 One approach to sizing involves "use factors" (average daily transactions divided by average daily enplanements) and "turnovers" (average day users or transactions divided by the number of restaurant and coffee shop seats available). Based on available data, the following ranges can provide general approximations for food and beverage service operations:

a) turnover rates: average daily 10 to 19 persons per seat. Some operators appear satisfied averaging 10 to 14 daily;

b) space per seat: 3.3 to 3.7 m^2 per coffee shop/ restaurant seat, including support space;

c) snack bars: 15 to 25 per cent of coffee shop/ restaurant over-all space requirement;

d) bar-lounges: 25 to 35 per cent of coffee shop/ restaurant over-all space requirement.

9.10.11 For large airports, the passenger building concept may justify more than one location for food and beverage services. Under these circumstances, space estimated should be divided accordingly.

9.10.12 Vending machines for beverages and other items should be considered to supplement staffed facilities at small airports, where traffic volumes might not justify operating during all hours in which flights are scheduled, or at large airports in remote parts of the passenger building.

Other concessionaire services

9.10.13 The kinds of services regarded as desirable vary according to traffic volumes and many of the other marketing considerations. Programming such space for any specific airport must be based on discussions with both existing and potential operators and concessionaires. Representative guidelines are summarized as follows:

a) Newspapers/books and tobacco: physically separate at most airports where annual enplanements exceed 200 000 per year, and may be combined with other services at airports with lesser traffic. Allow 14 m^2 minimum, and averaging 56 to 65 m^2 per million annual enplanements.

b) Gift and apparel shops: some items are sold at the newsstand at smaller airports, but separate facilities normally become viable when annual enplanements exceed one million. Allow 56 to 65 m^2 per million annual enplanements.

c) Barber and shoe shine: operations at some large airports call for one chair per million annual enplanements. Allow 10 to 11 m^2 per chair with 14 m^2 for minimum facility.

d) Car hire counters: space required will vary according to the number of companies. Allow 33 to 37 m^2 per million annual enplanements.

e) Displays, including courtesy telephones for hotels: allow 8 to 9 m^2 per million annual enplanements.

f) Insurance, including counters and machines: allow 14 to 16 m^2 per million annual enplanements.

g) Left luggage lockers: allow 6.5 to 7.5 m^2 per million annual enplanements.

h) Public telephones: allow 9 to 10 m^2 per million annual enplanements.

i) Vending machines: machines offering items such as hot and cold beverages, candy, tobacco, newspapers, etc., should be considered as supplementary to staffed facilities offering these items, especially where extended hours of operation are not justified by low volumes or multiplicity of locations. Providing passengers with more conveniently located options for these items has become even more important with the advent of security controls discussed in Chapter 14. Where vending machines are provided, they should be grouped or recessed to avoid encroaching upon circulation space for primary traffic flows. Allow 4.5 m^2 minimum or 14 m^2 per million annual enplanements.

Other Passenger Building Services

9.10.14 Passenger building services also include facilities common to most public buildings and others common to many airports, regardless of traffic volumes. Such facilities include:

a) Public toilets: must be sized for building occupancies in accordance with codes applicable to the local community, state, etc. Space allowances vary greatly, from 139 to 167 m^2 per 500 peak-hour passengers (in and out) down to 120 m^2 per million annual enplanements at large hub airports.

b) Airport management offices: space requirements vary according to the size of staff and the extent to which airport authority headquarters are located in the terminal.

c) Airport police/security office: space requirements vary according to number of staff and nature of arrangements with local community law enforcement agencies.

d) Medical aid facilities: range from first aid service provided by airport police to branch operations of off-airport clinics, etc.

e) Travellers aid: facilities vary considerably and space requirements are relatively minor 7.4 to 9.3 m^2, except at airports with annual enplanements of over 1 million.

f) Building maintenance and storage: varies depending upon the types of maintenance (contracted versus authority operated) and storage facilities available in other authority-owned buildings.

g) Building mechanical systems (HVAC): initial approximations of HVAC space requirements can be obtained by using 12 to 15 per cent of the gross total space approximated for all other terminal functions. This allowance will not cover separate facilities for primary source heating and refrigeration (H and R) plants.

h) Building structure: for building columns and walls, allow 5 per cent of the total gross area approximated for all other functions.

i) Circulation: all primary circulation is included in the methodologies for the various sub-elements of the passenger building. Additional space for vertical and horizontal circulation is not included, but will be required in varying quantities depending upon the building scheme.

j) Information: public address, flight information, signs and graphics, courtesy phones, and security alarm system are included under this heading.

k) Government offices: these facilities may require a considerable amount of space, depending upon individual State practices.

l) Contract service facilities and others.

m) Letter post.

9.11 CONSIDERATION OF DISABLED AND ELDERLY PEOPLE IN PASSENGER BUILDING PLANNING

9.11.1 The speed and comfort of air travel is becoming more and more appealing to people who are physically handicapped and the use of air transport by disabled and elderly people, including the chairbound, is likely to increase. For many, particularly the severely disabled, the most convenient method of long-distance travel is by air, provided the transition facilities match the convenience of the aircraft.

9.11.2 Both disabled and elderly passengers as well as visitors have rights to safety and convenience. It should be remembered that a person with a disability is not different in all aspects of behaviour. Their special problems and differences need to be recognized so that the planner/designer may accommodate them satisfactorily.

9.11.3 The transition between air and surface transport needs to be improved and terminal facilities must keep pace with the convenience offered by modern aircraft. Several States have developed design standards or building codes for disabled people that can be applied for airport passenger buildings. The following paragraphs include planning consideration of disabled and elderly people in airport passenger buildings based on the practices advocated by one State.

Planning Consideration for Access by the Disabled

Ramps

9.11.4 Unless the surface leading to a one in six ramp is flat or sloping down, wheelchair users have difficulty getting up this gradient. One in twelve ramps are difficult for other than the strongest wheelchair users; one in sixteen is better. Difficulties can also be experienced if ramps have to be approached from an angle. Curbs at sides of ramps can be a problem, and the location of handrail supports and the finish of both ends of handrails need to be carefully designed.

9.11.5 The height generally accepted for ramp curbs is 10 cm, although 5 cm minimum seems to be more acceptable. Curb edges need to be rounded and the finish at the top and bottom of the ramp carefully designed.

Stairs

9.11.6 The termination of handrails at the top and bottom of flights of stairs need to be individually designed to suit the circumstances.

Terminal Approach and Departure Areas

Car parking

9.11.7 It is desirable to provide identified reserved parking areas for physically disabled people, using the access symbol. Directional signs should indicate access routes to reserved parking areas, which should be located close to the terminal entrance. Regulations should be enforced to ensure exclusive use of reserved parking spaces by the disabled.

9.11.8 The parking spaces should be flat and protected from the weather. The route from the reserved parking to the terminal should be free of curbs and obstructions and located so that disabled people do not have to pass behind parked cars. Parking meters, attendants' windows, ticket machines and similar devices should be within the limited reach and grasp of a disabled driver. Wheelchairs should be available for people to move to taxi, bus or private car loading areas. This service should be clearly advertised.

External circulation

9.11.9 People using wheelchairs find ramps essential to negotiate changes in level and these are helpful for the ambulant disabled. Both ramps and stairs should be provided at every change in level. Ramps should not exceed one in twelve and should have non-slip surfaces. Handrails should be provided at least to one side.

9.11.10 Pedestrian walkways should be unobstructed and at least 1.5 m wide. At places where pedestrians or wheelchair users must cross curbs, a cut or ramp should be provided. Gratings, manhole covers and similar potential obstructions should be flush with the pavement. Pedestrian and vehicular traffic routes require effective separation.

Terminal entrances and exits

9.11.11 Safe, level areas, protected from the weather, should be provided for boarding and delivery of people from cars, buses, etc., adjacent to main building entrances and exits.

9.11.12 There should be at least one main entrance without steps usable by people in wheelchairs. Automatic opening doors are highly desirable. If doors are hand operated they should be openable by one hand and the handles should be of a lever type. Where revolving doors are installed, an alternative hinged or sliding door should be provided. Door closers should be of a type to permit opening of the door with a minimum of effort and slow closing to allow uninterrupted passage of a wheelchair. Time lapse devices which close doors after a prescribed delay should be avoided as they are dangerous to those who move slowly.

9.11.13 Interior and exterior floor surfaces should be level on each side of entrance doors, with floor mats recessed and fully secured.

Internal Circulation

9.11.14 All interior public spaces should be connected by ramped paths or identified lifts, and public corridors should be free of obstructions. All abrupt changes in floor level should be clearly identified by audio and visual means.

Doors and doorways

9.11.15 Attention should be given to the direction of door swing so that wheelchair occupants can open doors without complex manoeuvring. Revolving doors are to be avoided. Doors in corner positions must permit easy approach and there should be an unobstructed space adjacent to the door handle. Side hung doors are preferred to sliding doors. Kick plates are recommended on doors used by wheelchairs users.

Floors

9.11.16 All floors should be maintained in a non-skid condition. All carpet areas should be of the low-pile, tight-loop type and fully secured to prevent movement.

Ramps

9.11.17 Ramps should be at least 1.2 m wide (1.5 m is even better). Ramp slope should not exceed one in twelve. Surfaces should be non-slip. A level area, preferably 1.2 m long, should be provided at top and bottom of all ramps. Ramps more than 9 m long should have a level section at 9 m intervals (5 m for steeper ramps). At each change of direction a level landing should be provided. Handrails should be provided on each side of ramp. The disabled access symbol should be displayed at the approach to the ramp.

Stairs

9.11.18 Treads should be of non-slip material. A landing midway in a stair run between floors is desirable. Open risers and projecting noses should be avoided. Handrails should be provided on both sides. Ramps are preferable where minor changes in floor level occur.

Escalators and moving walkways

9.11.19 Wheelchairs, unless specially designed, cannot be easily moved on escalators. While escalators can be useful to the ambulant disabled, they can be hazardous to many elderly disabled people, and ramps or lifts are therefore preferable.

Elevators

9.11.20 The only really effective way of moving chairbound people from floor to floor is by elevator. Where elevators are provided, at least one should be accessible to and usable by the disabled, including those in wheelchairs, both at the entrance level and at all upper levels used by the public. The elevator should be large enough to accommodate a wheelchair and one or two standing persons. If automatic, the elevator controls should be located so they can be reached by a seated person. The cab should be self-levelling, and the doors should be adjusted to remain open for at least eight seconds, to close slowly, and to respond to both a sensitive safety edge and photoelectric cell door openers. An audio description of the floor reached is desirable. Directional signs to the lift should be placed at various points in the building.

Signs and Warnings

9.11.21 Because people in wheelchairs are normal people, to be treated in a normal way, it is wrong to provide special signposts indicating "normal" facilities available for them. But it is acceptable to provide signposting of "special" facilities for disabled people.

9.11.22 A pictorial symbol effectively advertises the availability of facilities for the disabled. This symbol should be prominently displayed as a ready means of identification to disabled persons of all routes and areas where suitable facilities are provided.

9.11.23 Directional signs and room identifiers are normally useless to blind people. It is desirable that identification of certain rooms, e.g. rest rooms, restaurants and gate positions by raised or depressed letters be placed on walls beside doors, not on doors, as sudden opening may result in injury. Audible and visual signals to indicate a hazardous area, e.g. a door to an area used by baggage trucks, are desirable to protect blind and deaf people. Curbs, which serve as a warning to blind people using a cane, should be provided at any change from a pedestrian area to a roadway for vehicles. Visual and audible passenger information is desirable.

Toilets and Showers

9.11.24 Toilet facilities should be accessible to wheelchair users and should include at least one WC compartment sized and fitted for use by the disabled, including wheelchair users.

Embarking and Disembarking

9.11.25 Passenger loading bridges or flush coupling transfer vehicles are desirable for level or ramped access to and from aircraft. Where this is not provided, alternative transfer facilities should be available.

Baggage Claim

9.11.26 Routes to baggage claim areas should be designated by audible and visual means. It is desirable that baggage claim areas be at the same floor level as that at which the arriving passenger enters the terminal, if ramped or elevator access if not provided. Airport or airline personnel should be readily available to provide assistance to disabled people.

Other Facilities and Services

Check-in facilities

9.11.27 Check-in facilities should be as close as possible to passenger set-down areas for cars, buses, etc.

Drinking fountains

9.11.28 Drinking fountain controls should be hand-operated; the fountain should be low enough for use by wheelchair occupants, but high enough to allow the arm of the wheelchair to move beneath it.

Telephones and post boxes

9.11.29 At least one in a group of telephones should be accessible by wheelchair users, with the handset and coin slots approximately 1 m above floor level. Telephone books should be located so they can be read from a seated position. Telephone operating instructions with raised lettering is desirable. Post boxes should have an opening which can be operated by one hand, not more than 1 m above floor. Splayed legs should be avoided. Tables 71 cm high with 71 cm between the legs are suitable.

Baggage storage

9.11.30 Areas for baggage storage should be located adjacent to main entrances and baggage claim areas. Storage systems should be easily operable by persons of limited manual dexterity.

Security

9.11.31 All security gates should be at least 90 cm wide. All security conveyor belts and check tables should be at a height of 76 cm above floor.

Special services

9.11.32 Airport guide maps for blind or otherwise handicapped persons should be available.

References

Annex 9 — *Facilitation.*

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Chapter 10. CARGO FACILITIES

10.1 ABOUT THIS CHAPTER

10.1.1 All planning for cargo facilities must begin with the air cargo forecasts (see Chapter 3). Accurate forecasts are essential to sound cargo facility planning both now and in the future when expansion may occur.

10.1.2 The same considerations which influence the siting of the passenger facilities also apply to the cargo area. The priority accorded to these two areas in deciding the compromise necessary to achieve over-all compatibility will depend on the nature of the traffic for which the airport is intended. In most airports at present, the amount of cargo traffic is considerably less than passenger traffic and it is, therefore, more important for passenger rather than cargo facilities to be as close as possible to the runways because there are fewer cargo aircraft movements and consequently less danger of congestion in ground movements. However, with the future development of air transport and the predicted growth of cargo traffic this may not continue to be the case and the relative locations of passenger and cargo areas should be carefully considered in the light of the traffic forecasts.

10.1.3 The future growth of traffic and problems of mixed passenger and cargo aircraft may require supplementary processing and warehouse facilities off the airport. In such cases the intermodal transfer of cargo containers becomes significant.

10.1.4 The purpose of this chapter is to examine some aspects of problems likely to be found when planning cargo facilities. One of the main considerations involved is the space required for this facility. It is recommended that this and other aspects be discussed with aircraft operators and other agencies involved.

10.2 SOUND CARGO FACILITIES PLANNING

10.2.1 The rapid rate of increase in air cargo traffic, the advent of very high capacity aircraft capable of accommodating large-size units as well as greatly increased quantities of cargo, and new developments in cargo handling methods, including the use of containers and automated equipment, make flexibility and expansibility an overriding necessity.

10.2.2 Cargo facility planning should be based on flow planning principles, as previously described for the passenger area. In the case of cargo, the concept of flow planning is easier to apply because of the inanimate and non-subjective character of the majority of cargo. However, in the handling of livestock it is important to consider physiological and environmental factors to ensure that animals are tranquil and well cared for.

10.2.3 Conclusions reached by the International Air Transport Association (IATA) substantiate the fact that uniform standards for air cargo facility design are impossible to develop, for the following reasons:

a) an international carrier needs bonded facilities;

b) cargo facilities are characterized by relatively large holding and storage areas, and customs oriented documentation procedures;

c) a domestic carrier needs far less warehouse space for a comparable volume of carriage, a small bonded area and relatively simple documentation procedures, as well as the means to rapidly receive, sort, and distribute air cargo through its terminal in relatively short time spans;

d) a carrier holding both international and domestic rights, with the resulting mixtures of in-bond and domestic air cargo, has all the requirements of both international and domestic carriers;

e) the terminal requirements of carriers are greatly influenced by the ratio of domestic to international cargo. Requirements for warehouse space are greater in relation to transfer cargo than for local cargo and the extent of such areas will largely depend upon the route structures and the degree of containerized traffic to be handled; and

f) the requirements of all-cargo carriers and combination carriers vary widely. As more high capacity aircraft are phased into route structures, the ratio of air cargo carried in passenger aircraft to that carried in cargo aircraft will also change.

10.2.4 As with passenger terminals, a single design concept cannot meet the varying needs of all carriers or all geographical areas. There are, however, common guidelines that a cargo terminal planner should follow:

— collect all possible information related to past, present and future cargo traffic from airline sources;

— determine the impact of cargo, mail and company stores upon the facility;

— determine the desired material handling system based upon the nature and volume of the forecast traffic and the operating method best suited to the particular locality;

— design the terminal to accommodate the ultimate material handling system and with the ability to be progressively expanded within the confines of the building or site;

— ensure that the site area will accommodate required aircraft stands, truck loading areas and customer/employee parking areas and desired access/egress roads, and will allow for future expansion;

— site the terminal with due consideration for the type of operations (all-cargo or combination) and to provide the shortest possible time for the movement of on-line, interline and in-bond cargo;

— provide sufficient space to accommodate the maintenance of fixed or mobile equipment, and the maintenance, parking and refuelling of powered ground equipment;

— maximize interval overhead dimensions, as well as clear floor space, to allow optimum utilization of available cubic capacity and to accommodate multi-level unit-load handling and/or storage;

— limit the amount of administrative area occupying warehouse floor space to the absolute minimum and consider second level administrative accommodations wherever feasible;

— consider means to prevent the unauthorized removal of air cargo and equipment;

— provide adjustable or flexible connexions at air side and land side to accommodate fixed loading bridges, mobile ramp equipment and variable delivery/collecting vehicle heights;

— provide terminal building bypass means to transfer unitized loads or large single pieces between air side and land side; and

— make adequate provision for holding or staging areas for unitized loads, including cargo containers and lower deck containers, both of which have specialized handling requirements. In the case of lower deck containers, particular attention should be paid to the necessity of ensuring that such facilities will enable the containers to be handled expeditiously at all times, including periods of unavoidable multi-operations, as it is essential to keep aircraft ground times to a minimum.

10.3 SITING

10.3.1 In site planning for cargo facilities, several factors should be taken into account. The site chosen should be in accord with all of the other elements of the airport master plan and incorporate flexibility and expansibility to accommodate cargo growth, including the possible introduction of all-freighter service to the airport, over a period of 20 years. This includes new aircraft which may use the airport during the next 20 years, as well as enlarged cargo terminals and facilities required to handle increased volumes of cargo and, at the larger airports, to implement new cargo handling concepts. When it is forecast that the majority of air cargo will be carried on passenger aircraft, the site must be conveniently located with regard to the passenger terminal building.

10.3.2 The site should be easily accessible from existing and future ground transportation links. The taxiing distances for aircraft between the terminal and the runway should be as short and direct as possible. Likewise, direct ground links should be available between passenger and cargo buildings, preferably by internal roads for exclusive use by airport vehicles.

10.3.3 The positioning of the cargo terminal should take into account prevailing winds during inclement weather. Finally, the cargo building and its aprons should be sited so that there will be no infringement upon obstacle limitation surfaces nor interference with electronic equipment or navigation aids.

10.4 SYSTEMS PLANNING

10.4.1 A well conceived cargo facility, like a passenger building, will be one that is planned and designed systematically. The entire cargo handling operation should be viewed as a system, from the cargo apron through the cargo building to the docks and forward to the road system. A clear understanding that a cargo building is a flow system is a prerequisite to proper planning of cargo terminal areas.

Cargo Flow Principles

10.4.2 The planning, design and layout of airport cargo facilities should recognize the importance of basic cargo flow principles. Foremost among these are:

a) all-cargo aircraft should be separated from combination (passenger/cargo) aircraft in the process of loading and unloading, preferably at a cargo terminal;

b) the flow of cargo to and from aircraft and between aircraft should be as smooth as possible and should cover the shortest possible distance in the flow sequence. Moreover, access to the cargo terminal from both the apron and the land side should be direct and convenient;

c) physical barriers between processing areas for the import and export of cargo should be avoided, if possible, to permit optimum use of available space in the cargo building, particularly with respect to storage areas; and

d) at the larger airports for which this manual is written, adequate provision should be made for the handling of large containers and pallets between trucks and cargo terminals, and between cargo terminals and aircraft.

The schematic in Figure 10-1 is a broad depiction of principles for achieving a continuous and direct flow of air cargo within the cargo terminal.

10.4.3 In planning air cargo facilities, two types of flow should be considered, namely, the flow of documents and the flow of cargo itself. The means by which the flow of documentation will move between the processing and administrative areas of the cargo terminal will have an effect upon the ultimate building design selected. The basic premise to be followed is that the documentation should not restrict the flow of cargo, but conversely should not permit cargo handling to get out of control.

10.4.4 The flow of cargo may be via many different automatic handling or manual handling systems. Labour availability and costs, as well as the cargo size and weight mix, will determine the handling and storage systems. The ratio between export and import cargo and the total percentage of international cargo will have a bearing on storage requirements.

Cargo Handling Principles

10.4.5 There are a number of generally accepted principles to follow when planning cargo terminal systems and selecting cargo handling equipment:

a) cargo should be handled in the largest convenient unit load, by the quickest means, over the shortest route, in the safest manner and by the most economical method;

b) the use of mechanical means instead of manual handling generally increases efficiency and economy;

c) cargo handling systems should be integrated with all associated control and operational paperwork procedures;

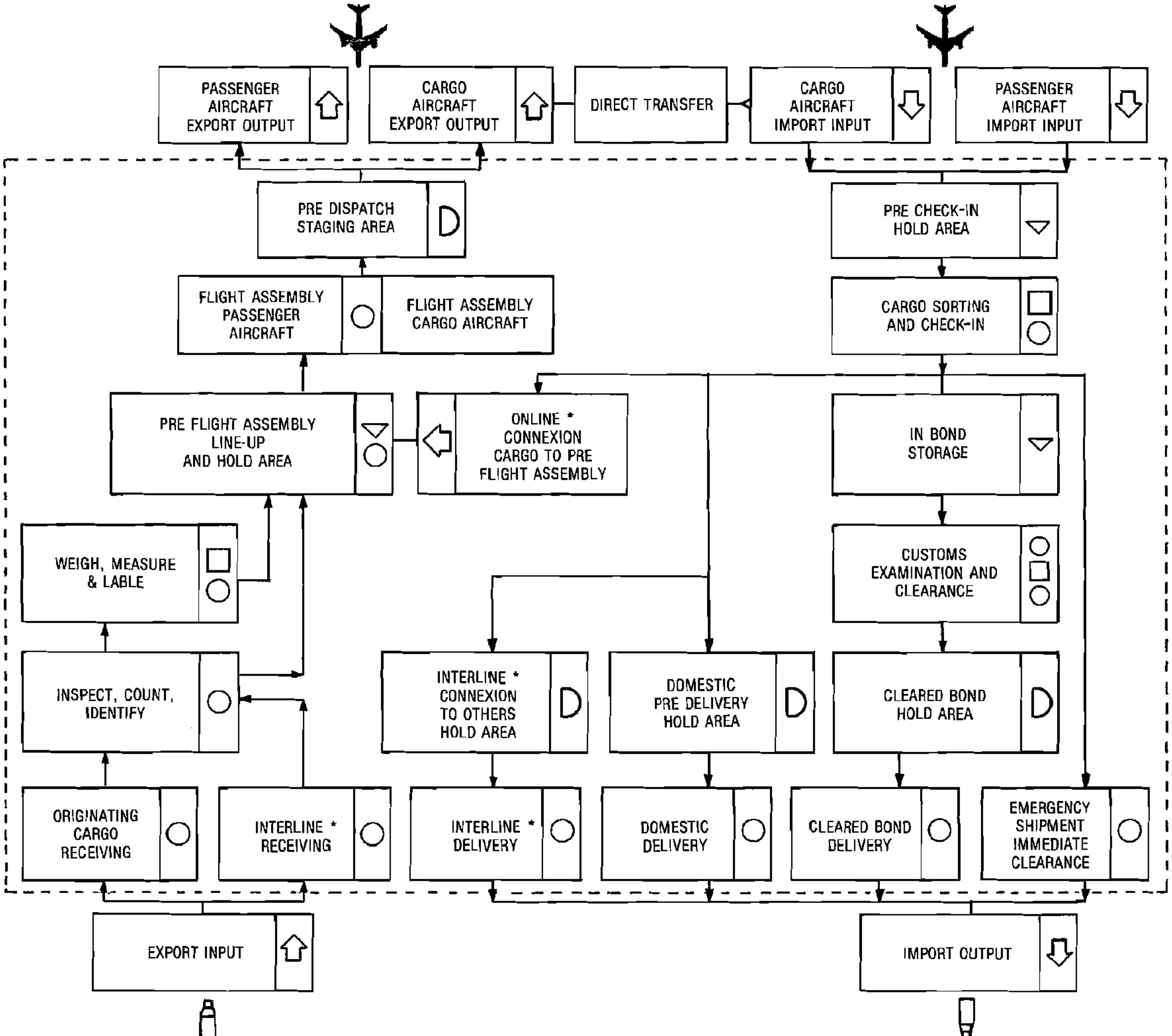
d) economy in the handling of cargo will result if control and operation procedures are so designed as to simplify handling systems;

e) handling systems should be so designed as to obtain the maximum utilization of equipment (e.g. maximum standardization in methods and in the types and sizes of equipment, maximum flexibility in the use of equipment, minimum turnaround times of mobile equipment);

f) infrequently used equipment should be as inexpensive as possible;

g) it is economically best if cargo in movement can, as far as possible, continue in movement without interruption; and

h) the design of storage systems should be such that maximum utilization of space is accomplished, measured in terms of cubic content, together with ease of selection with the minimum effort.



KEY TO SYMBOLS

OPERATION	○	An operation occurs when a unit of cargo is lifted up or put down or moved during a process. Marking and labelling is considered an "operation". An "operation" also occurs when information is given or received or when planning or calculating takes place (e.g. input or extraction of information from/to electronic data processing systems).
INSPECTION	□	An inspection occurs when a unit of cargo is examined to determine proper packaging, acceptability for carriage, weighed, measured, etc.
TRANSPORTATION	⇨	A transportation occurs when a unit of cargo is moved from one place to another beyond the limited movements which occur during some operations and inspections.
DELAY	D	A delay occurs to a unit of cargo when it is prevented from progressing to its next planned activity.
STORAGE	▽	A storage occurs when a unit of cargo is staged, prior to assembly, assembled, pending dispatch to aircraft, or held pending breakdown and/or customs examination and/or delivery.

* According to local circumstances, this may apply to air side, land-side or both.

SOURCE: INTERNATIONAL AIR TRANSPORT ASSOCIATION

Figure 10-1. Example of flow in cargo terminal

10.4.6 There are two principal factors which will govern the actual space required in the cargo terminal and the layout of this space. One is the rate of flow, which will depend upon the handling system employed and the cargo-carrying capability of passenger and all-cargo aircraft, as well as frequency of services. The other relates to the future storage requirements in the cargo terminal, which will depend largely upon the procedures used by airlines in preparing goods for shipment and delivery, and on the implementation of new procedures as the volume of air cargo increases.

10.5 THE CARGO BUILDING

10.5.1 The general principles described in this section apply to cargo terminals of all sizes and all types of handling characteristics. However, the effect of these principles is less marked in very small and very large terminals. For this reason the extremes of cargo terminal sizes have been disregarded, with reference in this manual directed at the vast majority of cargo terminals which are in the range of 325 m^2 to 10 000 m^2. These principles are also valid for a single terminal within a multiple-occupancy building for which varying requirements must be met to satisfy all users.

10.5.2 The following elements may be used in determining optimum cargo terminal dimensions:

a) connecting paths needed between diverse handling areas within a terminal — such paths should be as short as possible

— for minimum movement of cargo and mobile equipment,
— for optimum mobility of staff between functions,
— for maximum supervision of all handling activities,
— for maximum industrial safety and cargo security;

b) the required length of truck dock frontage during peak demand;

c) best use of floor space in accommodating fixed plant and storage equipment;

d) capability and flexibility for modular expansion of terminal area — such modules should be consistent with the planned installation of handling equipment; and

e) minimization of building perimeter to reduce construction costs.

10.5.3 Any cargo processing facility must be capable of supporting the following activities relative to export and import functions:

export (outbound) — acceptance
staging
load makeup

import (inbound) — load breakdown
storage
delivery

The area in which either of the above processes takes place can therefore be considered as a basic cargo terminal unit. However, at some locations the import and export functions may be totally integrated, with all activities being performed in the same area. In such a case, the area required for these functions should be considered as one basic cargo terminal unit.

10.5.4 Generally speaking, the criteria listed above are best met by a square terminal configuration. However, the significance of truck dock frontage requirements may be such that a rectangle with longer land side and air side frontages than building depth is required. Similarly, site availability may distort the square layout. As the limits of distortion are approached, efficiency of flow functions will deteriorate, creating bottleneck situations.

Single Occupancy Cargo Building

10.5.5 A single occupancy cargo building is one that accommodates a single user and may involve export, import or a combination of both. For a single occupancy cargo building, the following options may be considered:

a) If the occupant handles both international and domestic cargo, it is necessary to have the air side portion of the building divided into two separate areas to insure the segregation of international and domestic cargo. However, it is still possible to have a continuous frontage on the land side so that all truck dock facilities are located in one place.

b) If the cargo operation is large, or if the forecast for growth in cargo operations indicates a requirement for expansion of the cargo facilities in the near future, separate land side operations should be considered. Separate truck dock facilities for international and domestic cargo may be necessary to insure adequate frontier control and allow for future expansion.

Multiple Occupancy Cargo Building

10.5.6 Airport master planning frequently requires that a cargo building be developed which can accommodate a number of users. In planning such a building, detailed consideration should be given to potential expansion of each individual user's space and operation. Such expansion may be handled by locating the largest cargo operator at the end of the building so that its operation can be expanded without disrupting the other tenants, constructing the building so that internal walls can be relocated to allow one tenant to expand into adjacent space, and locating truck docks so that all tenants have access to land side transportation.

10.5.7 A mere summing up of individual airlines' space requirements and provision of a building to meet the total demand will not be an acceptable solution. The building must be shaped so that individual users' requirements are met in accordance with the principles laid down previously. In particular, the adoption of a common depth building is known to produce great difficulties caused by excessive distortion of the smaller terminal units.

10.5.8 When user agreements or leases are entered into particular attention should be given to the ability of the airport operator to relocate users to allow for expansion of the other building tenants.

10.6 CARGO APRON

10.6.1 The apron planning principles described in Chapter 7 also apply to cargo aprons. The apron should be planned to suit the cargo building handling methods to be used. Nose-in or tail-in parking with fixed mechanical loading systems minimizes the size of the apron. Loading methods which involve the use of large quantities of apron equipment increase the size of the aircraft stand required. Space must also be provided for aircraft servicing equipment. If cargo handling and aircraft servicing are carried out at the same time, it is important to minimize the amount of vehicles and equipment to keep aprons to a reasonable size and allow the maximum number of aircraft to be parked close to the cargo building.

10.6.2 To ensure efficient cargo handling, the cargo apron must be treated as a continuation of the cargo terminal. It is desirable for all-cargo aircraft to be loaded or unloaded on the apron directly outside the cargo terminal. In addition, sufficient reserve space should be provided in the long-range plans to permit expansion of the apron in line with intended expansions of the cargo terminal, and to accommodate increases in aircraft size or changes in characteristics.

10.6.3 Each apron layout and associated handling system analysis should include the following elements:

a) types of aircraft shown on forecast;

b) airline requirements as to ground time;

c) airline emphasis on schedule departure time;

d) airline consideration as to capital cost (equipment) vs. labour cost (workforce);

e) labour resources available for operational purposes; and

f) land resources available.

10.7 CARGO FACILITY REQUIREMENTS

10.7.1 As a guide to basic facility requirements in cargo terminals, the following requirements should be taken into consideration:

— the area allocated to the segregation of inward consignments should be readily accessible to the assembly area for outward consignments (this will facilitate the movement of transfer consignments);

— adequate space for presentation, opening and examination of air cargo for customs;

— adequate space, near to the final delivery area, for repacking of air cargo after customs examination;

— adequate warehousing areas, both free and bonded, inclusive of areas for preparation of load prior to shipment or disassembly of load from incoming aircraft (build-up breakdown stations) and including the handling of pallets or unitized loads;

— weighing facilities;

— space for cool storage of vaccines, perishables and foodstuffs, and additionally, where an airline so requires, deep freeze or other refrigeration methods;

— strong room for valuables and bullion;

— storage space for human remains;

— accommodation and specially designed holding areas for animals and livestock (specific details regarding construction of facilities and other requirements are contained in the IATA "Live Animals Manual");

— parking and storage space for loading vehicles and other equipment;

— public reception counters;

— provision for offices for control authorities as necessary;

— adequate office space for management and accounting functions as well as data processing, tracing archives and security requirements;

— storage space in a secure area for aircraft spaces and/or servicing tools;

— aircrew functional spaces and rest rooms;

— storage for dangerous goods;

— storage for empty ULD (unit load device) pallets, containers, etc.;

— lashing and tie-down material storage; and

— workshop facilities for cargo handling equipment including battery charging facilities.

10.7.2 The design and construction of both building and apron should ensure the maximum security of air cargo and mail from such risks as burglary, unlawful interference or unlawful removal. Due provision should also be made for the installation of mechanical or electronic devices which are associated with the latest cargo security procedures. For more complete details on this subject, application should be made to the Security and Fraud Prevention Department, IATA, 2000 Peel Street, Montreal, Quebec, Canada H3A 2R4.

10.8 CARGO TERMINAL AREA ACCESS

10.8.1 In the planning of public road systems linked to the cargo terminal complex, attention should be given to the following factors:

a) adequacy of the road system to cope at peak periods with the volume of pick-up and delivery vehicles, in addition to other traffic. A truck access road, separate from passenger vehicle roads may be necessary when air cargo volumes are expected to be heavy;

b) requirement for roadways to have sufficient bearing strength and height clearance to handle existing and projected cargo-carrying road vehicles, including container transporters;

c) the over-all traffic road pattern should be engineered to permit easy access from the major road system external to the airport;

d) the need for a public road link between passenger and cargo terminals which is in addition to, and does not conflict with, any service road link; and

e) the road system should have an expansion capability which is compatible with future cargo traffic growth forecasts.

10.8.2 A connexion from the road system direct to the cargo terminal apron should also be provided for the use of authorized airline or commercial vehicles.

10.8.3 Consideration should also be given to providing convenient access to the cargo terminal for vehicles which operate on the air side of the airport. Items to be considered include:

a) a separate network of roads linking terminal maintenance and cargo buildings, by the most direct routes possible, for use solely by airport service vehicles. This network should be capable of meeting the requirements of container-carrying equipment between the cargo terminal and the high capacity aircraft parking positions. Since cargo container transportation is generally a low speed vehicle operation, the addition of a low speed lane on either side of existing traffic lanes in the apron area would help to avoid traffic congestion;

b) adequate bearing strength, height clearances and turning radii to accept all projected road service vehicles and ground support equipment, including aircraft tugs when applicable;

c) adequate separation from runways, taxiways or other areas where aircraft manoeuvre, to ensure the safety of personnel, vehicles and equipment from aircraft blast; and

d) at existing aerodromes, special consideration of any new clearance requirements which may result from the introduction of high capacity aircraft.

10.9 CARGO TERMINAL PARKING

10.9.1 Adequate vehicle parking space should be available on the land side of cargo terminals if such terminals are to function effectively. Also, immediate and future parking requirements should be studied carefully and provision should be made for expansion of parking facilities in line with expected volumes of air cargo to be handled and the expansion of cargo terminals.

10.9.2 The parking requirements fall broadly into two categories: operational parking for vehicles for the pick-up and delivery of air cargo, and personnel parking which should be as close as possible to the working area. The operational parking requirements can be divided as follows:

a) *Pick-up and delivery parking:* this area is for loading and unloading on the land side of the cargo terminal, and should be zoned so as to ensure that the manoeuvring area is kept clear of vehicles awaiting their turn at the truck dock for loading and unloading. The depth required for manoeuvring vehicles into the docking space will vary by location and according to the type of vehicle used, and this factor will require careful evaluation at each airport. In all cases, however, the depth provided should be at least 30 m.

b) *Holding area parking:* this area is for vehicles waiting to unload and should be in the immediate vicinity of the pick-up and delivery area.

c) *Service parking:* is for use by agents, brokers, forwarders and government agencies and should be in the immediate vicinity of the cargo terminal.

10.10 CONTROL AUTHORITIES INSPECTION

For relief of airport congestion and provision of additional capacity, cargo processing facilities, including customs and health inspections, could be located off the airport. Local regulations may require such cargo to be transported in bond or under particular conditions, and may affect the form and operation of a transport system.

References

"Airport Terminals Reference Manual", Chapter 4, published by the International Air Transport Association.

Chapter 11. GROUND TRANSPORT AND INTERNAL AIRPORT CIRCULATION AND PARKING

11.1 ABOUT THIS CHAPTER

11.1.1 This chapter deals with the planning of that element of the airport necessary for the accommodation of ground transport of passengers, baggage and employees to, from, and within the airport. Cargo movement and handling has been treated separately in Chapter 10.

11.1.2 In order to adequately plan airport ground transport facilities, data must be developed from the forecasts made in accordance with procedures described in Chapter 3. In addition to estimates of future passenger levels, forecasts must be made of airport employees and visitors. Passenger/visitor ratios should be developed and vehicle occupancies quantified. Finally, the number of employees, their mode of travel to the airport and parking destinations should be determined. Other service vehicle traffic, including flight kitchen and fuel deliveries will have an impact on on-airport roadways and should also be quantified.

11.2 AIRPORT ACCESS — AUTOMOBILE AND PUBLIC TRANSPORT

Ground transportation to and from most airports is provided by two principle modes, namely private automobile and public transport, mainly taxis and buses. Although some airports are served by some means of mass transit system other than buses, e.g. train, subway or monorail, by far the dominant mode of airport ground access is the automobile, for both private and public transport. It is likely that the automobile will continue its dominance as an airport access vehicle.

11.3 AIRPORT TRAFFIC DATA

11.3.1 Most airport vehicular traffic is generated by passengers. The other significant components of vehicular traffic are employee, cargo, and support services.

11.3.2 To calculate vehicular traffic and its required facilities, the Design Year/Average Day/Peak Month/Peak Hour forecasts (including base year data) based on information developed in Chapter 3, will provide the volumes of passengers. The specific information necessary to transform the passenger forecast traffic volumes into volumes of vehicular traffic includes:

a) passenger arrival rates;

b) passenger/visitor ratio (visitors are wellwishers or greeters);

c) percentage of passengers by type of vehicle (private, taxi, limousine);

d) occupancy by type of vehicle (including passengers and visitors);

e) percentage of short-term and long-term parking; and

f) intra-airport vehicular traffic, e.g. between remote parking and terminal or between terminals.

Most of this information can be obtained only from actual surveys, which should include traffic data on employee, cargo, and support services. Many airport authorities maintain basic current information that can be an excellent source for initial planning.

11.3.3 Before a survey is conducted, the data collection needs to be organized in such a manner that the required detailed information can readily be tabulated. The results can be used to analyse traffic volumes on main traffic segments of the airport, such as between airport access and parking, between parking and terminal, between airport access and terminal. For example, surveys will provide information on the percentage of passengers arriving by private car, with visitors, which implies circulating traffic. The passenger with baggage may be dropped off at the curb, the visitor (wellwisher) will proceed to the short-term parking lot, join the passenger in the terminal, and, after aircraft departure, return to short-term parking and exit the airport. Taxis and private cars may have to make recirculation trips if they miss terminal entrances or exits.

11.4 INTERNAL AIRPORT ROADWAY CIRCULATION

11.4.1 At the larger airports to which this manual applies it may be desirable to separate service vehicles and trucks from the passenger and visitor vehicular traffic, either before or shortly after entering the airport property. This can be accomplished by three types of roadway systems:

1) the principal public airport road for use by passengers, visitors and employees;

2) public service roads with security control points permitting access only to authorized vehicles (e.g. air cargo delivery, flight kitchen supply, etc.); and

3) non-public service roads with security control points for use by authorized vehicles such as maintenance, fire and rescue, fuel, etc.

The public road system accommodating service vehicles needs to connect with the terminal only for delivery of goods at designated locations. The non-public service road system accommodating vehicles serving the aircraft parked on the terminal apron needs to be completely secured from the public road system.

11.4.2 Through the use of surveys, traffic volumes by vehicle type can be determined for peak hours on specific roadway segments as well as at points of entry and exit. The number of traffic lanes required can be estimated from this basic information.

11.5 PASSENGER BUILDING CURB

The passenger building curb space requirements are an important part of the aerodrome complex. The main features of this element of the aerodrome are vehicular traffic lanes, through lanes, bypass lanes, curb/manoeuvring lanes, sidewalk platform directional and identification signs, curb-side baggage check-in points and pedestrian crossings. Additional planning information with respect to curb-side dimensioning may be found in 9.3.3 through 9.3.14.

11.6 VEHICLE PARKING

Planning Principles

11.6.1 Vehicle parking should be considered in relation to the area it serves rather than any particular category of traffic, although the principle of separation of functions often leads to the vehicles associated with a particular area also being of a specific category, e.g. passenger cars, cargo vehicles, etc. Two basic principles should govern the provision of vehicle parking: it should be located as close as possible to the area served and should, other things being equal, occupy the least possible ground area. The smaller the ground area the closer all parts of it will be to the functional area. This is particularly important when pedestrian movement between the vehicle parking and functional area is necessary, but it is also important in reducing vehicle movements, and thus road requirements, and speeding up service times. These objectives can be achieved by developing multi-level car parking.

11.6.2 With the aim of locating vehicle parking as close as possible to the various functional areas, an analysis should be made of the types and numbers of vehicles generated by each area. The extreme physical characteristics of some vehicles may prohibit them from using multi-purpose or multi-level parking facilities, and in these cases separate provision should be made for them. The cost-effectiveness of structures necessary for multi-purpose use should be the determining factor in the siting and use of vehicle parking. It will, however, often be found best to locate buses, coaches, taxis on the lower levels and private cars on upper levels. Adequate access to curbs should be provided. Parking can often be sited to provide simultaneous access and exits from several points while maintaining segregation between categories of traffic.

Location

11.6.3 The location and use of vehicle parking should normally be determined by the vehicle parking period. As the parking period increases consideration should be given to locating the parking at more remote positions, such as on the airport perimeter. This is especially relevant in the case of staff car parking, although short-term parking for staff cars should be provided in operational areas for those staff for whom a vehicle is essential in carrying out their duties. Similarly, passenger cars and buses, which remain only for the period necessary to deliver or collect passengers, should be parked as close as possible to passenger buildings. Short-term parking for passenger vehicles is required in the passenger area for drivers meeting arriving passengers, as well as for many of the wellwishers accompanying departing travellers. The appropriate parking period for these vehicles may vary according to local conditions and the climate, which may affect aircraft arrival times. A period of 30 minutes has often been found satisfactory, but a maximum period of 2 hours should cover all requirements. The period for any specific airport should be determined by space availability and the local characteristics of the traffic.

11.6.4 Parking for passenger vehicles remaining for longer periods should be treated in a similar way as other long-term vehicle parks. The park may be managed and operated under a system which permits the passenger to drive to the passenger building and hand over the car to the car park management for transfer to the car park. On return the passenger's car is transferred back to the passenger building by the car park management and handed over to the passenger at the land side vehicle pick-up positions. An alternative is for passengers to park and collect their cars at the remote car park and to be transported between it and the passenger building by a shuttle service operated by the car park management.

11.6.5 If a system of curb-side check-in is used, ample provision should be made for it and all its consequences.

References

"The Apron and Terminal Building Planning Report", U.S. Federal Aviation Administration, Report No. RD-75-191, July 1975.

SECTION FOUR — AIRPORT SUPPORT ELEMENTS

INTRODUCTORY NOTES

A number of buildings for special purposes are necessary to support the operation of an airport. The need for all or some of the buildings described will vary from airport to airport, as will the specific space requirements; their locations in the airport or individual master plans should be determined by the functions they are to fulfil and their compatibility with the major features of the plan. When considering the size of buildings, the need for their growth along with the general growth of the airport should be taken into account.

Specific planning considerations which should be taken into account are noted under each individual facility. Consultation with experts knowledgeable in each specific field and the users of the facilities is recommended.

Chapter 12. AIRPORT OPERATIONS AND SUPPORT FACILITIES

12.1 ABOUT THIS CHAPTER

Buildings for a variety of operational purposes are required at an airport. These include accommodation for meteorological, air traffic control, communications, rescue and fire fighting services, fuel depot and all the facilities for administration and maintenance, staff, aircraft operators, general aviation facilities and police. Sometimes there is an hotel.

12.2 ADMINISTRATION AND MAINTENANCE BUILDINGS

12.2.1 Only functions which are essential for day-by-day operations should be accommodated in passenger and cargo areas, as their space is limited, and their size becomes unnecessarily and disadvantageously large if they are used to accommodate functions and staff which can be located at more remote positions. A separate area for administration and miscellaneous purposes should be provided; this can frequently be on the perimeter of the airport or incorporated with the maintenance areas. Such areas as these, which employ large numbers of staff, should be located as close as possible to primary public transport facilities and should have good access to the operational areas.

12.2.2 Facilities which can be appropriately included in an administration area include: office and other accommodation for airport management, aircraft operators, government control authorities, etc; police station; telephone exchange; airport maintenance depot; and flight catering kitchens.

12.2.3 Maintenance facilities will be required for motor vehicle repair, electrical repair (buildings, radio and visual navigation aids), painting (buildings and runway markings etc.) and mechanical repair. The maintenance facility should include storage for material, replacement parts and a fireproof area for flammable materials.

12.3 MEDICAL CENTRE

Facilities should be provided to staff and passengers for treatment of medical emergencies (first aid), for aircrew medical inspection and for emergencies and rescue. The scale of facilities and their purpose should determine the location, which, however, should be chosen whenever possible within walking distance of the passenger area(s). Facilities should be strategically located for easy accessibility in case of an aircraft accident and be capable of expansion to serve on short notice as an enlarged aircraft accident first-aid receiving station. The usefulness and efficiency of any medical emergency and rescue organization on an airport may be greatly enhanced if it is in continuous use dealing with day-to-day medical activities during the normal routine working of the airport.

12.4 GROUND VEHICLE FUEL STATIONS

A fuel station for land side ground vehicles can be a good source of revenue for an airport authority and may be necessary where fuelling facilities are not closely available on the main public routes from the airport. It should be sited where traffic entering and leaving it would not cross or slow down the fast continuous flow of other traffic on the main vehicle routes. A separate station for airport vehicles may also be justified.

12.5 GENERATING STATIONS

Generating stations may be required for heating, electricity, etc. After considering requirements for future expansion of other airport facilities, consideration should be given to siting such stations as close as possible to the areas they serve in order to avoid long service lines which can impose considerable inflexibility on future development. It may be necessary at some airports to provide standby power generators, independent of the main airport power system, as a secondary power supply. See also Annex 14, Chapter 8, Annex 10, Volume I, Part I, and the *Aerodrome Design Manual,* Part 4, in respect of secondary power supplies.

12.6 WATER SUPPLY AND SANITATION

The airport must be supplied with adequate water, properly processed and chlorinated and a sewage disposal system for handling and treating waste. A dump for refuse and garbage must be provided within a convenient distance of the airport or facilities provided for temporary storage on the airport if this refuse is to be carried away by others. Such dumps must be carefully planned in order not to create a bird hazard problem (see the *Airport Services Manual*, Part 3).

12.7 FLIGHT CATERING KITCHENS

Aircraft operators often require fairly large facilities for preparation and storage of food, drink and other aircraft cabin stores. These facilities should not be located in the passenger area but should have good access to the aircraft aprons using airside service road. The best location depends upon the nature of the airport traffic; for airports with a large proportion of originating and terminating flights, sites in the aircraft maintenance area may be appropriate. Customs regulations may require such facilities to be within customs controlled areas. Generally, preparation facilities and main stores should be included in the maintenance or administration areas with supplementary stores and facilities sited adjacent to the aprons.

12.8 METEOROLOGICAL SERVICES

Meteorological Office

12.8.1 Meteorological offices should normally be located so as to facilitate briefings between flight crew members and meteorological personnel. Offices should therefore be close to the other airport briefing and reporting offices (ATS reporting office, aeronautical information services unit, etc.), and proximity to or good communications with the airport COM centre and with local air traffic services units of the airport is also essential.

12.8.2 There should be sufficient space for the communications equipment needed to receive meteorological information and, where charts and forecasts are prepared by the office, there should be room for the plotting and analysis of the necessary charts. If it is intended to provide weather radar for forecasting and briefing purposes, suitable space should be made available for the radar display in a convenient location, and provision made for interconnecting cables to the antenna site.

12.8.3 The forecaster preparing the airport and landing forecasts should have a good view of the airport and the office should be in proximity to, or have good communications with, the aeronautical meteorological station.

12.8.4 Where all forecasts are received from outside sources, space requirements would be somewhat reduced. Where briefing is carried out by television or other electronic means, the television receivers should be easily accessible to aircrews, who should also be able to contact the office to deliver post-flight reports, etc. (see Annex 3, Chapter 5).

Aeronautical Meteorological Stations

12.8.5 An unobstructed view of the airport, particularly of the runway complex, and good communications with the meteorological office, the communications centre and the local air traffic services unit(s) are essential. Observations are usually made in the areas of runway intersections and/or the thresholds of instrument runways so as to be sufficiently representative (Annex 3, Chapter 4). Because of the difficulties involved in stationing observers close to the runway, the trend is towards the use of sensors at the necessary positions with distant reading instruments in the meteorological station. In the planning of new airports or improvements to existing airports, consideration should be given to provision of necessary electrical ducts to allow the satisfactory siting of sensors and distant reading equipment such as thermometers and anemometers near the runway, transmissometers near the threshold and ceilometers in the approach area or, where it exists, near the ILS middle marker.

12.9 AIRCREW BRIEFING AND REPORTING

12.9.1 Before a flight can depart from an airport the aircrew may be required to undertake certain pre-departure procedures. Aircraft operators may have their own aircrew briefing requirements and any facilities which they require for briefing their crews should be provided within their administration buildings. However, accommodation for aircrew briefing and clearance procedures required by government and international regulations should be grouped together at a location suitably related to the aprons.

12.9.2 Depending on the category of traffic and local regulations, aircrew may be subject to customs inspection of themselves and/or their aircraft. They may also be required to file flight plans or report to the air traffic control authority, and to obtain meteorological and aeronautical information service briefings. On arrival at international airports aircrew must report to government control authorities to clear themselves, the aircraft and stores.

12.9.3 Facilities for all these purposes should be located as close as possible to the main centre of activity of the aprons. At large airports with several aprons it may be essential for reasonable speed of pre-departure procedures and aircrew convenience to locate facilities in more than one area. The premises where crew members have to report for operational purposes should be readily accessible and next to one another, if possible in the same building, preferably located at apron level and on the main air side service roads. At large airports where the apron areas for general aviation traffic are located at a considerable distance from the main terminal area, consideration may be given to establishing a satellite facility for ATS reporting and AIS and MET briefing in order to facilitate flight preparation and reporting by flight crews. Adequate short-term vehicle parking space for aircrew and aircraft stores vehicles should be associated with these facilities. The objective should be to achieve the quickest and most convenient pre-departure and post-arrival formalities for aircrew.

12.10 AIRCRAFT MAINTENANCE AREA

12.10.1 Similarly, as for the passenger and cargo areas, siting of the aircraft maintenance areas will be influenced by the type of traffic for which the airport is intended and the aircraft operators' route structures which it serves. The number or aircraft moving between the maintenance areas and the aprons will depend on whether the airport is used by aircraft operators as a base for major maintenance, or only for line maintenance or for some combination of each. In the first case there would be a considerable number of aircraft movements between the aprons and maintenance areas, but somewhat fewer in the second case because maintenance is carried out during aircraft turnround.

12.10.2 Aircraft maintenance areas should be sited compatibly with taxiway systems to avoid aircraft having to cross runways. Due consideration should be given to noise problems.

12.11 RESCUE AND FIRE FIGHTING SERVICES

12.11.1 The airport fire station should be located so as to ensure that response times for aircraft accidents and incidents are two minutes, and do not exceed three minutes, to the end of each runway in optimum conditions of visibility and surface conditions. Other considerations, such as the need to deal with structural fires and other duties performed by rescue and fire fighting personnel, are of secondary importance and must be subordinated to the primary requirement. At a large airport it may be necessary to provide more than one fire station, each located strategically in relation to the runway pattern. Analyses of aircraft emergencies have revealed that a large proportion of aircraft accidents and incidents occur on, or close to, the runways and, thus, sites for fire stations that will give the shortest response time to these areas are essential.

12.11.2 The airport fire station will provide facilities for housing the rescue and fire fighting equipment and personnel, including in some cases ambulances and their crews. The equipment, amounts of extinguishing agents and number of vehicles and personnel will be determined primarily by the length of the aeroplanes using the airport and their frequency of operations. (See also Annex 14, Chapter 9, and the *Airport Services Manual,* Part 1.)

12.12 GENERAL AVIATION FACILITIES

12.12.1 General aviation is defined as all civil flying not classified as commercial air carrier and includes many different type and use categories of aircraft. General aviation includes such diverse activities as personal flying, transportation of personnel and cargo by privately owned aircraft, air taxi and agricultural flying, and instructional flying.

12.12.2 The various types of aircraft comprising the general aviation fleet range from single-engine aircraft to multi-engine turbo-jet. The growth of general aviation activities in many States has greatly exceeded that of the commercial airlines and has become an integral part of the national air transport system. The requirements of locally based and itinerant general aviation activity, both national and international, should be considered an integral element of airport master planning.

12.12.3 One of the primary considerations in the airport planning process is the anticipated level of the volume of general aviation operations the airport will experience, both initially and in the future. The accuracy of forecasts of the demand for general aviation utilization of runways, taxiways, apron and terminal facilities can become a major influence on the capacity of the entire airport system.

12.12.4 General aviation includes many different types of aircraft with a wide range of operational requirements. An airport that experiences a mix of general aviation and commercial aircraft may cause unacceptable delays in departures and arrivals, particularly during periods of marginal weather conditions. An airport that is to serve both scheduled commercial operations and a substantial volume of general aviation should, when possible, provide a separate runway and taxiway system to serve general aviation type aircraft exclusively. Such airport facilities should be positioned so that general aviation aircraft are not required to taxi, take off or land across airport facilities primarily provided for commercial aircraft operations.

12.12.5 When general aviation operations are substantial in volume they should be centred at a location on the airport apart from the passenger facilities provided for commercial airline services. The site selected for general aviation activities should include sufficient area for hangars, aircraft parking, and storage, fuelling and maintenance facilities. At some airports a relatively small passenger terminal may be required to provide accommodations for passengers and crews, if the airport is to be served by commuter or short-haul air services with general aviation-type aircraft. Customs and international clearance facilities for international passengers and for aircraft of foreign registry may be required in the general aviation service area.

12.12.6 At airports where either the scheduled operations or the general aviation operations are very low, separate facilities are not always required and combining of facilities may be prudent to support airport concessions.

References

"Utility Airports", U.S. Federal Aviation Administration, AC 150/5300-4B, 1975.

Annex 10 — *Aeronautical Telecommunications.*

Annex 14 — *Aerodromes.*

Airport Services Manual (Doc 9137), Part 1 — Rescue and Fire Fighting, and Part 3 — Bird Control and Reduction.

Aerodrome Design Manual (Doc 9157), Part 4 — Visual Aids.

Chapter 13. AIRCRAFT FUEL FACILITIES

13.1 ABOUT THIS CHAPTER

The handling of fuel at airports is an important subject to be taken into account when planning airport facilities, since special requirements have to be met with regard to:

— safety, because of the fire hazard that fuel constitutes, mainly on aprons where a number of other activities are taking place simultaneously with aircraft fuel servicing;

— minimizing aircraft gate occupancy times; the fuel flow rates required are a factor in the choice of the refuelling system to be adopted; and

— movements of large and heavy vehicles, which has an impact on the design of pavements for aprons, remote parking areas and service roads.

13.2 STORAGE CAPACITY

13.2.1 Storage capacity requirements must be estimated based on a forecast, taking into consideration:

— types of operating aircraft,
— frequency of operations,
— fuel uplift per aircraft,
— different types of fuel required,

for a period of time determined by the reserve policy in accordance with the distance to the source of delivery and the risks of disruption in the fuel transportation system.

13.2.2 The delivery of fuel is made from refineries or other associated main storage facilities. Its transportation to airports can be made by ship, barge, railway, truck or pipeline; the system to be used has a significant bearing on the capital cost of an airport, since the construction of special harbours and piers or great extensions of roads, railways or pipelines may become necessary. The movement of large and heavy trucks on existing roads is sometimes impossible and topographic conditions may preclude their improvement, or construction of new roads or railways. Thus the options are largely a question of economy and require a careful cost/benefit analysis.

13.3 LOCATION OF STORAGE

Storage areas should be located as close to the aircraft fuelling area as practical, with due recognition given to established clearances of flight patterns from obstacles. Adverse effects on the environment due to spills, leaks, sample and water drain disposal and the like should be minimized. The vapour densities of aviation fuels are such that released vapours, particularly under calm wind conditions, may travel considerable distances along the ground and collect in depressions where they may not readily dissipate. Thus an investigation of inhabited areas around the airport and wind directions is necessary.

13.4 FUELLING OF AIRCRAFT

13.4.1 Aircraft are fuelled at their parking positions either in stands close to terminal buildings or at remote ones, by fuel servicing tank vehicles, fuelling pits, or hydrant systems. The system chosen should be determined by the forecast rate of aircraft movements. Generally, tankers are most suitable where plenty of space is available, the rate of aircraft movement is not too high and the fuel requirements of aircraft are not too great. At busy airports, especially those where the aircraft operators' route structures make it necessary for very large quantities of fuel to be provided, problems arise due to both the number of tankers on the aprons and their very large size, which makes them slow and difficult to manoeuvre. In consequence, they may obstruct other servicing vehicles on the apron and around the aircraft, and stands have to be especially large to accommodate them. In these circumstances it is often desirable to install pipelines under the apron from the fuel storage area to the stands. Outlets are provided at stands and only a small road vehicle is then required to connect the hydrant outlets to the aircraft.

13.4.2 Considerable care should be exercised in locating hydrant outlets at the stands to ensure that they provide optimum flexibility and capacity, or provisions made for increasing the capacity (through future provision of more outlets), to meet possible future aircraft requirements. However, it is seldom possible to provide flexibility comparable with that of fuel servicing tank vehicles. Sometimes combinations of hydrants and tankers can be used with advantage. Hydrants to refuel tankers near the edge of aprons can also be useful.

13.4.3 There are, however, disadvantages associated with the use of trucks. Large jet aircraft require a considerable amount of fuel (nearly 70 000 litres for the Boeing 707-120 and DC-8 (domestic) to almost 115 000 litres for the Boeing 747). Two trucks are normally required, one under each wing. For the large jets, standby units are sometimes required if the fuel requirements are in excess of two units. This means that there are a large number of vehicles on the apron during peak periods, creating a potential hazard of collision with personnel, other vehicles, and aircraft. When a truck is empty, it must return to the storage area for refuelling before it can be used again. Thus extra trucks must be provided for use during the time when other trucks are being reloaded. When refuelling trucks are not in use, parking space must be provided for these vehicles.

13.4.4 The capacity of fuel servicing tank vehicles varies from 10 000 to 60 000 litres and modern tankers for DC-10, L-1011 and B-747 aircraft can reach a capacity of 75 000 litres. For the larger fuel servicing rank vehicles, axle loads are sometimes in excess of the bearing limits on highways; the airport designer consequently must provide adequate pavement strengths to support these vehicles.

13.4.5 Another method of fuelling is to install pipelines running from a central fuel storage area located adjacent to the landing area to pits located at the aircraft stands on the apron. Fuel is transferred to the pits by pumps located at the storage tanks. The pits must be located relatively near the fuel intakes in the wings of the aircraft. The advantages of fuel pits are that a continuous supply of fuel is available at all times, it is carried safely underground, and trucks are eliminated from the apron. The disadvantages are that for each pit separate meters, filters, hose reels, etc., are required; thus there is duplication of equipment. Also, a change in future operations at the airport may require a major change in installation. Because a concrete or steel pit is required, maintenance costs can be high due to intrusion of moisture. For the high rates required by large turbo-jet aircraft, the equipment is very bulky.

13.4.6 The trend at large airports is definitely toward the hydrant system, which requires a simpler installation than the pits while providing similar advantages. Essentially, the hydrant system consists of the same elements as the fuel pits, except that the pit is replaced by a special valve mounted in a box in the pavement and flush with the surface. The hose reel, meter, filter and air eliminator are contained in a mobile self-propelled or towed hydrant dispenser.

13.4.7 The principal advantages of the hydrant system are elimination of the need for duplicating the hose reel, meter and filter which are required in each pit. The principal disadvantage is that vehicles are not entirely removed from the apron. However, because of their small size, hydrant dispensers reduce possible collision damage to a minimum.

13.4.8 It is desirable that the hose line from the hydrant dispenser or pit to the intakes in the wings be from 6 to 9 m long. If a wide variety of aircraft are to be serviced at an aircraft stand, the precise spacing of the hydrant valves should be established in consultation with the airlines, as the number of hydrants required per gate position will depend not only on the type of aircraft but also on the number of grades of fuel required (each grade of fuel requires a separate hydrant).

13.5 SAFETY AND SPECIAL DESIGN REQUIREMENTS RELATED TO FUELLING SYSTEMS

Consideration should be given to the need for accessibility by emergency fire equipment when establishing aircraft fuel servicing locations and laying out airport fixed fuelling systems. Other important considerations include:

— Standards are prescribed by the competent authorities or stipulated by specialized institutes or associations. Codes, regulations and specifications are available from several agencies and different countries. Nevertheless, the consultation with airlines, as users, and oil companies, as providers of the product, is advisable when planning fuel supply systems at airports.

— Tanks located near or under aircraft movement areas such as aprons shall be of the underground type or mounded over with earth with depth and type of cover determined by consideration of aircraft wheel and/or impact loads.

— Fuel piping shall not run under buildings or passenger loading fingers (excluding movable loading bridges) except when run in buried steel casings enclosing only the fuel piping.

— Fuelling hydrants, cabinets and pits having a flow rate in excess of 23 L/min shall be located at least 15 m from any terminal building, hangar, service building or fixed enclosed walkways.

— The apron surfacing material shall be graded to form a gradual slope away from the rim or edge of fuelling hydrants or fuelling pits to prevent flooding.

— At aircraft stands where aircraft are fuelled, to prevent errors in measurement of fuel in the aircraft's tanks caused by parking with one wing low, the slope should not exceed 0.5 per cent in the transverse direction and 1 per cent in the longitudinal direction.

— The surface must slope away from the face of the terminal building for proper drainage and safety in case of fuel spillage.

— Fuel-resistant pavements should be used on aprons wherever refuelling operations or engine shut-downs are likely to take place regularly.

References

"Manual of Standards on Aircraft Fuel Servicing AK 71-20 (Draft)", Canadian Air Transportation Administration.

"Aircraft Fuel Servicing", National Fire Protection Association, 407.

"Flammable Liquids Code", National Fire Protection Association, 30.

"Planning and Design of Airports", Third Edition, Robert Horonjeff, Francis X. McKelvey, 1983, McGraw Hill Book Company.

"Airport Terminals Reference Manual", published by the International Air Transport Association.

Chapter 14. SECURITY CONSIDERATIONS

14.1 ABOUT THIS CHAPTER

14.1.1 More detailed information on aviation security is contained in the ICAO *Security Manual for Safeguarding Civil Aviation Against Acts of Unlawful Interference* (Doc 8973). Distribution of the document is restricted. It is available only through State Administrations. Airport security is an integral part of airport planning and operations, but details must be restricted. As a result, the subject can only be discussed in general terms in this manual. Attention is directed to the document cited above for detailed planning data.

14.1.2 At each airport a basic level of security is required under normal operating conditions. In addition there are measures and procedures which will be required during periods of heightened tension. These requirements will need to be determined at the earliest possible stage in the preparation of plans or designs. Consultation with airport security authority will be essential in order to assure that all security requirements are taken into account.

14.1.3 In order for security to be effective, a systems approach is required and this includes the basic plan for the design of the airport. All of the measures listed in this chapter need not be implemented at every airport but they should be considered against the level of security which it is desired to achieve. They should be implemented in such a way as will cause a minimum of interference with, or delay to, passengers, crew, baggage, cargo and mail. It should be recognized that the airport design is relatively inflexible once the structures are completed and should the security requirements become greater in the future, it may be difficult, if not impossible, to modify the buildings and structures at a reasonable cost.

14.1.4 Concurrently with determining the level of security to be provided, there is a need to define the areas on the airport to be protected. As a minimum, this would include the air side, but at some airports, protection of the entire airport property may need to be considered. In addition, other functions vital to air navigation which may not be located on the air side, such as air traffic services, radio navigation aids, petroleum storage areas, water and electrical power supplies, will also need to be protected.

14.2 LAND SIDE SECURITY

Passenger Buildings — Inspection/Screening of Persons

14.2.1 The most important security consideration in the design of passenger buildings is that it should not be possible for unauthorized persons to pass from the land side to the air side. This requires that access from public areas of the building to operational areas (including baggage and cargo areas) be strictly controlled.

14.2.2 In this context, adequate provisions must be made for the inspection/screening of passengers and their cabin baggage. For example, adequate space must be provided to separate X-ray devices from walk-through gate-type metal detectors by a minimum of 1 m as well as to separate electromagnetic security equipment from other airport equipment that will generate electrical fields which may adversely affect the operating efficiency of security equipment. This precaution will equally apply to ducts and cable runs provided for security equipment.

14.2.3 Passenger inspection/screening preferably should not take place in the immediate passenger boarding area or near the aircraft door. A preferred location would be a sufficient distance from the aircraft boarding area so as to permit adequate time for security procedures to be initiated in the event of a security alert. The *Security Manual for Safeguarding Civil Aviation Against Acts of Unlawful Interference* describes the basic plans for the inspection/screening of passengers at gates, hold areas and concourses, and sets out the advantages and disadvantages of each. A room or other facility should be provided in close proximity to each inspection/screening point where manual or other special search of persons may be carried out in privacy.

14.2.4 Regardless of the plan selected it is essential that the design provide for:

a) the physical separation of persons who have been subjected to inspection/ screening from others at the airport; and

b) the prevention of unauthorized access from land side or air side to passenger waiting (sterile) areas in which passengers are waiting after they have been inspected/screened and prior to boarding an aircraft.

VIP Lounges

14.2.5 VIP lounges should be so designed that they do not permit unauthorized land side/air side access. Persons boarding an aircraft from a VIP lounge should be subjected to the passenger and cabin baggage inspection/screening process.

Visitors' Observation Areas

14.2.6 Consideration may need to be given to the desirability of providing observation areas for the public to overlook aprons. If observation areas are to be provided, consideration should be given to enclosing them with glass or providing for surveillance by security guards. In cases where persons in the observation area would be able to pass material to departing passengers, the observation area should be made sterile by subjecting everyone to inspection/screening prior to being permitted access.

Airport Emergency Operations/Security Services Centre

14.2.7 The airport design must provide for an airport emergency operations centre and a security services centre. These two operations may usefully be located in one complex, either in the passenger terminal building or other suitable structure nearby. Use of accommodation in the air traffic services facility, the airport control tower or other remote facility on the air side for these purposes is not recommended.

Public Storage Lockers

14.2.8 Locations of public storage lockers should be selected to facilitate public access and to minimize public exposure in the event of an explosion in a locker facility. If constructed in terminal buildings, a vent should be provided so that the force of an explosion is directed away from locations in which there are concentrations of people and in a direction which will not adversely affect essential airport facilities. Provision for supervised storage facilities should be considered in lieu of lockers if any threat exists.

Baggage Handling Facilities

14.2.9 Adequate space will be required to enable the airline operator to establish procedures to ensure that only checked baggage for which a passenger is on board will be allowed to be transported on the aircraft. The exception to this would be if the airline operator has authority for some other form of security control for unaccompanied baggage, such as X-rays.

14.2.10 Another feature which should be considered in terminal design in relation to baggage handling is the ability to control access from land side to air side through the baggage conveyor system. If direct access is possible, a method of locking or otherwise controlling the access areas should be provided.

14.2.11 Many States have prohibited the use of off-airport check-in or curb-side baggage check-in. Terminals should be designed in such a way that checked baggage can be handled in the normal fashion if it is necessary to prohibit off-airport or curb-side check-in.

Storage of Mishandled/Misrouted Baggage

14.2.12 Consideration will need to be given to providing a secure storage area in the passenger terminal building where mishandled baggage may be stored until forwarded, claimed or disposed of.

Physical Separation of Arriving/Departing Passengers

14.2.13 The design of the passenger terminal building should provide for the physical separation of arriving passengers from departing passengers in the area after the inspection/screening point. There must be no possibility of mixing or contact between passengers who have been inspected/screened and other persons who have not been subjected to that process.

Cargo Handling Facilities

14.2.14 Special security facilities may be required for cargo. In certain situations it may be necessary to provide security controls for cargo, such as planned delays or physical or electronic searching. Airport planning should consider special requirements for cargo.

14.3 AIR SIDE SECURITY

Location of Operational Areas

14.3.1 Security of operational areas, where aircraft may be present, will be materially advanced by the physical separation of runways, taxiways and aprons from public areas. In any case, separation should be ensured between public and operational areas, although the extensive area required for the latter and the need for public access to passenger terminal buildings makes this difficult to achieve. No precise distances can be given but the greater the separation, the higher the level of security. A particular problem may be runways and taxiways which overpass public roads. Where such overpasses are planned, special measures may be needed to restrict access to runways or taxiways at this point and to counteract the possibility of sabotage to the structure of the bridge. Other potential danger areas are the approach and departure paths to runways where aircraft fly at low altitude. If it is considered necessary to protect these areas, it will be expedient to extend the airport boundaries during the initial design of the airport to include them in the land acquired as airport property.

14.3.2 To adequately protect air operation areas from unauthorized access, it is important to consider physical security measures including fencing or other barriers, lighting, locks, alarms, guards and guard houses in the planning process of air side facilities.

Airport Roads

14.3.3 Roads located on the air side should be for the exclusive use of airport personnel. Separate means of access to public buildings not involving travel on the air side will need to be provided for non-airport personnel. Perimeter roads around the air side area, normally just inside the airport fencing, are required for the use of both maintenance personnel and security patrols.

Fencing

14.3.4 Physical barriers should be provided to deter the access of unauthorized persons onto non-public areas. These should be permanent barriers and, normally, fencing is the most suitable means. Care must be taken to ensure that the provision of fencing does not conflict with the operational requirements of the airport. It will be necessary for access points to be made in the fence to allow the passage of vehicles and persons; the number of access points should be kept to a minimum and equipped so that they can be securely closed should conditions require it. If a gate is used frequently, a security guard will be required, together with a shelter for protection against the elements. The shelter should be designed in such a way so as to permit maximum visibility over the immediate area of the gate and to provide easy access for the guard to carry out the duties of inspecting vehicles and their contents. When night use is anticipated, the area surrounding the gate should be illuminated. Discreet communications should be provided between the security post and the airport security services office as well as a discreet and audible alarm by which assistance may be summoned in the event of emergency. Security of an airport will require that underground service ducts, sewers and other structures which provide access to the air side or other restricted area be barred. If access to these facilities is required for maintenance purposes, locked doors or gates should be provided.

14.3.5 Buildings may be used as a part of the physical barrier and incorporated in the fence line provided measures are taken to restrict unauthorized passage through the buildings. Care should also be taken to ensure that the roofs of the buildings do not provide a possible route for unauthorized access to the air side. For additional security, flood-lighting of the perimeter fencing and/or the installation of an alarm system may be considered.

Isolated Parking Position

14.3.6 An isolated parking position will need to be designated to which aircraft suspected of carrying explosive or incendiary devices may be taken. It should be located at the maximum distance possible (at least 100 m) from other aircraft parking positions, buildings or public areas and the airport fence. If taxiways and runways pass within this limit, they may have to be closed for normal operations when a "suspect" aircraft is in the area. The isolated parking position may also be used to handle unlawfully seized aircraft which land at an airport and require servicing and attention. Care should be taken to ensure that the position is not located over underground utilities such as gasoline, aviation fuel, water mains, or electrical or communications cables.

14.3.7 Facilities for the examination of baggage, cargo, mail and stores removed from an aircraft subjected to an act of unlawful interference should be provided as part of the isolated parking position and consideration given to the provision of shelter in the case of inclement weather.

Security Parking Area

14.3.8 In addition to the isolated parking position, consideration may need to be given to the provision of an aircraft stand where an aircraft likely to be the object of an act of unlawful interference may be parked until it is required or for the loading and unloading of passengers. The objective in the selection and design of this area is to eliminate the possibility of persons physically reaching or being able to launch an attack against the aircraft.

General Aviation Parking Area

14.3.9 It is advisable to designate a parking area for general aviation aircraft separate from that used by commercial air transport aircraft. This practice safeguards against the possible use of a general aviation aircraft as a means of circumventing security control at the airport.

14.3.10 Taxiways to such general aviation parking areas should be identified and should, where possible, be planned so as to avoid aprons used by commercial air transport aircraft.

Explosives Holding Area

14.3.11 A holding area should be provided for any suspicious articles found on the airport or on an aircraft. It should be located in a remote area, and in order to allow bomb disposal experts to deal with any devices, the provision of a shelter, bunker or building is recommended. This should be constructed in such a way that vehicles used to transport explosive devices can be driven inside for unloading.

References

Annex 17 — *Security — Safeguarding International Civil Aviation Against Acts of Unlawful Interference.*

Security Manual for Safeguarding Civil Aviation Against Acts of Unlawful Interference (Doc 8973 (Restricted)).

Appendix A. GLOSSARY OF TERMS

Terms which are defined in the *ICAO Lexicon* (Doc 9294) and the Annexes are used in accordance with the meanings and usages given therein. A wide variety of terms is in use throughout the world to describe facilities, procedures and concepts for airport operations and planning. As far as possible the terms used in this document are those which have the widest international use.

Administration area. All the ground space and facilities provided for administration and management purposes of airport management, aircraft operators and airport tenants. It may include control tower, estate maintenance facilities, contractors' depots, vehicle parks, staff and aircraft catering, etc.

Aircraft maintenance area. All the ground space and facilities provided for aircraft maintenance. It includes aprons, hangars, buildings and workshops, vehicle parks and roads associated therewith.

Aircraft stand. A designated area on an apron intended to be used for parking an aircraft.

Air side. The movement area of an airport, adjacent terrain and buildings or portions thereof, access to which is controlled.

Air side waiting area. Space between the departures concourse and air side exits from the passenger building.

Apron. A defined area, on a land airport, intended to accommodate aircraft for purposes of loading or unloading passengers, mail or cargo refuelling, parking or maintenance.

Arrivals concourse. Space between baggage claim area or customs inspection and land side exits from the passenger building.

Baggage claim area. Space in which baggage is claimed.

Baggage container. A receptacle in which baggage is loaded for conveyance aircraft.

Baggage sorting area. Space in which departures baggage is sorted into flight loads.

Baggage storage area. Space in which baggage is stored pending transport to aircraft.

Cargo area. All the ground space and facilities provided for cargo handling. It includes aprons, cargo buildings and warehouses, vehicle parks and roads.

Cargo building. A building through which cargo passes between air and ground transport and in which processing facilities are located.

Cargo warehouse. A building in which cargo is stored pending transfer to air or ground transport.

Check-in. The process of reporting to an aircraft operator for acceptance on a particular flight.

Check-in concourse. The space between the passenger building land side entrance and the check-in positions.

Check-in position. The location of facilities at which check-in is carried out.

Departure concourse. The space between the check-in positions and the air side waiting area.

Expansibility. Means the ability to be physically extended to the limits of the site to provide additional space and extra capacity using either new or existing operating procedures.

Flexibility. Means the ability to adapt to new and radically different technical and physical requirements and methods of operation, with consequent changes in the use and population of specific areas, and also the ability to be gradually modified in accordance with evolutionary changes. It also means the ability to increase the operating capacity within existing physical limits.

Immigration control. The immigration and/or police inspection of arrivals passengers.

Land side. That area of an airport and buildings to which the non-travelling public has free access.

Movement area. That part of an airport to be used for take-off and landing of aircraft and for the surface movement of aircraft.

Obstacle. All fixed (whether temporary or permanent) and mobile objects, or parts thereof, that are located on an area intended for the surface movement of aircraft or that extend above a defined surface intended to protect aircraft in flight.

Off-airport processing facilities. A passenger or cargo transport link terminal at an urban population centre at which processing facilities are provided.

Passenger amenities. Facilities provided for passengers which are not essential for passenger processing.

Passenger area. All the ground space and facilities provided for passenger processing, including aprons, passenger buildings, vehicle parks and roads.

Passenger building. A building through which passengers pass between air and ground transport and in which processing facilities and amenities are located.

Passenger loading bridge. A mechanically operated, adjustable ramp to provide direct passenger access between aircraft and buildings.

Passenger processing. The reception and control of passengers during their transfer between air and ground transport.

Passport control. The immigration and/or police inspection or departures passengers.

Pier. A corridor at, above or below ground level to connect aircraft stands to a passenger building.

Port health control. The medical inspection of documents and/or passengers, baggage, cargo.

Transfer passengers/baggage. Passengers making direct connexions between two different flights.

Transit passengers. Passengers departing from an airport on the same flight as that on which they arrived.

Transport link. Any form of transport system provided exclusively for operation between an airport and urban population centres.

Transporter. Any vehicle used to convey passengers between aircraft and passenger buildings.

Terms Related to Airport Capacity

Aircraft traffic demand (at an airport) (for a particular hour). The sum of:

a) the number of aircraft desiring to land at the airport during that hour plus

b) the number of aircraft desiring to depart from the aerodrome during that hour.

Busy hour aircraft traffic demand (at an airport). The aircraft traffic demand which is reached, or exceeded, in the forty (or thirty) most active hours of the year, averaged over two consecutive hours.

Current movement rate (for a particular hour). The sum of:

a) the number of aircraft which land during that hour plus

b) the number of aircraft which depart during that hour.

Hourly airport capacity. The maximum number of aircraft operations that can take place in an hour. Once it is estimated that the hourly airport capacity will be reached in the near future, prompt and careful investigation of the terminal area capacity is required to determine whether the delays are due to runway congestion, airspace conflicts, ATC facilities, or a combination of these and other factors, and what remedial action is needed.

Peak aircraft traffic demand (at an airport). The aircraft traffic demand which will be reached in the most active hour, averaged over two consecutive hours.

Saturation of an airport. Reached when the aircraft traffic demand equals, or exceeds, the corresponding airport capacity.

Note.— The terms "demand" and "capacity" refer to a single airport or a complex of airports serving a particular community.

Service rate. The maximum aircraft movement rate which could be reached at an airport with:

a) the mix of aircraft and of take-offs and landings for the conditions being analysed, and

b) the distribution of service times between aircraft movements typical of the aircraft traffic demand at which saturation occurs.

Sustainable capacity (of an airport). The highest movement rate which could be continuously maintained for three hours or more under defined conditions.

Theoretical airport capacity. The maximum movement rate which could be reached with the mix of aircraft and of take-offs and landings under defined conditions for that airport, minimum separation being maintained between all aircraft.

Appendix B. OTHER ICAO PUBLICATIONS RELATED TO AERODROME MASTER PLANNING

Many other ICAO publications contain information related to airport master planning, and brief descriptions of some are given below. Further information on these or any other ICAO publications may be found in the ICAO Catalogue or obtained from any of the addresses listed on the inside front cover of this manual.

Annex 9 — *Facilitation*

Provides, *inter alia*, that the "International Civil Aviation Organization shall adopt . . . international standards and recommended practices and procedures dealing with . . . customs and immigration procedures . . . and such other matters concerned with safety, regularity and efficiency of air navigation as may from time to time appear appropriate."

Annex 10 — *Aeronautical Telecommunications*

Volume I (Part I — *Equipment and Systems;* Part II — *Radio Frequencies*)

Volume II (*Communication Procedures including those with PANS status*)

Annex 14 — *Aerodromes*

Annex 16 — *Environmental Protection*

Volume I — *Aircraft Noise*

Volume II — *Aircraft Engine Emissions*

Annex 17 — *Security — Safeguarding International Civil Aviation against Acts of Unlawful Interference*

Manuals

Aerodrome Design Manual (Doc 9157)

Part 1 — *Runways*

Discusses factors affecting the siting of runways and the use of stopways and clearways. Provides information on runway length requirements of different aircraft.

Part 2 — *Taxiways, Aprons and Holding Bays*

Contains guidance on the design of taxiways, including fillets, aprons and holding bays. Information on procedures to segregate aircraft and ground vehicular traffic is also provided.

Part 3 — *Pavements*

Provides information on the evaluation and reporting of pavement strength and several design techniques used in different countries. Describes methods for constructing pavement surfaces to provide good braking action.

Part 4 — *Visual Aids*

Contains information on the design of airport lights and their maintenance. Detailed material is included on visual approach slope indicator systems, apron floodlighting and taxiing guidance and control systems.

Part 5 — *Electrical Systems*

Provides guidance on the design and installation of electrical systems for aerodrome lighting and radio navigation aids.

Airport Planning Manual (Doc 9184)

Part 1 — *Master Planning*

Part 2 — *Land Use and Environmental Control*

Guidance is provided on environmental considerations to be taken into account at airports and for land use planning in the vicinity of airports. Methods for land use control are described and types of land use that are compatible and incompatible with airports are identified.

Part 3 — *Guidelines for Consultant/Construction Services*

Provides a general overview on contracting for planning or construction services. Serves for both persons who are directly involved in the preparation and administration of a contract as well as supervisors of such persons.

Airport Services Manual (Doc 9137)

Part 1 — *Rescue and Fire Fighting*

Virtually all aspects of rescue and fire fighting at airports are covered including equipment requirements, operational and emergency procedures, and personnel training.

Part 2 — *Pavement Surface Conditions*

Describes methods for clearing contaminants and debris from the movement area, snow removal techniques and how to measure and report runway braking action on wet and snow or ice-covered surfaces.

Part 3 — *Bird Control and Reduction*

Provides a general review of the bird hazard problem at airports giving information on the type of birds, the magnitude of their hazard to aircraft and why birds are at the airport. Means for modifying the airport environment to make it less attractive to birds are reviewed and techniques outlined for driving off birds that do come to the airport. Information is also given on the use of radar to detect birds.

Part 5 — *Removal of Disabled Aircraft*

Organizational procedures to remove an aircraft disabled on the airport are reviewed and a list of necessary equipment provided.

Part 6 — *Control of Obstacles*

Provides information on the use of inner and outer horizontal surfaces and the application of the shielding principle. A practice for treating temporary hazards on the movement area is presented and techniques for conducting obstacle surveys are included.

Part 7 — *Airport Emergency Planning*

Provides information related principally to matters concerning preplanning for airport emergencies, as well as co-ordination between the different airport agencies (or services) and those agencies in the surrounding community that could be of assistance in responding to the emergency.

Part 8 — *Airport Operational Services*

Describes all operational services provided by the airport in detail. References to specific ICAO documents are given if another manual covers the subject in greater detail such as in the case of rescue and fire fighting.

Part 9 — *Airport Maintenance Practices*

Provides guidance material required for maintenance practices at an airport to maintain the safety, efficiency and regularity of aircraft operations.

Manual of Surface Movement Guidance and Control Systems (SMGCS) (Doc 9476)

Provides information on the provision of guidance to, and control in question of, all aircraft, ground vehicles and personnel on the movement area of an aerodrome.

Security Manual for Safeguarding Civil Aviation Against Acts of Unlawful Interference (Doc 8973 (Restricted))

Air Transport Studies and Economics Publications

Manual of Airport and Air Navigation Facility Tariffs (Doc 7100)

Manual on Air Traffic Forecasting (Doc 8991)

Manual on the ICAO Statistical Programme (Doc 9060)

Statements by the Council to Contracting States on Charges for Airports and Route Air Navigation Facilities (Doc 9082)

Facilitation Publications

Selection of ICAO Facilitation B-Type Recommendations (Circular 152)

The Recommendations adopted at the various Sessions of the Facilitation Division fall into two categories: those concerning amendments to Annex 9 (Facilitation) and the other type which does not affect the amendment of Annex 9. The former type of Recommendations has been designated, in the Reports of the last four Sessions, as "A" type Recommendations, while the latter have come to be referred to as "B" type Recommendations. This publication is concerned only with a selection of "B" type Recommendations.

International Signs to Provide Guidance to Persons at Airports (Doc 9430)

The question of developing an international sign language, without the use of words as far as possible, to facilitate travellers has been considered by several bodies in recent years. In response to a growing need for such signing a set of signs was approved by the Air Transport Committee and the Council and are contained in Section I of this document. Section II of the document contains certain information concerning the use of the signs, their location, and colours to be used.

Miscellaneous Publications

ICAO Lexicon (Doc 9294)

Volume I: *Vocabulary*

Volume II: *Definitions*

Volume I of the Lexicon brings together a number of terms, in English, French, Russian and Spanish, which are relevant to the work of ICAO.

In addition to strictly aeronautical terminology related to aircraft and their operation, the vocabulary presented therein extends to various allied fields to which an important part of ICAO's work is devoted, particularly meteorology and telecommunications.

The Appendices in Volume I contain lists of abbreviations and data on various scientific and technical subjects connected with aviation.

Volume II contains a list of definitions, most of which are from the Convention on International Civil Aviation and the Annexes thereto, while others are from the Procedures for Air Navigation Services.

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