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ABSTRACT

This research covers the studies made for constructing airports, especially planning studies on this subject. For this aim search was made on published items, connection with related institutions was provided and investigations was made on Adnan Menderes Airport.

The publishments made by International Institutions especially by ICAO (International Civil Aviation Organization) on technical matters and master planning, different books, periodicals and brochures have provided information on worldwide airport planning studies, planning criteria and standards.

Development and present condition of civil aviation and planning studies in Turkey is another part of the study. In the privacy of Çeşme STOL Port, STOL system which has a widespread application today and will have weight in the long-term development evaluated from the planning point of view.

As a result, it was observed that, there is lack and inefficiency in airport planning studies in Turkey and STOL Ports with their requirement programs and typical architectural projects have the same problems. For this reason, with the information achieved by research in hand, an alternative project in urban design scale have prepared for Çeşme STOL Port.

ÖZ

Bu araştırma bir havaalanının gerçekleşme sürecinde yapılan çalışmaları özellikle planlama boyutunda ele almaktadır. Bu amaçla yayın taraması yapılmış, ilgili kurumlara gidilmiş ve Adnan Menderes Havalimanında incelemelerde bulunulmuştur.

Bu konuda ulaşılabilen uluslararası örgütlerin yayınladığı, özellikle ICAO (Uluslararası Sivil Havacılık Organizasyonu)'nun planlama konusunda yaptığı teknik yayınlar, çeşitli kitap, dergi ve broşürler, dünyada havaalanı planlama çalışmaları, planlama kriterleri ve standardlar çalışmanın kaynağını oluşturmuştur.

Türkiye'de sivil havacılık gelişimi, bugünkü durumu ve planlama çalışmaları araştırmanın bir diğer bölümünü oluşturmaktadır. Günümüzde yaygın bir şekilde uygulanan ve uzun vadede uygulaması devam edecek olan STOL Havaalanları sisteminin bir parçası olan Çeşme STOL Havaalanı özelinde planlama çalışmaları irdelenmiştir.

Sonuç olarak, havaalanı planlaması konusunda Türkiye'de yapılan çalışmaların eksik ve yetersiz olduğu, STOL Havaalanlarınında ihtiyaç programları ve tip projeleri aynı sorunları paylaştığı gözlenmiştir. Bu sebeple araştırma sonucu elde edilen bilgiler doğrultusunda Çeşme STOL Havaalanının kentsel tasarım düzeyinde öneri projesi hazırlanmıştır.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

Transportation sector is one of the most important branches of planning which shouldn't be taken in hand independently from other sectors. It is necessary to evaluate also all modes of transportation together because of their interdependency. This attitude should be valid for preparation of macro level plans at different scales. Air transport is the newest mode of transport and safety, speed and comfort makes it preferable. Its incredible growth trend in less than a century shows that, it will be more widespread means of transport in the future.

The aim of this study is to investigate airport planning studies at different levels. First part of the study is covering the results of the investigation made for this aim. In the second part of the study, these results have been evaluated with a sample study. Çeşme STOL Port, which is now under construction and located in the borders of Çeşme-İzmir was chosen for this aim.

This study covers five principal chapters such as; civil aviation, airport planning, airport system, environmental impacts and sample study-Çeşme STOL Port. The content of each chapter and their related parts are given shortly below.

In the first chapter the aim is searching the history and development of civil aviation, especially air transportation in the world and in Turkey. Social, political, economic factors affecting the growth of aviation, especially the effect of tourism, developments in aircraft technology, aviation organizations and the elements of the air system such as; aircraft operator, aircraft manufacturer, airport terminal and ATC systems are all mentioned in this chapter. Future of aviation, its growth trend, planned investments especially in Turkey and sectoral problems are all explained.

Second chapter outlines the planning process at different levels. We can evaluate this process under three headlines, such as; system planning, master planning and project planning.

Transportation is a multimodal system and it is necessary to analyse all modes together. Transportation system planning is the first step of system planning. There is also a need for evaluating each airport within the system of airports.

This chapter also outlines the important factors which authorities must consider in preparing an airport master plan. Here the importance of consultation and co-operative planning and the need to develop a systematic approach in determining future airport requirements are explained. Functions and stages of master planning such as preplanning considerations, forecasting, financial arrangements and controls, airport site evaluation and selection, and preparation of airport plans explained detailly.

The content of airport project planning and different factors which should be considered while preparing projects are also mentioned in this chapter.

Airports can be defined as an area on land or water with its facilities or buildings, used for landings and takeoffs of aircraft. With this definition many classification of airports can be made. Here classification by type such as; conventional airports, heliports, STOL ports and vertiports and seaplane terminals is used in order to explain functional requirements of each in the third chapter.

For conventional airports we can investigate the development under three main headlines, such as; airside development, landside development and airport support elements.

Airside development should be considered first because of their physical characteristics and land requirements. Runways and taxiways have limited free choice of layout, so their dimensions, pavement strength, the capacity and configurations should be determined before other elements of airside such as apron and navigational and air traffic control aids. Aircraft characteristics which are important in planning especially for configuring airside of an airport are also explained.

Landside development include passenger building, cargo facilities, ground transport and vehicle circulation and parking. This area have free access for non-traveling public and also non-public portions of operational, security and governmental services take place here. Passenger building provides passage between the ground and air modes of transport. It has a complex system which could be divided into its components, such as; access interface, processing and flight interface. For providing ease in this passage between two interfaces, planner and designer should know firstly passenger and baggage flow principles and characteristics. Airport traffic and service characteristics and scale of facilities to be provided are also important. General design considerations, different passenger building concepts, passenger amenities are also explained. We can apply the same considerations for passenger buildings, while siting cargo buildings. Space requirements of building, apron and parking and also access facilities are important features of planning.

Airport access system include; ground transport of passengers, baggage, employees, cargo and service vehicles to, within and from the airport. Planning of roadways and vehicle parks which are based upon forecasted requirements, and terminal area access system configurations are all explained in this part.

Airport support elements are some buildings and operations for special purposes which are necessary in this system. The need for them and their number and complexity vary depending on the volume of traffic at all airports. While locating them their functions and compatibility with major elements of airport are important factors. We can categorize support facilities such as operational and security facilities. Meteorological, air traffic control, communications, rescue and fire fighting services, fuel depot, administrative and maintenance facilities, aircraft operators, staff, general aviation facilities, medical services, technical services, and even an hotel are all support facilities for airport operations. Security should be provided in landside and airside with causing minimum interference with, or delay to, passengers, crew, baggage, cargo and mail.

Heliports are used for takeoffs and landings of helicopters or VTOL (vertical takeoff and landing) vehicles, STOL ports by STOL (short takeoff and landing) craft, and vertiport by tilt-rotorcraft and rotor-craft. Design criteria for each of them, their characteristics and facility requirements are all mentioned in this chapter. Seaplane terminals and design considerations of their different operating areas such as; water operating area, the shoreline area, service, tie down and storage area, administration and common use area are also explained in this chapter.

Transportation sector have many negative impacts on the environment, especially by means of causing air pollution and noise. Contribution of this sector to global warming is also important. The cost of transport explained under the headline of 'transport and sustainibility' with all aspects including control measures. Compatible land uses are also explained in this chapter named as 'environmental impacts', for the purpose of airport planning and land use planning in the vicinity of airports.

The last chapter forms the second part of the study which was made for examining the planning process in Turkey with a sample project. Çeşme STOL Port was chosen for this sample study. First, objections of the study determined and the methods of research described and then the study area defined with all its characteristics. Here, the study area has two meanings. One is the bordered land area which STOL Port development has located on, the other is its impact area. We can say that it will create a definite impact on the life of Çeşme. Constructing a STOL Port in Çeşme, parallel to the other touristic regions for providing air taxi services between them is the main reason of this investment. Tourism potential of Çeşme is important from this aspect. For this reason, planning decisions and macro level investments are also important for feasibility of this investment. By means of their locations Urla and Karaburun are also evaluated as settlements in the impact area of Çeşme STOL Port.

The master planning process, the institutions involved in this process, typical requirement lists and plans and inefficiencies are all explained in another part of this chapter named as 'evaluation of the planning process'. It was shown that there is a necessity to modify these lists and plans according to different characteristics of each port. Some assumptions had been made by means of the statistical data and information in hand, and these assumptions guided to the decisions which had been the base of the project study made for eliminating inefficiencies.

CHAPTER 2

CIVIL AVIATION

Aviation is a general term which includes the science and technology of flight and which describes the mode of travel provided by aircraft. Military aviation, general aviation, etc. determines the employment of an aircraft. Manufacturing, marketing, repairing of an aircraft or working in allied industries are all the world of aviation.

Aircraft is a vehicle which carries one or more persons and which navigates through the air and it can be classified as lighter than air and heavier than air (1).

2.1. History of Aviation

French Joseph and Etienne Montgolfier Brothers invented that an object which is lighter than air can fly and by using hidrogene and helium gases they succeeded to hover a balloon to 5000 m height which had 12 m radius and 750 m3 volume in June, 4 1783. All aircraft which sustain their weight by displacing an equal weight of air is called as lighter than air.

The two milestones of aviation generated by lighter than air craft; the first controlable flight by an aircraft was succeeded by a nonrigid airship and in the 1850s and the first passenger air service was generated by zeppelins. Zeppelin Company and its subsidiary Delag began carrying passengers on flights within Germany in 1910 and from 1929 to 1937 provided a unique transatlantic air service, but their weakness against strong winds because of their large body and the use of easily burned gases such as hidrogene and helium caused several accidents.

Modern airship vehicle concepts are partly heavier than air and partly lighter than air and they are used for STOL (short take off and landing) vehicles or some have VTOL (vertical take off and landing) capability.

> "Heavier-than-air craft are supported by giving surrounding air a momentum in the downward direction equal to the weight of the aircraft. Aircraft' s fixed wings impart a small downward momentum a large quantity of air because they have a large

downward velocity. Aircraft with rotating wings, such as helicopters, are also sustained by the downward momentum which they impart to the surrounding air because they operate at slower speeds, the momentum change is imparted to a smaller mass of air by the change in velocity is correspondingly greater" (1).

First flight of a heavier-than-air craft was succeeded by Otto Litienthal (1848-1896) by a glider in 1890. He determined the methods and techniques for flight of an heavier-than-air craft so became the pioneer of the passage from glider to plane. Clement Ader who was the real pioneer of aviation history had flown 50 m with his glider in 1890.

The first powered flight in a heavier-than air aircraft was succeeded by Orville Wright on December 17, 1903, in North Caroline. This 120 ft flight was the first such statistic recorded in aviation history and bicycle repairer Wright Brothers' success was a real surprise in the aviation world (2) (fig.2.1).

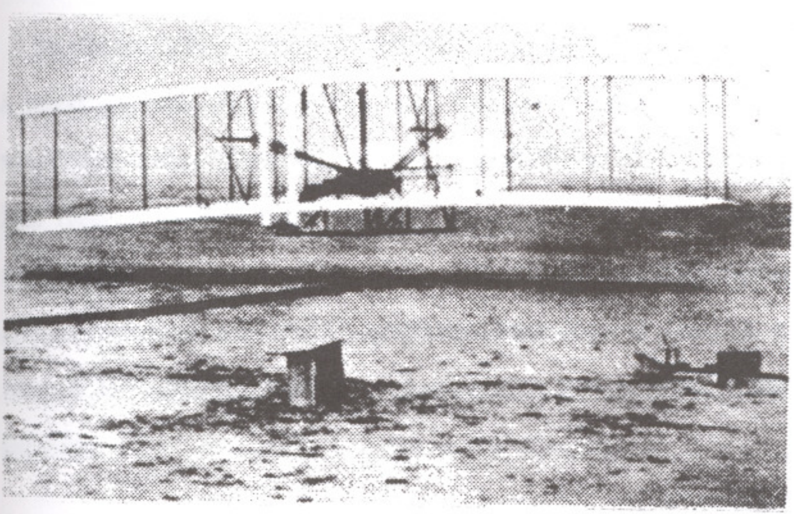


Fig. 2.1 First Flight at Kitty Hawk (USA)

source: Dictionaire Larousse

In July 25, 1909, French engineer Bleriot had flown over the English Channel (la Manche). Then for the construction of aircraft aluminum had begun used instead of wood and cloth. By using aluminum in bodies and wings and by adding high power engines, the time, speed and capacity of flight increased. Parallel to this growth in 1920 the first scheduled flights had begun between Hamburg-Copenhagen-Amsterdam. In May 21, 1921, Charles Lindberg became the first man who crossed the Atlantic Ocean with his aircraft named as 'Sprit of St. Louis'. His 5 883 km travel between New York and Paris had lasted 33 h 39 min and then aircraft have begun a safe and speedy transport means for human and freight.

In 1930s the necessity of ground facilities for passenger became important and first air station was built in 1925, in Berlin and after 1930 during the 2nd World War, civil and military aviation had grown rapidly. By the introduction of jets into the arena airfields had turned to airports. Air transport is the newest mode of travel, safest, most expensive, most speedy and also it uses the latest developments of related industries especially electronic at a maximum level. Higher prices caused by high costs of aircraft and by high construction costs of airports.

2.2. Growth of Aviation

In the mid 1930s international air transport was began but until 1950s we couldn't see a rapid growth. From 1950s to 1960s average annual growth rate in the number of worldwide passengers was nearly 14 percent in 1970s less than 7 percent and in 1980s less than 5 percent (2). Growth of aviation directly related with the growth of air transportation system whose major elements are aircraft operator, aircraft manufacturer, airport terminal and ATC systems. Sociological factors especially tourism activity, aircraft technology, aviation organizations and economic and political factors are also effective.

2.2.1. Aircraft Operator

Basic flight services, maintenance of the aircraft and customer services provided by aircraft operator. "The operator may be an airline providing for-hire service to any and all customers on a commercial basis, or may operate the aircraft entirely for personal use. Scheduled and nonscheduled for-hire services are provided by a wide variety of airlines offering different classes of service"(1). Some specialized airlines have only cargo services or operate only helicopters. Airlines are the primary means of passenger carriers and they obtain 87 % of their revenues from passenger fares. Many of the airlines are members of the International Air Transport Association; an organization primarily concerned with international tariff levels but also active in legal and safety matters.

International air transportation matters handled by the International Civil Aviation Organization, including technical standards and practices; provides an international language, including standard chart and identification codes; and makes statistics on the world's airlines.

2.2.2. Aircraft Manufacturer

The design and production of the airplane is the result of the combined efforts of airframe manufacturer and engine manufacturer. They also provide continuos technical help to the aircraft operator. The design, development and fabrication of a major aircraft is from beginning of the design stage, a project which requires billions of dollars. Different components of airplane, produced by thousands of subcontractors and then taken by manufacturers. Several nations may involve during this process and in many times government support is necessary for financing or advanced technology (1).

Transport manufacturers work closely with leading airlines in order to determine specifications and features of proposed aircraft. In approximately every 12 years a new aircraft and with variations derivatives of the basic airplane produced.

IATA member countries' demand for services of aircraft fleets in general are met by 25 % wide-body, 62 % medium body and 15 % propeller aircraft. Aircraft manufacturers Boeing (53 %), Airbus (22 %) and McDonnell Douglas (9 %) are followed by relatively little firms such as British Aerospace and Canadair.

2.2.3. Aircraft Technology

Aircraft technology develops in a speedy manner and most important advances have been the development of jet and fan-jet engine, the high by-pass ratio jet engine, major increases in aircraft size and improvements in aerodynamics, materials, design techniques and manufacturing. Despite the continuous improvements in technology, commercial aircraft are long-lived vehicles and are often used for 20 years or more.

We can say that since 1950's in every five year a new aircraft model attend to the World Civil Aviation and the improvements in aircraft technology causes a certain amount of decrease in air transportation costs. From 1980 to 1990 although a fairly large increase occurred in the number of passengers handled, aircraft operations has been less significant and even decreased because of the greater use of wide-bodied aircraft for passenger travel during this period of time.

Jet transport which was introduced in 1958 have advantages such as; economics, speed, range, capacity, comfort and safety. From mid 1950's to mid 1980's the fatality rate dropped from approximately 0,50 to 0,05 fatality per 100 000 000 passenger miles. Main factor of this improvement is the replacement of propeller aircraft with jet airplane. The Concorde, which is a new type of high-speed airplane in the late 1970s capable of flight at speeds more than twice that of sound but only 16 aircraft built because of its relatively high costs, limited range, small payload, and restricted flight capabilities. Widespread use of supersonic commercial aircraft is only possible by means of operating more economically with much greater range and payload capability and with acceptable environmental characteristics that necessitates advanced technology (1).

2.2.4. Airport Terminal

"The airport terminal characterized primarily by a runway and a passenger or cargo service facility, provides a central location for the airplane to take off and land and for passengers to begin and end the air portion of their journey. Major parts of the airport include the runways, taxiways, control tower, and buildings to service passengers, cargo, aircraft, and administrative needs"(1). Construction of a new conventional airport is so costly and also land acquisition is difficult. Noise, congestion, landuse changes and potential accidents are all the factors caused the rejection of people to airports. Flexibility and expandability is important for airports in order to adapt present conditions. Some airports serve variety of different functions but some are specialized such as; general aviation, private, military, passengers, cargo, etc.

In 1993 European Commission proposed a scheme which was named as "Transportation Network Directory Scheme related to European Airports". This Scheme necessitates coordination among European Countries in project making. Naturally airport planning is the complement of National Airport Plans and National Development Plans. International agreements are also effective in planning. Speed, motivation, flexibility, comfort, security are advantages of airports and when they form a whole with a speedy transportation network, these advantages may spread out countrywide.

2.2.5. Air Traffic Control System

ATC systems mostly located at the airport terminal and controls the movements of the aircraft both on the ground and during flight and provides a means of allocating available runways and airspace between user aircraft. Radar, radios, light signals and other electronic instruments are all parts of this system. The airport control tower directs the air traffic only in the vicinity and on runways and taxiways. ATC operators are also provide voice communication, navigational aid, weather information, etc., to the flying crew.

In United States there is one ATC system operated by government agency FAA (Federal Aviation Administration) which is part of the Department of Transportation, but in Europe there are 18 different ATC systems which cause problems.

2.2.6. Aviation Organizations

ICAO is the most important international agency concerned with airport development which was formed during a conference of 52 nations held in Chicago in 1944. Annex 14 published by ICAO contains the international design standards and recommended practices for applicable to all commercial airports.

There are also so many groups involved in technical and promotional aspects of aviation at international level such as HAI, ACI and IATA. 400 large airports and airport authorities throughout the world are members of the Airports Council International (ACI) which is based in Geneva, Switzerland. The Helicopter Association International (HAI) is an association represents the interests of each manufacturers and users and located in Alexandria, Virginia. The International Air Transport Association (IATA) is an association of scheduled carriers in international air transportation with headquarters in Montreal, Canada (2).

2.2.7. Sociological Factors

Air transportation cause important sociological changes by providing speedy access even to the farthest points in the world. People have become closer together, exchanges of cultures and information, better understanding of interregional problems, business opportunities in farthest lands become easy by air transport. For a long time, business travelers provide the main portion of the demand but recently this was changed by pleasure or private travelers. Tourism activity became the most important sociological and economic activity which have a bearing effect on air transport.

The first touristic flight was a tour to Seeburg and made on 1932 from London to Switzerland with the organization of 'Polytechnic Touring Institution', and then tourism have become an important factor affecting the growth of aviation. The main aim of international tourism activities is to provide access to the tourism centers with minimum cost. This decrease in travel costs will increase the night stay period. Tourism period is the total of transportation and night stay periods of time. Especially for thermal tourism access as fast as possible and relative lengthening of night stay period is important so air transportation is preferable. After 1950s with the beginning of GIT (Group Inclusive Tour) tourism became important for airlines. Today cheap and standard travel services as called "package tour" accelerate the group tourism movement and generally made by air transportation in an efficient way. According to the report of ICAO, the number of people traveled by airlines in domestic and international lines reached to 1 172 000 000 in 1992. When we thought that airlines were spent 90 % of their times to tourism, we can easily understand the importance of tourism in aviation sector (3).

As in any other sectors, supply and demand factors and also economic, social and political factors will be effective for the future of tourism. We can say that due to the spread out use of charter flights and package tours this growth trend in aviation will continue. Airports play an important role in the tourism of Spain and Italy because of their land formation and because of the importance of accessibility to the core of touristic regions.

There is a strong relation between the tour routes, night stay areas and location of the airport and there is also a relation between the definition of tourism areas and airport size and qualities.

2.2.8. Economic and Political Factors

Through the end of 1980s growth in aviation was positive parallel to the economic growth in the world, but after the second half of 1988 economic stagnation becomes to be dominant. Especially in 1990-91 because of the Gulf Crises and general economic stagnation, aviation sector had effected negatively, in which directly and indirectly 21 million person worked, and every year approximately 1 billion people traveled and paid more than 200 billion dollars. Economic stagnation caused decreases in the number of passengers traveling for holiday or business and especially with the effect of Gulf Crises traffic had decreased 25 %, 30 % every year. Especially 1991 became a turning point in aviation and most of the airlines got losses, some have bankrupted and some have made partnership with others at that period. In reverse to the worldwide economic stagnation, airlines of Asian-Pacific region showed a growth trend in 1990s. Thailand, Hong Kong, Singapore, Taiwan and Malaise showed the highest economic progress in recent years, throughout the world. Increasing commerce and liberalization in air transportation caused increases in passenger traffic and this region seems to be the first in the worldwide market of aviation.

In general negative effects disappeared after 1992 and the development of traffic after that time can be seen easily. Generally increase in traffic caused by economic growth and changing life standards due to this growth and decreasing transportation prices due to the liberalization politics of some countries. In 1990, more than 1 billion passengers flew more than 1.1 trillion passenger-miles and also, there has been a substantial increase in the carriage of mail and freight by air which was estimated about 16 billion ton-miles by U.S. airlines and almost 44 billion ton-miles worldwide (2). Estimates were made on the 6.3 percent annual growth through 2000.

2.2.9. Problems of Air Transportation Sector

Energy, noise and congestion will go on being the main problems of the sector although several researches have been made in order to prevent these problems.

2.2.9.1. Energy

In 1973 with the Arab oil embargo, the importance of energy was first brought to public attention. Large number of commercial flights were canceled, fuel prices increased and airplanes set idle, several major airlines bankrupted and some were forced to sell aircraft at bargain prices. By means of these changes in order to increase the fuel performance of aircraft, several actions were taken. Airlines increased the number of passenger on each flight, change their flight profiles, etc., and manufacturers developed a new series of fuel-conserving aircraft by utilizing advanced aerodynamics, material, engine technologies, etc. and reach 35% improvement in the airplane miles obtained per gallon of fuel. These aircraft began appearing in 1982. We know, as it is today in the future to increase fuel efficiency will be one of the basic problems of aviation.

2.2.9.2. Noise

Impacts of aircraft noise on people living near airports caused certain efforts in order to minimize this impact. Improvements in the noise characteristics of jet aircraft by means of applying the advances to the existing fleet or designing new aircraft for this aim is the end of these efforts. These new aircraft which are capable of meeting the restrictive noise standards began to service after 1982. In some countries three noise zones are determined around airports as seen in figure 2.2.

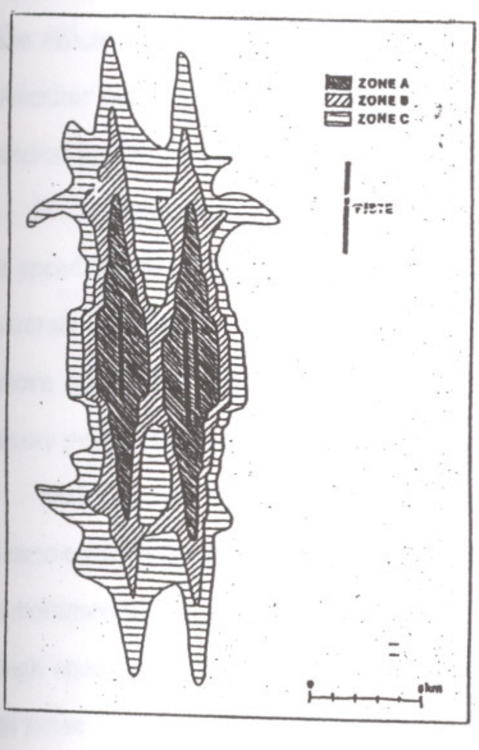


Fig.2.2 Noise zones around airports

source: O.Kuntay (4)

1st zone - Effective noise pollution. Residential use is prohibited.

2nd zone - Effective noise pollution. Residential use is prohibited.

3rd zone - Medium noise pollution. Mass housing is prohibited. Garden houses with noise control should be let.

Settlements such as Ataköy and Yeşilköy are developed with the lack of such zoning in Turkey and we can see similar problems at some other settlements, too. As seen from the scheme, an airport necessitates a safety zone of 30 km in length and 5 km in width (4). Such zoning decrease the negative effects of noise to some extent but the best way to reduce noise is removing the source by locating or relocating airports far from residential, urban areas and in unpopulated, rural regions. We can see examples such as; Dulles International Airport, which serves Washington DC is far removed from its major urban area, and Beijing, China which is 80 km from the city. It is not easy to move airports in operation and an easier way is to reduce the major source of noise, that from commercial aircraft jet engines, by slowing the speed of the exhaust or of the blades of the machinery within or external to the engine. This reduction in the speed can reduce the efficiency of the engine and increase fuel consumption and thereby increase costs. Another way is restricting flights during the evening hours or changing the flight paths and/or insulating buildings.

For commercial jets, the greatest noise exposure comes during landing while jets have a speed of over 165 km/h and an angle of 3 degree required. This gentle slope makes aircraft close to the ground for many kilometers. Although jet takeoffs produce much more noise than jet landings, climbing more rapidly reduces the noise exposure, but for many people takeoff noise is dominant.

Noise produced by helicopters is important but aircraft sound especially caused by commercial jets is more effective. A helicopter produces less noise, it has less power than a commercial jet, but it flies closer to the ground so noise exposure can be extreme. At high speed or with heavy load, helicopters produce annoying and even frightening kind of noise.

2.2.9.3. Congestion

The congestion both ground and air is a problem and of course parallel to the growth of air transportation, it will become severe. Ground congestion reduced the time and cost savings obtained by air transport, air congestion affected by many variables and with the introduction of wide-body aircraft in the early 1970's this problem decreased but after 1970s and 1980s especially at the bussiest terminals crowding and chaotic conditions occurred and long delays, stacking of airplanes over airports became common. Against one ATC system in USA, there are 18 different ATC systems in Europe and this also causes congestion in crowded periods. We can say that airfield and airspace congestion will go on being an important problem in the future.

Crowded, insufficient and badly organized airports with ATC systems in one hand and the airlines developing their fleet in order to reply increasing demand in the other hand brought out the inefficiencies of infrastructure. These problems may be solved by means of expanding present airports or constructing new ones but it takes long time to construct a new airport so congestion will go on effecting air services. Improvement projects forecast that in future 10 years the cost will be approximately 100 billion dollars and in 2010 it will reach to 250 billion dollars.(1994)

Airports are generally belong to public sector and investments are made by national budgets but it is certain that privatization of airports and/or their management will be on agenda in the future because of their high costs and increasing demand.

2.3. Future of Aviation

International Civil Aviation Organization (ICAO) has divided the world into six regions for statistical purposes such as Asia and Pacific, Europe, North America, Latin America and Caribbean, Africa, and Middle East. We can see the distribution over regions in Table 2.1 As seen from the table over 70 percent of all traffic is generated in North America and Europe and also we can see that the traffic growth is not parallel in Asian and Pacific region to the growth of importance in other sectors. We can say that this region will have a higher portion in the worldwide traffic through 2000. If 5 percent growth rate between 1990 and 2000 occurs, in the year 2000 the number of passengers will reach to 1,9 billion and this means nearly 63 percent growth in passenger traffic for the same period (2).

Table 2.1 Regional percentage distribution of total-ton-kilometers performed on scheduled service

Year	Asia and Pacific	Europe	North America	Latin America and Caribbean	Africa	Middle East
1968	8.4	19.8*	63.8	4.3	2.0	1.5
1972	8.4	35.9	47.6	4.4	2.0	1.7
1976	12.4	36.5	41.0	4.8	2.5	2.8
1980	15.5	35.0	38.6	5.5	2.6	2.8
1984	17.6	33.0	38.0	4.9	2.8	3.7
1988	19.8	31.0	39.3	4.6	2.2	3.0
1990	19.8	31.9	38.5	4.7	2.2	2.9
2000†	22.8	25.1	41.5	5.6	2.3	2.7

*Data for 1968 do not include the U.S.S.R. since these data were not available.

†Forecast by Boeing Commercial Airplane Group.

(source: Horonjeff and McKelvey) (2)

Cargo transportation is neglected relative to passenger transportation although the worth of the cargo transported by air is more than 1 trillion dollars a year. Cargo inputs constitute 14% of the total airline inputs. On-time handling, prices, reliability and low storage costs are the reasons of preference.

There are two opposing opinions in cargo transportation; one is transporting passenger and cargo together in order to achieve high capacity, the other is separating them which causes increase in operational costs. Each of them have advantages and disadvantages. It is forecasted that in future cargo and passenger transportation will be combined on main lines but on the lines where productive and commercial activities are dense the cargo transportation will be made by cargo aircraft. In 1991, 50% of cargo transportation generated at regional level. It is forecasted that the major part of cargo transportation will be generated in Asia-Pacific region in future years.

2.4. History of Civil Aviation in Turkey

Establishment of a commission in 1911 was the first step in aviation field and this was also became the foundation of Turkish Air Forces. In 1912, two hangars and an apron was built in the northern part of today's Atatürk Airport and a R.E.P for one person and a "Deperdussin" for two was bought in the same year.

We can see only military aviation until the establishment of "Government Management Directory of Airlines" on May 20, 1933. For a period only a hangar and two aircraft served to civil aviation then first scheduled passenger and mail transportation began between Ankara and İstanbul with the contribution of DeHavilland Dragon and Rapid type six seat capacity aircraft to the fleet. The main aim of this establishment was constructing airports, so in 1935 aligned to Ministry of Public Works.

The first flight abroad which was a turning point was made on 1947. In 1955 airport and airline management was separated and airline management was let to General Directory of Turkish Airlines Share Company, and airport management with ground services and air navigational traffic control and communication services was let to the General Directory of Government Airport Management. In addition to these institutions for handling control, catering and some other services Aircraft Service Share Company (USAŞ) was established after 1958. All activities related to air transportation was held by THY, DHMİ and USAŞ after that time on (5).

Today 'Civil Aviation General Directory' which is bounded to 'Ministry of Transportation' is the governmental authority of aviation. DLHİ (Railways, Harbours, Airports Construction) is the institution which is responsible of airport construction and DHMİ (Government Airports Enterprise) is the institution which is responsible of airport management. USAŞ was privatized and also private sector involvement in construction and management of airports is on the agenda in recent years. There are also several private airlines operating in recent years.

2.5. Growth of Civil Aviation in Turkey

Significant growth of air transportation sector can be seen after the second half of 1980s with the involvement of private sector and with the direction of THY to international lines. At that period investments are made in order to improve the standards of present airports not for constructing new ones. At the end of 1980s at some regions with the support of local authorities the construction of STOL ports have begun and studies for opening military ports to civil use have accelerated. This growth trend continued in 1990s until the beginning of the Gulf Crises.

Today, Turkish Airlines makes scheduled flights to 58 points abroad and from abroad to Turkey 52 Airlines make scheduled flights. Other than Turkish Airlines 12 private Airlines make non-scheduled (charter) flights to 56 points abroad and 120 foreign Airlines make charter flights to Turkey especially in summer months (6).

2.5.1. Civil Aviation Regulations

Civil Aviation Law number 2920, was approved on Oct 14, 1993 which was aimed to organize civil aviation activities parallel to national profits and international relationships. This Law also enables private sector participation in commercial air transportation operations and airport construction and management processes. In addition to the Law, there are 18 different instructions and directions in order to regulate civil aviation in Turkey.

Technical improvements, and the necessity of taking precautions against dangers from air, makes it necessary for absolute domination of country's airspace and international regulations have been made for this aim by the end of World War I. The first International Civil Aviation Agreement is the Paris Convention which was signed on October 13, 1919 with the contribution of twenty-seven countries. This was followed by Madrid in 1926, Havana Convention in 1928, and Varshow Convention in 1929 and these regulations had been valid until the acceptance of Chicago Convention in December 17, 1944 with the contribution of 52 countries' representatives. This Convention was approved by Law number 4749 in June 5,1945 in Turkey. International Civil Aviation Organization (ICAO) which was established due to this Convention, was contributed more than 183 countries in 1994 and determines international standards and regulations and provide their implications in every field of Civil Aviation. Due to the Convention, these standards and recommendations prepared by ICAO should be Annexes of this Agreement and 18 Annexes were prepared for this aim. Chicago Convention mainly prepared for scheduled flights, because at this date non-scheduled flights are not so widespread. After 1950 the level of non-scheduled flights made it necessary to make a regulation, and in 1956 with the contribution of Turkey an Agreement was made about European non-scheduled flight operators' commercial rights.

Today Turkey is the member of ICAO (International Civil Aviation Organization), ECAC (European Civil Aviation Conference), EUROCONTROL (European Air Navigational Security Organization) and IATA (International Air Transportation Agengy). As mentioned above ICAO was established due to this Convention and Annexes prepared by ICAO are not only used by the members but also by some other countries and are changed according to the improvements in aviation technology by working groups formed by educated persons of member countries. Turkey is a member of ECAC which organizes the aviation activity among European countries. 32 European countries are members of ECAC which was established in 1955 and the top working unit of ECAC is the Transportation Ministers Meeting. Turkey became the member of EUROCONTROL in March 1, 1989, which has 16 memberships. This was the Convention of European Enterprises for providing International Air Navigation Security. As a general practice, the transportation between Turkey and other countries organized by dual agreements. After this coordination at governmental level additional regulations was made for airlines or details of transportation. IATA, by providing coordination and working for the determination of ticket prices; organizes the relationships between air transportation organizations.

2.5.2. Institutions

We can categorize institutions according to their different features, such as aviation institutions, ground servicing and catering institutions, education institutions and airline operators. There are four public institutions which are responsible of different features of aviation in Turkey.

Civil Aviation General Directory (Sivil Havacılık Genel Md.) is the top authority of aviation and its functions was determined by Act number 3348. In short, we can say that Civil Aviation General Directory is responsible of planning, coordinating and controlling of the civil aviation activities countrywide in order to provide the safety, regularity and efficiency of sector.

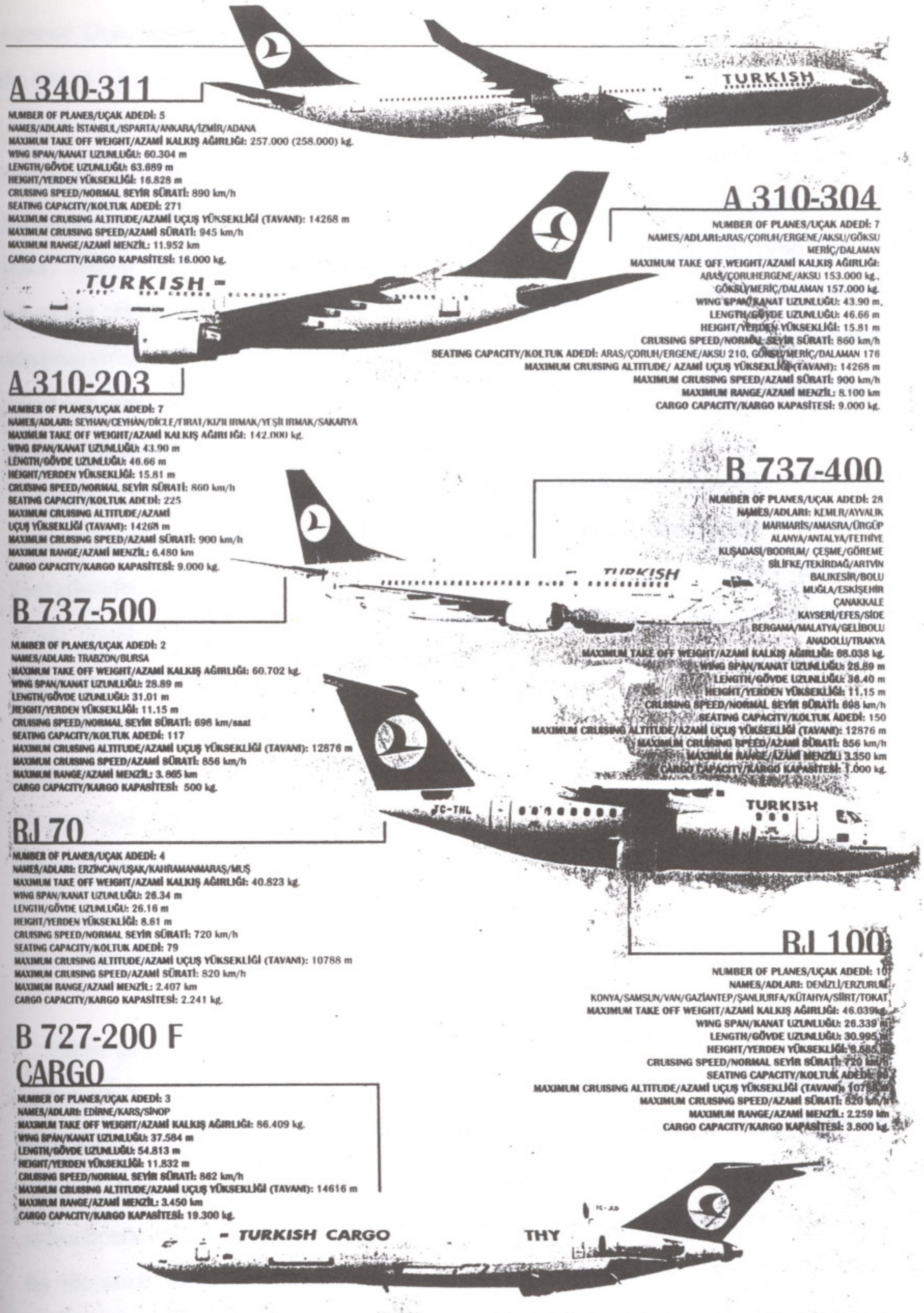
Government Airports Enterprise (Devlet Hava Meydanları İşl.-DHMİ) is responsible of the provision of airport management services, ground handling services, air traffic control services, construction and management of air navigation systems and related services, according to the regulations and standards of ICAO at the airports given to its management.

Railways, Harbours, Airports Construction (Demiryolları, Limanlar, Havameydanları İnş.-DLHİ) is responsible of the preparation of the plans and programs of railroads, harbours and airports and their related structures, in coordination with related institutions and taking precautions for implementation of these plans; by preparing projects by constructing or providing their construction and maintenance.

Prime Ministry Government Meteorological Services General Directory (Başbakanlık Devlet Meteoroloji İşleri Genel Md.) is responsible of the provision of healthy and safe information which is necessary for civil aviation and for this aim to construct meteorological stations and to provide their related equipment.

The number of institutions which are completely or partially involved in ground servicing and catering activities in Turkey are 134 and Havaş (public-partially privatized in 1998), Çelebi Air Service (private), and Usaş (privatized in 1989) are the main firms directly involved in these services.

Turkish Airlines (THY) is the leading public airline operator and in the framework of modernization and standardization, have grown its fleet and increased its service standards while giving weight to international lines. There is a certain growth of private sector, with its number of operators, fleet and share in the sector. In 1983 Turkish Airlines had a fleet capacity of 30 aircraft and Bursa Airlines had 2, and this fleet with 32 aircraft and seat capacity of 4472 reached in 1993 to 78 aircraft and 19594 seat capacity. In addition to these there were 30 Agricultural Struggle Management with 75 aircraft in 1993. Turkish Air Institution (THK) which was established in 1925 with the directives of Atatürk continue its activities which were mainly educational, with 102 different types of air vehicles at the same date and licenses given to flight crew reached to 3609 and technicians reached to 3110. Today while some airlines cooperate with others, some leave IATA for implementing free price policies. In Turkey, although Turkish Airlines effected negatively from inflation and increasing oil prices its number of aircraft which was 53 in 1995 reached to 66 in 1997 and the aim is 125 aircraft in the year 2000 (fig.2.3). Parallel to the growth of private sector, the number of aircraft reached to 44 with the seat capacity of 7683 in 1994. The share of new generation aircraft in Turkish



A 340-311

NUMBER OF PLANES/UÇAK ADEDİ: 5
NAMES/ADLARI: İSTANBUL/ISPARTA/ANKARA/İZMİR/ADANA
MAXIMUM TAKE OFF WEIGHT/AZAMİ KALKIŞ AĞIRLIĞI: 257.000 (258.000) kg.
WING SPAN/KANAT UZUNLUĞU: 60.304 m
LENGTH/GÖVDE UZUNLUĞU: 63.689 m
HEIGHT/YERDEN YÜKSEKLİĞİ: 16.828 m
CRUISING SPEED/NORMAL SEYİR SÜRATİ: 890 km/h
SEATING CAPACITY/KOLTUK ADEDİ: 271
MAXIMUM CRUISING ALTITUDE/AZAMİ UÇUŞ YÜKSEKLİĞİ (TAVANI): 14268 m
MAXIMUM CRUISING SPEED/AZAMİ SÜRATİ: 945 km/h
MAXIMUM RANGE/AZAMİ MENZİL: 11.952 km
CARGO CAPACITY/KARGO KAPASİTESİ: 16.000 kg.

A 310-304

NUMBER OF PLANES/UÇAK ADEDİ: 7
NAMES/ADLARI:ARAS/ÇORUH/ERGENE/AKSU/GÖKSU
MERİÇ/DALAMAN
MAXIMUM TAKE OFF WEIGHT/AZAMİ KALKIŞ AĞIRLIĞI:
ARAS/ÇORUHERGENE/AKSU 153.000 kg.,
GÖKSU/MERİÇ/DALAMAN 157.000 kg.
WING SPAN/KANAT UZUNLUĞU: 43.90 m,
LENGTH/GÖVDE UZUNLUĞU: 46.66 m
HEIGHT/YERDEN YÜKSEKLİĞİ: 15.81 m
CRUISING SPEED/NORMAL SEYİR SÜRATİ: 860 km/h
SEATING CAPACITY/KOLTUK ADEDİ: ARAS/ÇORUH/ERGENE/AKSU 210, GÖKSU/MERİÇ/DALAMAN 176
MAXIMUM CRUISING ALTITUDE/ AZAMİ UÇUŞ YÜKSEKLİĞİ (TAVANI): 14268 m
MAXIMUM CRUISING SPEED/AZAMİ SÜRATİ: 900 km/h
MAXIMUM RANGE/AZAMİ MENZİL: 8.100 km
CARGO CAPACITY/KARGO KAPASİTESİ: 9.000 kg.

A 310-203

NUMBER OF PLANES/UÇAK ADEDİ: 7
NAMES/ADLARI: SEYHAN/CEYHAN/DİCLE/FIRAT/KIZIL IRMAK/YEŞİL IRMAK/SAKARYA
MAXIMUM TAKE OFF WEIGHT/AZAMİ KALKIŞ AĞIRLIĞI: 142.000 kg.
WING SPAN/KANAT UZUNLUĞU: 43.90 m
LENGTH/GÖVDE UZUNLUĞU: 46.66 m
HEIGHT/YERDEN YÜKSEKLİĞİ: 15.81 m
CRUISING SPEED/NORMAL SEYİR SÜRATİ: 860 km/h
SEATING CAPACITY/KOLTUK ADEDİ: 225
MAXIMUM CRUISING ALTITUDE/AZAMİ
UÇUŞ YÜKSEKLİĞİ (TAVANI): 14268 m
MAXIMUM CRUISING SPEED/AZAMİ SÜRATİ: 900 km/h
MAXIMUM RANGE/AZAMİ MENZİL: 6.480 km
CARGO CAPACITY/KARGO KAPASİTESİ: 9.000 kg.

B 737-400

NUMBER OF PLANES/UÇAK ADEDİ: 28
NAMES/ADLARI: KEMER/AYVALIK
MARMARİS/AMASRA/ÜRGÜP
ALANYA/ANTALYA/FETHİYE
KUŞADASI/BODRUM/ ÇEŞME/GÖREME
SİLİFKE/TEKİRDAĞ/ARTVİN
BALIKESİR/BOLU
MUĞLA/ESKİŞEHİR
ÇANAKKALE
KAYSERİ/EFES/SİDE
BERGAMA/MALATYA/GELİBOLU
ANADOLU/TRAKYA
MAXIMUM TAKE OFF WEIGHT/AZAMİ KALKIŞ AĞIRLIĞI: 68.038 kg.
WING SPAN/KANAT UZUNLUĞU: 28.89 m
LENGTH/GÖVDE UZUNLUĞU: 36.40 m
HEIGHT/YERDEN YÜKSEKLİĞİ: 11.15 m
CRUISING SPEED/NORMAL SEYİR SÜRATİ: 698 km/h
SEATING CAPACITY/KOLTUK ADEDİ: 150
MAXIMUM CRUISING ALTITUDE/AZAMİ UÇUŞ YÜKSEKLİĞİ (TAVANI): 12876 m
MAXIMUM CRUISING SPEED/AZAMİ SÜRATİ: 856 km/h
MAXIMUM RANGE/AZAMİ MENZİLİ 3.350 km
CARGO CAPACITY/KARGO KAPASİTESİ: 1.000 kg.

B 737-500

NUMBER OF PLANES/UÇAK ADEDİ: 2
NAMES/ADLARI: TRABZON/BURSA
MAXIMUM TAKE OFF WEIGHT/AZAMİ KALKIŞ AĞIRLIĞI: 60.702 kg.
WING SPAN/KANAT UZUNLUĞU: 28.89 m
LENGTH/GÖVDE UZUNLUĞU: 31.01 m
HEIGHT/YERDEN YÜKSEKLİĞİ: 11.15 m
CRUISING SPEED/NORMAL SEYİR SÜRATİ: 698 km/saat
SEATING CAPACITY/KOLTUK ADEDİ: 117
MAXIMUM CRUISING ALTITUDE/AZAMİ UÇUŞ YÜKSEKLİĞİ (TAVANI): 12876 m
MAXIMUM CRUISING SPEED/AZAMİ SÜRATİ: 856 km/h
MAXIMUM RANGE/AZAMİ MENZİL: 3.865 km
CARGO CAPACITY/KARGO KAPASİTESİ: 500 kg.

RJ 70

NUMBER OF PLANES/UÇAK ADEDİ: 4
NAMES/ADLARI: ERZİNCAN/UŞAK/KAHRAMANMARAŞ/MUŞ
MAXIMUM TAKE OFF WEIGHT/AZAMİ KALKIŞ AĞIRLIĞI: 40.823 kg.
WING SPAN/KANAT UZUNLUĞU: 26.34 m
LENGTH/GÖVDE UZUNLUĞU: 26.16 m
HEIGHT/YERDEN YÜKSEKLİĞİ: 8.61 m
CRUISING SPEED/NORMAL SEYİR SÜRATİ: 720 km/h
SEATING CAPACITY/KOLTUK ADEDİ: 79
MAXIMUM CRUISING ALTITUDE/AZAMİ UÇUŞ YÜKSEKLİĞİ (TAVANI): 10788 m
MAXIMUM CRUISING SPEED/AZAMİ SÜRATİ: 820 km/h
MAXIMUM RANGE/AZAMİ MENZİL: 2.407 km
CARGO CAPACITY/KARGO KAPASİTESİ: 2.241 kg.

RJ 100

NUMBER OF PLANES/UÇAK ADEDİ: 10
NAMES/ADLARI: DENİZLİ/ERZURUM
KONYA/SAMSUN/VAN/GAZİANTEP/ŞANLIURFA/KÜTAHYA/SİİRT/TOKAT
MAXIMUM TAKE OFF WEIGHT/AZAMİ KALKIŞ AĞIRLIĞI: 46.039kg.
WING SPAN/KANAT UZUNLUĞU: 26.339 m
LENGTH/GÖVDE UZUNLUĞU: 30.995 m
HEIGHT/YERDEN YÜKSEKLİĞİ: 8.585 m
CRUISING SPEED/NORMAL SEYİR SÜRATİ: 720 km/h
SEATING CAPACITY/KOLTUK ADEDİ: [illegible]
MAXIMUM CRUISING ALTITUDE/AZAMİ UÇUŞ YÜKSEKLİĞİ (TAVANI): 107[illegible]
MAXIMUM CRUISING SPEED/AZAMİ SÜRATİ: 820 km/h
MAXIMUM RANGE/AZAMİ MENZİL: 2.259 km
CARGO CAPACITY/KARGO KAPASİTESİ: 3.800 kg.

B 727-200 F
CARGO

NUMBER OF PLANES/UÇAK ADEDİ: 3
NAMES/ADLARI: EDİRNE/KARS/SİNOP
MAXIMUM TAKE OFF WEIGHT/AZAMİ KALKIŞ AĞIRLIĞI: 86.409 kg.
WING SPAN/KANAT UZUNLUĞU: 37.584 m
LENGTH/GÖVDE UZUNLUĞU: 54.813 m
HEIGHT/YERDEN YÜKSEKLİĞİ: 11.832 m
CRUISING SPEED/NORMAL SEYİR SÜRATİ: 862 km/h
MAXIMUM CRUISING ALTITUDE/AZAMİ UÇUŞ YÜKSEKLİĞİ (TAVANI): 14616 m
MAXIMUM RANGE/AZAMİ MENZİL: 3.450 km
CARGO CAPACITY/KARGO KAPASİTESİ: 19.300 kg.

Fig.2.3 Turkish Airlines' fleet (1997)

(source: Skylife, Dec,1997)

Airlines' fleet, which is suitable to noise and environmental standards reached to 90 % at the end of VI. Five Year Development Plan period (DHMİ).

Civil Aviation Institutions, from the beginning till today have provided its personnel mainly from Turkish Armed Forces. This tradition will go on until the educated personnel who was graduated from the new civil aviation education units will take their place. DHMİ opens courses for the education of its personnel. In 1986 the new education center of Turkish Airlines opened in Yeşilköy. Here, commercial, technical, administrative and language courses are organized. Turkish Air Institution, is the oldest education unit and mainly related with aviation sports and also pilot education and agricultural medication.

Aircraft Engineering Department of İTÜ (İstanbul Technical University) and Aviation Engineering Department of METU (Middle East Technical University) provides high level educated technical personnel and manager to the sector. Civil Aviation High School of AÜ (Anatolia University) which was established in 1986, provides technical personnel and pilots by 40% teoric and 60% applied education according to ICAO standards with the supports of ICAO and UNDP (United Nations Development Programme). Havaş and Usaş organized courses for the education of their own personnel. Tusaş (Turkish Aviation and Space Industry Share Company), established a technical school in its own structure for education of personnel for F-16 project (Civil Aviation General Directory).

2.5.3. National Airports

Public airports managed by DHMİ and organized in 29 airports. With the protocol made with Turkish Armed Forces, total 24 military airport opened to civil use and 10 of them are managed by DHMİ. In 1997, total 34 396 334 passenger traffic with 42,5% share of Atatürk Airport was generated in these airports (table 2.2). The number of airline operators servicing Atatürk Airport was 202 and Adnan Menderes Airport was 85 for the same year. At Adnan Menderes Airport among 2 236 935 international line passengers, 1 140 018 of them are departures and 453 119 of them prefer foreign airlines and 365 589 of them prefered unscheduled flights. In cargo traffic, in 1994 total 491 750 tonne load traffic generated and increase was 6.4% to the previous year and 340 310 tonne was in international lines and 201 121 tonne of it was deplaning load. Total load traffic of 1994 nearly generated only in Atatürk Airport in 1997 with 489 499 tonne and

Table 2.2 Passenger traffic of airports managed by DHMİ, 1997

YEARS / AIRPORTS	1994	1995	1996	1997		
	REALIZED	REALIZED	REALIZED	REV. PROG	REALIZED	REAL %
ATATÜRK	10.088.622	11.925.118	13.394.666	14.726.386	14.607.897	99,2
ESENBOĞA	3.176.285	3.596.111	3.653.860	3.842.674	3.889.320	101,2
A.MENDERES	2.333.581	2.989.647	3.268.561	3.436.159	3.422.925	99,6
ANTALYA	3.056.499	4.727.669	5.592.905	6.690.989	6.687.633	99,9
DALAMAN	1.543.983	2.081.705	2.347.157	2.605.344	2.587.742	99,3
ADANA	702.278	776.415	813.131	891.641	900.892	101,0
TRABZON	412.615	446.242	465.422	473.693	482.382	101,8
MİLAS-BODRUM	0	0	0	375.034	338.866	90,4
S.DEMİREL	0	0	0	451	2.258	500,7
BURSA	22.216	26.839	23.891	24.728	23.117	93,5
ÇARDAK	8.589	14.980	25.076	35.398	37.460	105,8
DİYARBAKIR	264.031	296.833	282.794	305.417	310.534	101,7
ELAZIĞ	38.396	23.209	55.744	62.746	63.222	100,8
ERZİNCAN	16.767	16.521	17.250	18.301	18.951	103,6
ERZURUM	113.521	131.029	139.346	171.330	170.111	99,3
GAZİANTEP	87.846	127.170	139.393	164.832	181.951	110,4
KARS	66.277	84.049	85.995	107.493	103.747	96,5
MALATYA	61.036	87.769	61.872	69.622	74.216	106,6
MUŞ	36.130	46.048	54.423	56.898	56.572	99,4
SAMSUN	46.366	60.101	55.182	62.461	64.128	102,7
SİNOP	0	336	447	1.042	950	91,2
SİVAS	3.977	6.307	4.987	7.731	8.710	112,7
ŞANLIURFA	23.758	31.293	37.877	49.436	49.348	99,8
VAN	231.513	269.884	259.357	295.073	294.433	99,8
TOKAT	0	185	1.026	924	950	102,8
ÇANAKKALE	0	1.919	252	362	362	100,0
K.MARAŞ	0	0	48	6.361	7.673	120,6
AĞRI	0	0	0	7.121	7.824	109,9
KÖRFEZ	0	0	0	3.453	2.160	62,6
TOTAL	22.334.286	27.767.379	30.780.662	34.493.100	34.396.334	99,7

source: DHMİ (6)

the total was 791 746 tonne with the 21.3% increase to the previous year. The 579 747 tonne was in international lines and 338 391 tonne of it was deplaning load. Total number of different type of vehicles serving at airports reached to 735, and parking facilities for 7123 vehicles are provided according to statistics made in 1997 (DHMİ).

Increasing the number of airports is important in order to provide air transportation countrywide, parallel to the improvements in civil aviation activities. Although different climatic conditions and hilly structure of land increase the importance of air transportation in domestic lines, in many cities today we couldn't see this facility yet. Regional transportation is also important in countries which have spread out commerce and tourism centers such as Turkey. Policies have been developed in order to increase the number of regional airports and "An Airport to Every City" effort have been continuing with the contribution of local authorities and Ministry. Selçuk, Aydın, Çanakkale, Tokat, etc., are some airports constructed with these policies. These were constructed by local authorities and contributed by DLHİ General Directory in technical and financial matters.

2.5.4. Air Navigation

Air traffic control (ATC), air information units, air channels, navigational aids and facilities and communication systems are all elements of air navigational system.

In airspace of Turkey, appropriate to the international standards for flight security, present air traffic control and search and escape facilities and flight following activities are as follows: 3 air control center (ACC) in Ankara, İstanbul, İzmir; 18 approach control point (APP); 29 tower control center; 2 FIC (flight information center) at Atatürk and Esenboğa; 7 AIC (airport information center); 13 search and escape units.

Turkish airspace is equipped with navigational aid instruments and facilities proper to international standards for the provision of flight security. There were 47 air channels and the length of network is 18 923 km in 1994, with 19 entrances used for aircraft entrances to Turkish Airspace (4). Today there are 81 air channels with 30 632 km network length. There are 14 ILS, 45 VOR, 41 DME and 60 NDB (totally 160) air navigation control instruments in countrywide, which serves 24 hours and also 5 primary radar and 12 secondary radar integrated to specific centers.

Fast and perfect aeronautical communication is very important in providing flight security. Fixed communication system (AFTN) set up in Atatürk and Esenboğa Airports and international messages are taken and transported to 20 communication centers from there. In addition, there are a number of receivers, transmitters (HF,UHF,VHF) and also 9 peripheral stations at mountains and airports for providing air to ground, ground to ground wireless communication (Civil Aviation General Directory).

2.5.5. Problems

The main problem is of course lack of planning. Although some studies were made for this aim such as 1983-1993 Transportation Master Plan (Ulaştırma Ana Planı) with the contribution of all related bodies, it had been valid only for very short period of time and evaluation at project scale have become a common practice. Naturally this type of practice open political pressures and cause diversions from the main objectives. The projects prepared with the lack of goals and objectives, and economic, financial, and technical analysis as a system cause decreases in capacities and unproductiveness in the sector.

Another problem is lack of coordination which was caused by the lack of evaluation of system as a whole. As made for DLHİ in recent years, all the related bodies of transportation in subsectors such as roadways, railways, sealines, airlines and pipelines should be directly responsible to the Ministry of Transportation in order to establish coordination in an efficient way. In order to improve civil aviation activities in a secure and orderly manner Civil Aviation General Directory should have higher sanction and adequate personnel, equipment and management structure.

Air taxi operations are important in civil aviation in countries such as Turkey which has spread out commerce and tourism centers. In 1986 for increasing the regional airports with the contribution of local authority and Ministry, 'an airport to every city' policy was developed. The airports constructed by means of these studies have not created an air traffic at the desired level, not because of the inefficiency of facilities but because of the disorder in airline operations. Today private sector wants to make flights to these airports with average 50 seat capacity aircraft. In Turkey domestic flights are made by Turkish Airlines with large body aircraft between conventional airports so the passenger profile for this service is bordered with people who is capable of paying these high prices and this situation effects development negatively. For the efficient use of these regional airports and for constructing new ones it is necessary to release scheduled flights between airports in the concept of "air taxi transportation" and to solve the operational difficulties of these airports.

Airports and aircraft are expensive investments so finance is an important problem. Education of required qualified personnel is another important factor for development of civil aviation. In order to reach the objectives the projects in the investment programme should be realized in the programmed period of time. It is programmed to realize conventional airports with the contribution of private sector and foreign capital investments, and regional airports by general budget possibilities and STOL ports by contribution of local authorities. Although inefficient, investments funds couldn't release on time so this cause delays in the construction programme.

2.6. Future of Civil Aviation in Turkey

We can summarize goals and objectives for 1993-2002 period as to widespread air transportation by means of constructing STOL ports in many settlements; to increase the capacity of present airports; to construct new passenger terminal complexes; to construct new airports in Bodrum Peninsula, in the content of GAP and in Isparta and Samsun (Çarşamba); to open military airports to civil use by means of adding special apron, taxiway and terminal buildings to the present infrastructure.

Air traffic increase in Turkey not shows an orderly pattern but we can say that growth will be between 7 % and 10 %. According to this growth rate in passenger capacity of 10.6 million in 1991 will reach to 27 million in 2002. The rate of Turkish companies in the traffic of Turkey is 39 % in 1994 with 89 aircraft and 13 100 seat capacity, and this will reach to 50 % until 2002 with 200 aircraft and 30 000 seats.

2.6.1. Tourism and Air Transportation

As mentioned in the tourism report of 7th Five Year Development Plan it is a must to increase the capacity of present airports and to construct new ones till the year 2000. Some goals determined in this report are as follows. In order to decrease seasonal changes; according to the properties of regions, primarily to support air transportation financially out of season; to support charter companies with credits for improvement of their financial power; to support marine and air transportation of East Blacksea Region; to provide coordination among intercontinental air transport firms; to provide integration among sectors which have primary importance for sustainable development such as; industry, agriculture, energy, transportation and tourism; to increase the share of Turkey in international tourism income.

70% of tourism activity in the world take place in Mediterranean Region where the share of Turkey increase 5% annually between 1982-1992. In the world each one person among 15 of working population is in tourism sector. 55% of the world's net product is related with tourism activity and 112 million person work in this sector. Tourism income level is 3,2% in gross national income of Turkey. Turkey's share in the world tourism income is 1,3% and in Mediterranean tourism 7,8%. In 1982 1,3 million tourist had visited Turkey and this had reached to 7 million in 1992. In 1982, 370 billion dollar income reached in 1992, to 3,6 billion dollar. Turkey should increase its share in the world and Mediterranean tourism. In 1990, 5 370 000 foreign tourist visited Turkey and in 1989, nightstay of one tourist is; 2,21 in Turkey, 6,48 in Spain, 5,25 in Greece and 4,57 in Italy. In the case of Turkey where tourists come for short periods of time, it is not logical to organize 10 day long tours by bus. Here composite tours with heavily use of air transportation means, are preferable. Decreasing travel time will increase the time tourist involve in other activities. Constructing STOL ports at points of attraction for tourists will serve this aim and wider use of faster and safer means of transport will attract more tourists to Turkey.

Another important factor is that, there is a necessity to provide speedy access from airport to centers. We can see this in Antalya example where tourists generally came from their countries in two or three hours and could reach Alanya in two hours. Alternative tourism potentials other than sea, coast and plateau should be searched in order to avoid excessive changes in number of tourists especially at seasonal level.

Speed, security and comfort are the main factors for the preference of air transportation. In Turkey, the Turkish Airlines with its fleet of 66 aircraft is inefficient in responding the demand and couldn't established its "charter fleet" in international lines which will provide cheap and secure mass transportation possibility. When Turkey would provide efficient air transportation network, it is obvious that there would be an important increase in the number of tourists visit that country.

CHAPTER 3

AIRPORT PLANNING

In Aviation and airport planning although many different type of studies made related to facility planning, financial planning, traffic and markets, economics and environment at different levels such as community, county, region and country planning; we can classify them under three main headings such as system planning, master planning and project planning.

3.1. System Planning

Airport system plan is part of the transportation system plans at regional and national level. The nature of transportation also necessitates co-ordination among countries, especially in air transportation, this has a higher importance. Parallel to the globalization and with the effect of environmental, economic, and technological factors this becomes a must.

3.1.1. Transportation System Planning

Travel demand modelling is a new practice and the frontiers have backgrounds in engineering, economics, etc.. Transportation demand and performance and the processes of evaluation and choice is another subject which should be considered in wider perspective.

Transportation systems analysis has emerged as a recognized profession in the last twenty years. Specialists in many different disciplines and professions are working together on this issue, as its multidisciplinary character necessitates. Air transport is one part of this multimodal system, together with land and marine. This system has multisectoral character with encompassing the problems and viewpoints of government, private industry, and the public. "The objectives considered relevant often include national and regional economic development, urban development, environmental quality, and social equity, as well as service to users and financial and economic feasibility"(7).

3.1.1.1. Factors Affecting Transportation Decisions

There is a strong interaction between transportation and the rest of society so rapid change in the world is significant for transportation systems analysis. There are three dimensions of change relevant to transportation. One of them is change in demand for transportation. While the population, income and landuse patterns of metropolitan areas change the demand pattern changes with the amount and distribution. The second dimension of change is in technology and it is effective in all modes of transportation, especially in air transportation; with "jumbo" jet aircraft, vertical or short takeoff and landing (V/STOL) aircraft, and air cushion vehicles for water and land transport. The third dimension of change is in the values and it affects the decision making process.

Another factor to be concerned is the social and environmental effects of transportation such as air pollution, noise pollution, community disruption, and ecological effects, which have increasing weight in transportation decision making. In a region, changes in the transportation system directly affect the social and economic activity. In the short-term individuals change their decisions about modes and routes of travel or for firms the modes and routes to ship to market may change but in the long-term changes in distribution and intensity of these activities occur.

Activity systems and demand function is important in transportation systems analysis. Demand is directly related with the behavior of consumers. Consumers with different socioeconomic characteristics may display different behaviours, at the same service levels or consumers with similar socioeconomic characteristics may behave differently at different service levels. As there are widely varying socioeconomic characteristics and transportation service levels; there should be different choice behaviours. For analysis it is necessary to predict the behaviours of group of consumers. There are some procedures and modeling systems for this purpose (8).

3.1.1.2. Characteristics of Transportation System

Transportation is a complex system which have many components such as vehicles, guideways, stations, control and communication systems, maintenance systems, and management and other organizations. Available technologies, fixed facilities, network structure, vehicles, organizational and operating strategies, schedules and pricing policies are all the factors effecting system performance.

We can define capacity, for any system, as the maximum number of items processed per unit of time. We can say congestion occurs when the average processing time per unit increases because of demand for service. Physical capacity determines the maximum number of units that can be processed per unit of time. In order to tolerate delays practical capacity is usually chosen at a lower level than physical capacity.

Congestion becomes significant with the creation of greater marginal time (or cost) than the average time (or cost). Traveler behavior is an important factor and for example for international air travel a three hour transfer time at an airport with minimum facilities and at a major international terminal with tax-free shops and other facilities; extremely differs. The trip purposes and demographic characteristics of travelers are significant considerations for planning and directly affects system capacity. In the case of air travelers, these characteristics such as age, sex, income level, visitor or employee, etc., affect the traveler's choice of ground travel mode, parking requirements and other factors relating to ground transportation.

Temporal variations of travel is also important. In the case of air travel, change is seasonal, monthly, daily and even hourly. Peak hour changes influenced by the location of airport in the metropolitan area and with respect to other airports, air travel time, etc. It is necessary to translate air travel peaks to ground transport peaks with the zero effect of through air passengers (those continue on the same plane) and transfer air passengers (those continue their trip on another plane) in mind.

User and operators view to the system is different, while users see the system from a disaggregate perspective, operators are interested primarily in the aggregate performance of a total system, as reflected in economic and other measures. Intensive community interaction is as important as technical analysis for transportation decisions.

The transportation sector forms an important part of national and regional economies with creating wide labour potentials, with its visible impacts, and with its large budget. All these factors necessitates politically and economically powerful, public transportation agencies and private transportation firms.

3.1.2. Airport System Planning

Within the framework of transportation system planning; airport system planning is a representation of the aviation facilities required to meet present and future needs of the metropolitan area, region or country. The National Plan of Integrated Airport Systems (NPIAS) is an example of this kind, which is representing the airport needs of the United States.

The objectives of system plan include;

- the orderly and timely development of a system of airports adequate to meet present and future aviation needs and to promote the desired pattern of regional growth relative to industrial, employment, social, environmental, and recreational goals,
- the development of aviation to meet its role in a balanced and multimodal transportation system and to foster the overall goals of the area as reflected in the transportation system plan and comprehensive development plan,
- the protection and enhancement of the environment through the location and expansion of aviation facilities in a manner which avoids ecological and environmental impairment,
- the provision of the framework within which specific airport programs may be developed consistent with the short-and long-range airport system requirements,
- the implementation of land-use and airspace plans which optimize these resources in an often constrained environment,
- the development of long-range fiscal plans and the establishment of priorities for airport financing within the government budgeting process,
- the establishment of the mechanism for the implementation of the system plan through the normal political framework, including the necessary coordination between governmental agencies, involvement of both public and private aviation and

nonaviation interests and compatibility with the content, standards, and criteria of existing legislation (2).

A flowchart identifying a typical airport system planning process is shown in fig.3.1. We can say that, system plan presents the recommendations for; location and characteristics of new airports and heliports, and the nature of expansion for existing ones, identifies the aviation role of present and proposed airports, determines time and cost of development, relates the planning with the policy and objectives of relevant jurisdiction, establishes a balanced and integrated system of airports by determining the qualities of new ones, and provides a basis for detailed airport master planning.

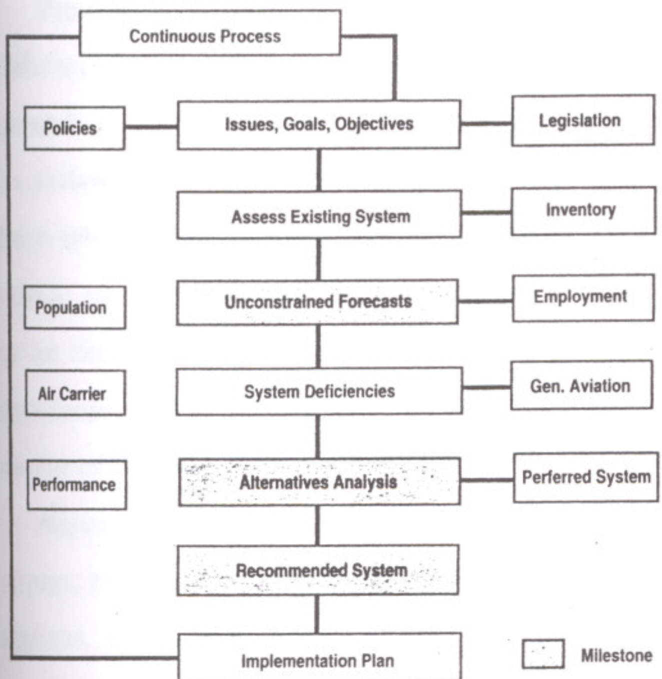


Fig. 3.1 Airport system planning process

(source: Horonjeff and Mckelvey) (2)

3.2. Airport Master Planning

We can't consider airport planning in isolation from the whole transportation system so comprehensive airport system and master plan studies are necessary for successful developments. Here, in this study, the aim is to outline the important factors which are effective in preparing an airport master plan, such as preplanning, forecasting, and site evaluation and selection, and also financial considerations. Whether preparing master plans for expansions of existing airports or for constructing new ones consultation and cooperative planning is a necessity.

An efficient plan should provide the required capacity for aircraft, passenger, cargo and vehicle movements with maximum passenger, operator and staff convenience and with lowest capital and operating costs. Flexibility and expandability are also important factors which should be kept in mind.

The elements of a large airport may form two major components; the airside and the landside as seen from fig 3.2 and the connection points of two are the aircraft gates at the terminal building.

Planning of airports is a complex matter. It is necessary to integrate so many different facilities and services for the movement of aircraft, passengers cargo and ground vehicles associated with them. It is a complex process and every activity should be analysed with the effect of other activities in order to achieve acceptable solutions. Each activity have different and even conflicting requirements and 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 expandability for future development.

Airport master plans are guides for; the development of physical facilities of an airport, the development of surrounding land-uses, determining environmental effects of airports, establishing access requirements of the airport. A master plan is used to; provide short and long range policy/decision guidance, identify potential problem and opportunities, secure financial sources, generate local interest and support. The master plan is only a guide and it involves policy- coordinative planning, economic planning, physical planning, environmental planning and financial planning.

A master plan starts with preparing a master planning work program, then collection of documents and inventory stage comes. Forecast for future air traffic demand, evaluation of constraints, followed by determination of airport type. Political and other considerations should be evaluated. Conceptual and master plan alternatives occur after all these studies. Comparison of alternatives and selection of most appropriate one followed by modifying if necessary and preparing in final form. A master plan should be reviewed annually and every five year or less it should be evaluated and modified

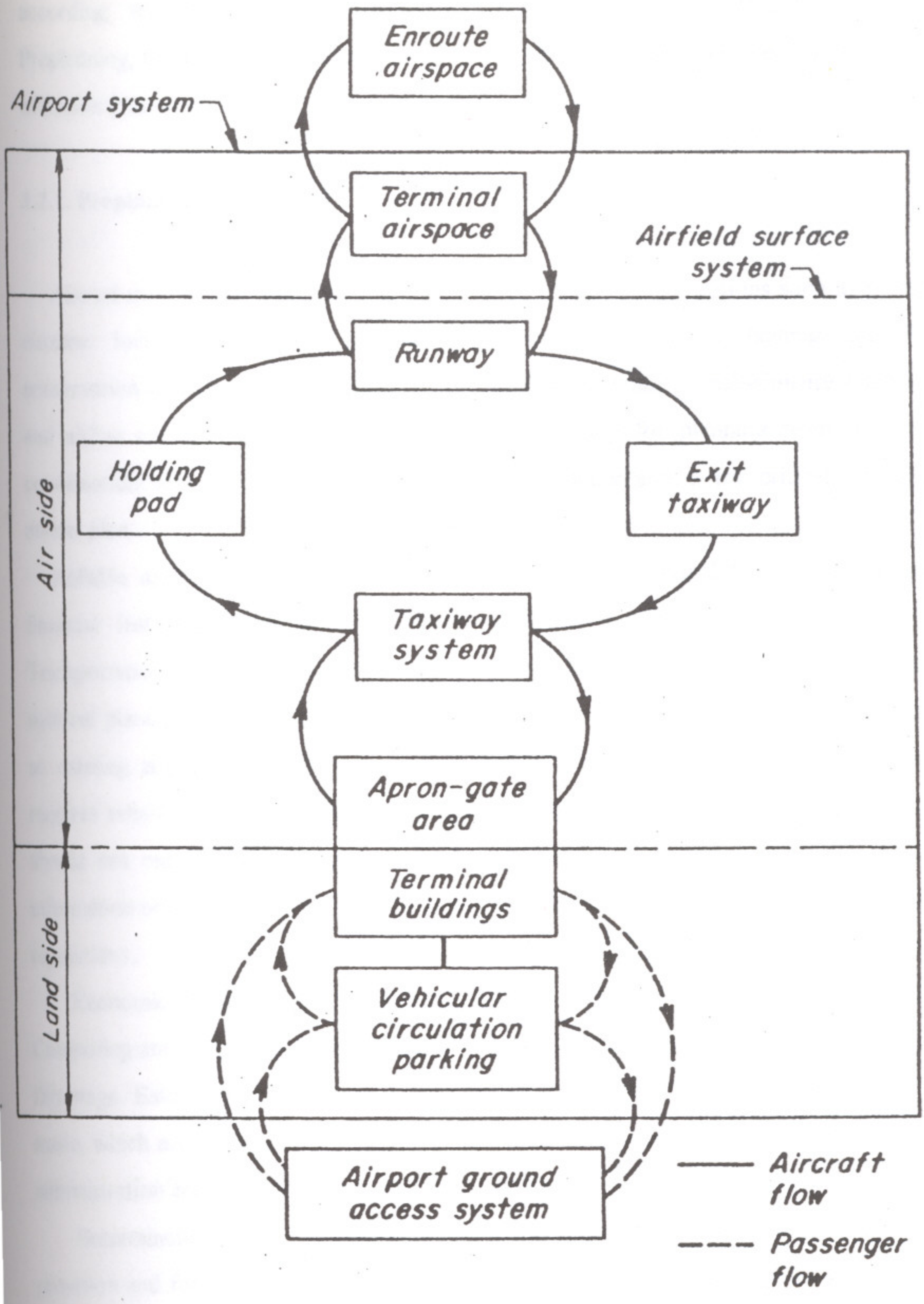


Fig. 3.2 Components of the airport system for a large airport

source: Horonjeff and McKelvey (2)

according to the economic, operational, environmental and financial changes. Preplanning, forecasting, financial considerations, site evaluation and selection are stages of master planning.

3.2.1. Preplanning Studies

Airport master plan, interests a diversity of people and organizations such as private citizens, local and national organizations, aerodrome users, planning agencies, conservation groups, ground transportation officials, and also concessionaire interests, and airline and other aviation interests. It is necessary for planning team to be in coordination with these interest groups at the beginning and at the critical stages of master plan.

Reliable data are varied and can be achieved from national banks, international financial institutions, national and local government agencies, International Air Transportation Association, airlines, regional offices, aviation trade association, local and national planning agencies, and from ICAO documents. If master planning is made for an existing airport, data achieved from airport management. Airport master planning requires reliable forecasting techniques and meaningful statistical data collection which should not only cover the physical facilities of the airport but should also provide information on traffic, cost, airline operations and government transportation policies and regulations.

Economic Feasibility studies should be made at the early stages of master plan. Computing and estimating of cost/benefit ratio and rate of return should be necessary at this stage. Estimation of costs which are spread out over a period of years should be made, which are for land acquisition if necessary, construction equipment, maintenance, administration and operating costs and financing fees.

Determination of sources and extent of the financial means available for initial provision and for continuing operation and maintenance of airport facilities and services is necessary. Government grants or loans and sometimes commercially negotiated loans, and international financial institutions, are the sources of capital costs. At the later stages; 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 are the chief revenue earning means of airports.

There is a need for a skilled planning team for economic and operational forecasts, operational research surveys, statistical and sociological data analysis, cost-benefit analysis of alternative solutions, aircraft operations in the air and on the ground, building construction and traffic and road planning. All these studies necessitates statistician, economist, financier, operational research scientist, architect, civil, mechanical, electrical and traffic engineers, pilot, air traffic controller and airport manager. An expert in management techniques who has a wide aviation background should be the planning coordinator of this team. Consultation with other interested agencies, with national and local government transport and planning authorities and aircraft operators are also important in airport planning.

Establishment of a planning organization to perform in policy formulation, advice and coordination, and technical planning is necessary in order to avoid public controversy, unrealistic recommendations and unimplementation.

The plan should provide a framework for future development and expansions. We can summarize this planning procedure such as forecasting, analyzing the requirements, developing system concepts, and airport master plan.

In master planning process, the first step is the establishment of ground rules which may be termed policy objectives. Determination of the time frame and geographical limits is necessary at the beginning in order to guide, data collection, forecasting or site selection. Policy development may take place at every stage of master planning process, during preparation, discussion etc., and there is a need for review of long-range policies. Feed-back is a necessity as in all other planning studies. Master plans are made for twenty year period of time since it may take as long as ten years for a major airport to be established, after its need has been identified.

3.2.2. Forecasting

For physical planning and for financial assessment purposes, certain forecasts should be needed. Here the lack of precision in the forecasts and converting them into planning criteria is important. Forecasts are needed related with aircraft, passenger, cargo and mail traffic categorized by international and domestic by scheduled and nonswcheduled and by arrivals, departures, transit and transfer. It is also necessary to make forecasts related with airlines, peak hour traffic, visitors, workers and also access system requirements.

It is difficult to forecast general aviation activities so these activities and nonscheduled activities (charter activities) both distributed away from the peak. The level of detail of the forecast differs as it is required for site selection or expansion for an airport. Long-term forecasts are guides for master-planning stage. Short-term forecasts (3-5 years) are necessary for actual development work, medium-term forecasts (between 5-20 years) are also necessary for the subsequent phases of development. The accuracy of forecasts depend on large number of factors so its very difficult to estimate precisely the timing and size of future requirement. Forecasting method, base data, socio-economic factors are some factors effecting the accuracy. Estimation of planning parameters from the forecasts carry risk and should be considered in the risk analysis.

It is important to convert the passenger traffic forecast into annual, seasonal and peak aircraft movements, as well as into seasonal and peak passenger flows. At large airports, by systematic approach annual data can be translate to hourly peaks, but its hard for small airports where all the situation can be changed by a single movement of an aircraft.

Forecasts based on an understanding of the process, generating the observed traffic variables are more confident so we can classify them under four main headings such as economic, social, technological and political. General indicators of these areas should be used for determining air traffic activity. Projecting past trends of traffic volumes to the future is the simplest way of forecasting. In a complex technique air traffic demand should be evaluated in relation to the effecting factors above. A relationship between these variables and traffic demand is called as a demand model.

3.2.3. Financing

Airports are owned and operated by either private interests or public agencies. In United States more than two-thirds of the 17 451 airports were privately owned in 1990. Privatization; by means of transferring some level of airport management, operation, or ownership from the public sector to the private one in order to introduce market competition into the operation of airports and to share the large investments government have to made for constructing and operating airport systems; is a significant issue in aviation. It is not common in U.S. as in the other countries because there is a specifically designed system improvements such as the Airport and Airway Trust Fund which provides financial support to aviation.

In preplanning stage, the estimates of costs should be made and possible sources of funds should be considered. In the later stages of master planning process, these data become more detailed and guide to the preparation of project's financing plan. In financing plan both capital costs and operational costs should be thought separately.

While concerning capital costs, financing plan should provide information as; estimates of component costs such as labour, materials, equipment etc., the amounts of funds required at various stages, the currencies in which payments are to be made and the sources of funds and their interest rate, repayment period, etc.

Foreign funds are necessary for most of the projects so financing for the project can be expected to accommodate foreign exchange problems. In the planning process, potential sources of funds to finance the project should be surveyed and selected as early as possible in order to guarantee financing and to avoid delays caused by lengthy procedures.

Costs to be met in domestic currency may be financed by various means such as loans, grants or government sources, commercial loans negotiated through banks or other financial institutions, etc.

Foreign financing may also be available from foreign governments and the reason of this assistance may be the development of transport facilities and the consequential benefits to the national economy or the desire to promote trade and cultural relations between two countries and also the wish to facilitate the export of technology and equipment required for the project, may be the reasons of this assistance.

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.

Operational costs come into action once the airport project or any part of becomes operational and they involve operating, maintenance and administrative costs, interests and taxes.

Distinct from any grants and subsidies; the sources of earned income of an airport are various and may be classified by two broad kinds of activity such as air traffic operations and non-aeronautical operations. Changes of facilities and services provided to meet the basic operational needs of aircraft operators are the main source of earned income. The most important of them are landing charges, passenger and cargo charges, parking and hangar charges.

The other source of earned income is from ancillary or non-aeronautical activities such as; concession fees from aviation fuel and oil companies and other commercial concerns doing business at the airport, revenue from the rental of airport land and equipment, income derived directly from the airport's own operation of shops and services. The kinds of concessions and commercial concerns operated at airports throughout the world shows a great variety from duty-free shops to restaurants, parking facilities to less usual ones such as swimming pools and tennis courts. Some of them are more appropriate and provide optimum financial benefit so each airport has to determine the best ones under its own circumstances. We should know that user charges and revenues from non-aeronautical activities are sources for defraying operational costs and also for earning foreign exchange.

Financial control of an airport project means to arrange the flow of income according to design. At first the comparison of revenues and expenses should be made than if there is a significant difference, it is necessry to determine the reason of this difference.

The basic purpose of financial control is to ensure that all the resources are being effectively utilized. This control is important for the ones involving in the management of the project and also for obtaining outside finance in the most favorable manner. Effective financial control can be obtained by establishment of a budgeting process as a complement to the accounting system. A budget is a projection of expected revenues and expenses over a predetermined period of time, so it is helpful for financial control and for establishing a series of financial objectives for budget period. Budgeting is a continuing operation of planning process and continued not only in the construction stage but also in the operational future (7).

3.2.4. Airport Site Evaluation and Selection

While constructing a new airport in order to prevent waste of financial and material resources there should be sufficient ground area for progressive development with growth in air traffic demand. There is also need for safety of aircraft operations and avoidance of hazards or discomfort to the surrounding community in this growth process. Financial and social costs in the long term development should be kept in mind in the site selection process.

The assessment of the suitability of an existing site or selection of a new site is the definition of the purpose for which the airport is required. This necessitates future demand forecasts and type and quantity of traffic, and all these derived from economic and operational forecasts. The type of airport and operational system definition is necessary for the forecast of passenger and cargo traffic. These information guide to the site selection process with the determination of the shape and size of the area required. Then the location of sites with potential for development, examined and evaluated.

Site evaluation and selection process for an existing or entirely new airport include stages such as determination of the broad land area requirement, selection of possible sites, office study on possible sites, site inspection, review of potential sites, preparation of outline plans and estimates of costs and revenues, final evaluation and selection, and reporting.

3.2.4.1. Determination of Broad Land Area Requirement

Determination of the land area requirements, achieved by considering the space need for runway development which forms the major proportion of land required for an airport. The length, orientation, and number of runways determine this requirement.

The parameters effecting runway length and calculation of length for specific aircraft for airport planning purposes are all explained detailly in the ICAO Aerodrome Design Manual. Adequate space for future development should be provided. While determining number and orientation of runways which is mainly affected by wind distribution, not to decrease the usability of airports under 95% is important. For this reason wind strengths according to aircraft reference field length should be determined. Affective wind distribution covering at least 5 years and the observations 8 times a day with equal time intervals are necessary.

Annex 14- Aerodromes is a good source for detailed information about runway orientation. Directing aircraft to unpopulated areas and avoiding obstructions are the main factors effecting orientation. If the wind is consistently from one direction they should be oriented in the prevailing wind direction. While maneuvering on the runway for takeoff and landing, aircraft can subject to winds at right angles to the direction of travel, which defined as cross-wind. The maximum allowable cross-winds determined by aircraft size, its wing configuration and the condition of pavement surface. Although transport category aircraft can maneuver in cross-winds as high as 30 knots, lower values used for planning purposes. The orientation of runways should let landing of aircraft at least 95 percent of the time with cross wind components of 20 knots for category A and B runways, 13 knots for category C runways, and 10 knots for category D and E runways.

Code letter	Runway Length
A	2 100 m and over
B	1 500 m- 2 100 m
C	900 m-1 500 m
D	750 m-900 m
E	600 m-750 m

Weather records can be obtained from government weather bureaus, but generally wind data for an entirely new location haven't been recorded. The records shouldn't be used if the terrain is hilly. The wind pattern change by the topography and it is dangerous to utilize the records of stations some distance from the site for determining the directions of runways. First the wind data (direction and percentages) achieved listed on a table, then from these data a wind rose plotted. By the help of the wind rose the orientation which will permit operations 95% of the time with the allowable cross-wind components can be determined. The next step is examining wind data during restricted visibility conditions. Wind coverage should be analyzed in that specific direction during periods of restricted visibility.

There is a necessity to meet the forecasted aircraft traffic demand, so a sufficient number of runways are required. The 95 percent usability specified in Annex 14 with regard to surface cross-wind velocity is a minimum and inability to operate in 5 percent or eighteen days per year creates disadvantages at busy airports so one or more secondary runways may need to be planned for these conditions. At airports where maintenance work affect the regularity of air service, secondary runways may also be provided. If the cross-wind runways would be used only under high headwind components, their lengths can be shorter than the main runways.

3.2.4.2. Evaluation of Possible Sites

After the determination of land area requirements and layout capable of satisfying the airport master plan; some information should be collected for evaluation either for an existing airport site or potential site for new airport. The information should include aviation activity, development of surrounding area, atmospheric conditions, accessibility to ground transport, availability of land for expansion, topography, environment, presence of other airports, availability of utilities. After the approximate size and type of the airport has been determined and all the above factors have been analyzed, at this stage on charts and maps the possible airport sites and additional land requirements of an existing airport plotted. Then these potential sites should be investigated, from operational, social, cost and environmental point of view.

Operational considerations can be summarized as providing adequate airspace, obstruction free approaches and clear visibility conditions. Adequate airspace is so important for the efficient operation of an airport and the ICAO document and Annex 14 give the requirements related to this factor. In the location of new airports, the overlapping of airspace with present airports' as a capacity minimizing factor should be thought and avoided. The volume and type of traffic and the equipment of airport to operate under poor visibility conditions are determinants of the minimum distance between airports. "The location of several airports in a metropolitan area can greatly influence their respective capacities. If the locations are too near each other, operations can be restricted to the extent that two airports will have no more capacity during IMC (instrument meteorological conditions) than a single airport"(2). Fig.3.3 shows the interaction of airspace at Chicago O'Hare International and Midway Airport.

Fig. 3.3 Airspace interaction between Midway and O'Hare International airports

source: Horonjeff and McKelvey (2)

Sites should have obstruction free approaches necessary for the ultimate development of the airport. Airports involve large areas of land-15 kilometers on the axes of runways from the airport boundary- so it is difficult to obtain sites with all desired clearances and features such as high terrain, trees and man-made structures which constitute obstacles need to be avoided. Sometimes marking and lighting can assist in directing attention to the structures but in low visibility conditions it shouldn't be efficient. In the early stages of plan to provide clear approaches with few restrictions is important. The required clearances for the approaches to the runways and in the maneuver area directly above and adjacent to the airport are outlined in detail in Annex 14. Several imaginary surfaces are established with relation to the airport and to each runway in order to determine whether an object is an obstruction to air navigation depending on the category of each runway and on the type of approach planned for that runway.

By creating hazards some local factors should be important in the location of individual sites. Sometimes industrial areas which produce smoke should effect visibility with the effect of prevailing wind and sites adjacent to natural areas which pulls birds and on migratory routes of birds especially large birds such as swans become hazardous. In the same general area weather conditions should vary between sites. Wind distribution is important for visibility and for runway orientation. Particular localities may be subject to fogs, turbulence or higher rainfall which are important factors for operations.

Social considerations are also important at the site inspection stage. Noise problem for populated areas created by being adjacent to airports or under the flight paths in one hand and the necessity to locate airports adjacent to the towns and commercial areas they serve in the other, creates an opposing fact which should be evaluated carefully.

Proximity to demand centers is important. The acceptability of the location of a site relative to the areas it serves; such as populated centres and commercial and industrial areas, can be measured in terms of journey time and cost. Access time to the airport is quite important especially for short-haul operations where the door-to-door travel time interested people more than the travel time in the air. Ground access or transit time from the origin to the destination is so important while in many cases the ground time exceeds the air time by a considerable margin. It is essential for an airport to provide easy access either by private motor vehicles or by public transport systems, such as public bus, rail, taxi or some cases by vertical or short take-off (V/STOL) aircraft. In metropolitan areas popularity of automobile as a personal means of transportation in one hand and the lack of concentration of origins and destinations in the other prevents large use of public transit. The use of private automobile as a major form of access to the airport is proven by the statistics and this trend will continue despite the greater availability of mass transit. "Access to airports is required by both air passengers and other users of the airport, such as employees, visitors, trucks hauling freight and express mail, and businesses dealing with airport's tenants"(2). During the early stages of investigation for construction of a new airport or for major extensions to existing ones, it is necessary to inform the authorities responsible for roads and public transport systems.

Noise is a serious problem in the vicinity of airports. Especially land area beneath and adjacent to the aircraft approach and departure paths expose to high level of noise, and this will cause social reactions. Noise level at and around airports is a primary environmental cost associated with the facility. It is not always feasible to site an airport far away from population centers because of the increasing travel time and cost. Proper site selection and adjacent landuse planning can help to eliminate this problem. Serious effort has been given to quiet engines and to modify flight procedures resulting substantial reduction in noise.

Compatibility with the surrounding land uses is an important factor in site selection. In general, sites with approach over water, but free of bird hazards are preferable than the sites adjacent to residential areas. If there is a necessity for a change in landuse, it causes social problems and also legal and economic difficulties. In these cases compulsory purchase should be necessary and delays may occur. Development of compatible land uses should be controlled in order to prevent future problems.

Cost is an important factor which should be considered. Topography, soil, construction materials, availability of services and land values are important in order to minimize construction costs and maximize profits. Topography is important because the slope, natural elements or man-made structures can effect the requirements for clearing, filling grading or drainage. Terrain which is close to desired levels and which is well drained is advantageous. Soil surveys and sampling are necessary for mapping soil types and rocky areas of potential sites from the cost point of view. Determination of the locations and distances of water sources is also important. It is preferable to be adjacent to services such as power and water supplies, sewage and gas mains, drainage lines and telephone, etc. in order to prevent the necessity to provide them specifically for the airport and so reduce costs. Airports require adequate space for future development, especially in metropolitan areas where population growth and rising life standards effect demand positively. Land values in these areas especially where change from rural to urban use occur, increase significantly so early reservation of adequate sites often enable airports to be better located and at lower costs. Construction of new roads and providing utilities for airports increases the values of adjacent lands and their attractiveness for development, parallel to the demand of housing for employees and servicing industries. While providing planning control over these areas for compatible land uses it is necessary to provide adequate land for future development. Time factor should be evaluated with the current land values and movements in property prices and the possibility of housing, industrial, agricultural or other developments which may increase values.

Environmental factors should be carefully considered and the impact of 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 should be carefully investigated. Today, general tendency in the world is requiring an "environmental impact analysis report" for any kind of activity which may have serious impacts on the environment. These reports should include; description of the activity, its possible impacts on the environment, the precautions to be taken , inspection methods and emergency plans and the investments should be let according to these reports. Sustainability will be one of the most important issues of 21st century. Sustainable transportation and environmental effects of airports are widely mentioned in chapter 5.

3.2.4.3. Review of Potential Sites and Final Evaluation

With the information in hand as a result of field investigation and office study the number of potential sites should be reduced by the planner. Then for the remaining sites there should be made further studies such as: detailed surveys of site and obstacles, preparation of outline plans, preparation of broad estimates of cost and revenues, including items such as access roads, communications to population centers, etc., and in the case of expansion of existing sites, 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..

At the final evaluation stage cost plays an important role, on the choice of sites which have equal characteristics, least cost is the basis of choice. In reality, generally varying degrees of advantage and disadvantage should be weighed before reaching a decision. By the analysis of benefits and costs over the useful life of the airport; determination of cost-benefit ratios which serve as a guide to the value of the project and the choice of the best site, could be possible. Two different type of cost-benefit analysis are necessary. One; operational which covers land availability, airspace availability, effect of any restrictions on operational efficiency and potential capacity, the other; social, which involves proximity to demand centers, adequacy of ground access, potential noise problems, and current landuse and need for control measures. At the final evaluation stage operational, social and cost efficiencies should be compared.

After all these studies a report should be prepared, which covers the result of site surveys and evaluation, the advantages and disadvantages of different sites and the reasons of selection and recommendations for further study.

3.2.5. Preparation of Airport Plans

After the site selection process, airport plans can be developed for the functional requirements which airport has to get. In order to develop these plans; concepts for the various operational systems have to be considered and compared. Physical characteristics and the land requirements of runways and taxiways, the apron, and navigational and traffic control aids at the airside, the passenger building, cargo facilities, and ground transport and vehicle circulation and parking on the landside are the principle factors to be considered. Their operational systems, and planning and design criteria, etc., are investigated in following chapter in detail.

Airport layout plan, terminal area plan, airport access plan, noise compatibility plan are some examples which should be prepared at this stage. All these plans and maps should cover information about; other settlements and transportation facilities in the vicinity, ownership pattern, present or proposed utilities, expected noise levels around airports, obstructions and runway clear zones, topography, all facilities within the airport and their reserved areas for future development and phases of development, dimensional data related with runways and taxiways, airport boundaries, north point, windrose and legend. Meteorological data, runway lighting, marking, runway gradient and electronic and visual aids are other necessary information.

Before undertaking a master plan study, there should be reasonable assurances that the airport operator could finance the development. For each phase of development implementation schedule prepared with the accompanying estimated costs, at the master planning stage. An implementation schedule should cover technical and financial considerations. The technical considerations should include time for; land acquisition, project planning and detailed design, and complete construction. The financial considerations should include availability and timing of capital financing. The airport operator should associate at all phases of development.

3.3. Airport Project Planning

"An airport is like a total city devoted to dynamic movement. It comprises many varied structures that facilitate passenger and cargo movement, maintenance, and aircraft control, and other structures that provide for auxiliary support functions. The very nature of an airport's complexity makes it necessary to isolate its segments for design purposes"(9).

All the movements and functions of the passengers, the cargo, and the airline employees to and from an airport are regulated by a printed schedule. Passenger's actions are based on the printed timetable of the airline he has chosen to fly. Cargo movements depends on the normal working hours of the community. Flying schedule and working hours couldn't coincide, so it creates conflict and necessitates a special correlation by the airline. The employees' working hours are predicated upon the functions of each discipline as it relates to the schedule. All the movements to and from the airport tend to take place upon a preestablished, programmed basis. Changes in the technology of the aviation industry creates changes of this printed schedule. New aircraft with greater speeds and greater carrying capacity are the main reasons of this change. Therefore, in the development and design of all functions flexibility and expandability should be main determinant. The on-time record of aircraft is also important for the design programme. The actual arrival and departure times are subject to weather conditions, mechanical difficulties and other special considerations that will arise from time to time. So while designing consideration must be directed toward the capability of handling the peak condition plus an overload factor caused by deviation from the schedule. The designer should be aware of the fact that peak capacity may-be reached only at two or four hours a day depending upon the airport, and for other hours of the day elements of the airport operate at very low efficiency. For an economically correct solution it is necessary to control carefully the amount of structure designed.

The size of the airport affects the surrounding community and with careful site selection and site planning there should be created a potential for improvement of environment and economics of a community. Proper site planning and building design eliminates or minimizes the problems of noise, air pollution and ecological balance. There is a need for cooperation with the surrounding community for successful operation of the airport which is directly affected especially by the economic impact of airport.

An airport project planning is necessary for constructing an airport. It is a detailed plan of the specific development. It may be for an additional runway or modification or for renovation of terminal building facilities or modification of ground access facilities. "The overall objective of the airport project plan is to provide the specific details of the development identified in the airport master plan that will satisfy immediate aviation needs and will be consistent with the objectives and constraints identified in the airport master plan"(2).

A project plan; developes architectural and engineering designs for physical facilities at an airport, assess the environmental effects of the development through construction and operational phases, determines detailed cost, and financially plans the development, determines the schedule of construction and phases of other development items. In the early days of airport planning, the project plan had seen only a technical matter, but today many complex technical, environmental, social, economic, financial and political considerations influence the airport plan. The resulting product, may not be the best in technical point of view but it usually represents a compromise among many diverse requirements. In order to develop any kind of plans, projects, and designs of airports it is necessary to understand the system of airports.

CHAPTER 4

AIRPORT SYSTEM

The world's first airports were no more than cow pastures, often surrounded by trees and farm buildings, from which flight was achieved off grass runways no more than a few hundred meters long. Today, large airports occupying several square meters of land with their paved runways over 3000 m are very common.

We can broadly define airports as areas used or intended to be used for aircraft landings and takeoffs and which may includes buildings and facilities. Many classifications can be made by type, by ownership, by usage, by activity or facilities available. Sometimes they are classified by the type of aircraft they are designed to serve. The basic utility (BU) and the general utility (GU) airports, the basic transport (BT) and the general transport (GT) airports in US classification are of that kind. Perhaps airports on artificial lands will be another class in future. Osaka Airport in Japan and Chek Lap Kok Airport in Hong Kong which have constructed 20 billion dollars and opened a few months ago, are two examples which locate on artificial islands in metropolitan areas and with their vast size and traffic, they are samples of largest and bussiest conventional airports in the world.

Here in this chapter airport system should be investigated according to the classification by type such as conventional airports, heliports, stolports, vertiports and seaplane terminals.

4.1. Conventional Airports

Design and construction of an airport involves three major areas of examination; the runways, taxiways, and aprons, the terminal, and the circulation roads and parking. In general, we can divide airport development as landside and airside; while runways, taxiways and aprons take place at the airside, circulation roads and parking areas take place at the landside and terminal building serves as a gateway from one side to another. There is a strict distinction between the two sides in order to provide safety so airside is a prohibited zone for an ordinary person who only let for aircraft boarding and leaving in a controlled manner. Other facilities which we can name as airport support elements, may serve only landside or airside such as meteorological services or the two sides such as fire fighting services.

Runways and taxiways, because of their physical characteristics and land requirements and other factors affecting their layout choice are the first to be considered at the airside. After determination of the dimensional criteria, pavement strength, and airfield capacity and configuration, the other elements of the airside such as aprons and navigational and traffic control aids should be considered.

The forecasted aircraft movements, the nature of traffic, type of aircraft, and other factors such as standards are effective in determining the dimensions of runways, access taxiways and aprons. After the determination of the layouts for these systems, the possible schemes should be considered in conjunction with passenger and cargo buildings and aircraft maintenance areas so as to choose the best one.

Major elements of the landside development are passenger building, cargo facilities, and ground transport and vehicle parking. It includes all the areas to which the non-traveling public have free access and also the non-public portions of some facilities such as, airline operations and cargo facilities and airport administration, etc.

4.1.1. Runways and Taxiways

A runway is a rectangular area which has used for takeoff and landing of aircraft. An airport may have one or several runways; sited, oriented and configured differently with the effect of weather conditions, especially wind direction, topography, etc., in order to provide safe and efficient use of the airport under different conditions.

Runways and taxiways requires large areas of land, so in consideration of airport layout they are essential, but of course relation with other major operating elements; such as terminal area, vehicle parking, access systems, and services at the planning stage is a necessity in order to achieve balance in system. Runways and taxiways are the least flexible elements in this system so they should be considered first.

For providing uniformity in landing facilities and a guide for airport planners, dimensional criteria of runways have been established by ICAO in Annex 14. Widths and gradients of runways and other features of landing area must incorporate wide variations in aircraft performance, pilot technique and weather conditions. It is desirable to minimize the longitudinal grade changes, but it may not be possible because of economic reasons. Reference codes based upon runway length have been developed for identifying standards for various sizes of airports.

There are some principal elements for identifying runways; such as structural pavement, shoulders, runway strip, blast pad, safety area, stopway and clearway. The structural pavement supports the load of aeroplane, adjacent shoulders resist erosion caused by jet blast and accommodate maintenance equipment and patrol. Runway strip covers a cleared, drained and graded area in addition to structural pavement and shoulders. It should support fire, rescue, crash and snow removal equipment and in extraordinary cases, veering of aircraft as well. Blast pad is a paved or turfed area designed to prevent erosion of surfaces adjacent to the ends of runways which exposed jet blast. Safety area is for reducing accidents of aircraft undershooting or over-running the runway, which extends beyond the runway. Stopway is an additional paved area at the end of runway which should support occasional aircraft loading. Published runway lengths shouldn't cover stopway. A clearway is an unobstructed, unpaved area beyond the end of runway and it is controlled by airport operator. There shouldn't be any obstructions in clearway.

The speed of aircraft on taxiways are less than on runways so dimensional criteria are not as stringent as for runways. Taxiway widths are described in Table 41. In order to prevent eroding of adjacent areas taxiway shoulders built. Exit taxiways or turnoffs are for minimizing runway occupancy time by landing aircraft and can be placed at right angles or for higher speeds, 30 (high-speed exit) to 45 (rapid exit) degrees. Right angle or 90° exit taxiways are not desirable for minimizing runway occupancy especially for busy airports. The location of exit taxiways depends on several factors, such as the mix of aircraft, approach and touchdown speeds, point of touchdown, the exit speed, rate of decceleration, which in turn depends on the condition of the pavement surface, i.e., dry or wet, and number of exits (2). Consultation with the airlines is important, because the performance characteristics of the aircraft which will operate is the main determinant for exit locations. Typical runway occupancy times for high speed exits are 35 to 45s., for a regular exit 45 to 60s. for air carrier aircraft. The rapidity and the manner of in which air traffic control can process arrivals, and the location of runway relative to terminal area is also very important in the location of exit taxiway.

Taxiways should be evaluated in combination with runways and aprons as a system. The greater the complexity of this system, it is possible to reduce operating costs through a comparison of alternative taxiway systems. Several simulation models have been developed for this purpose related with aircraft traffic flow (10). For minimizing construction costs taxiway system should be suitable to current needs but also suitable for additional taxiway components for future needs. If an aerodrome is forecasted to serve a higher category of aircraft type in the future, the current taxiway system should be designed to accommodate the greatest separation distances that ultimately will be required.

When delays to departures average four minutes during the normal peak two-hour period (adjacent hours) of the week occurred we can say that runways have reached capacity. This departure delay level is two minutes for the peak hour of the week for runways used by small aircraft. There are some techniques developed for capacity measurement. With suitable taxiway facilities, a single runway airport can exceed 150 000 operations annually. However, the development of additional runway may be considered even if the demand is less than 150 000, but the traffic is increasing. There are some configurations of runways such as single runway, parallel runways, dual-lane runways, intersecting runways and open-v-runways. The last two are not recommended, unless the terrain and noise obstacles make them practical. There are also some other configurations which are not common (fig. 4.1). Single runway is the simplest form and the hourly capacity of a single runway in VFR (visual flight rule) conditions is between 50 to 100 operations per hour in IFR (instrument flight rule) conditions is between 50 to 70 operations per hour.

Capacities of parallel runways effected by the spacing and number of runways. It is not proposed more than four runways because of the difficulties in air traffic control systems and large airspace requirements. Terminal building may be placed between parallel runways, in order to provide the segregation of runways in the extent for building, apron and taxiway land requirements is important. Even if there are four parallel runways the pairs should be spaced far apart in order to provide this necessity. One pair of parallel runway capacity changes between 60 to 200 in VFR conditions and changes between 50 to 60 in IFR when closely spaced, 60 to 75 intermediate and 100 to 200 when spaced far apart.

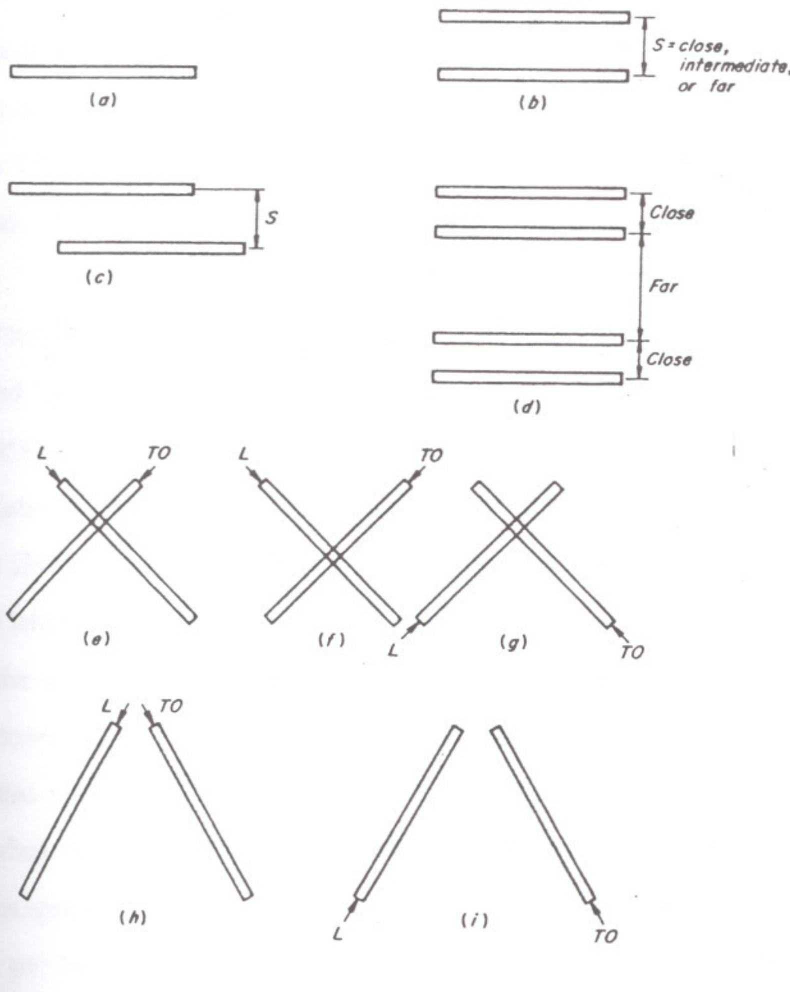


Fig. 4.1 Typical runway configurations a) single runway b) two parallel runways-even threshold c) two parallel runways-staggered threshold d)four parallel runways e) intersecting runways g) intersecting runways h) open-V runways I) open-V runways.

(Source: Horonjeff and McKelvey) (2)

Two closely spaced parallel runways with appropriate exit taxiways named as dual runways. Here locating runway farthest from terminal building for arrivals and closest to terminal building for departures is desirable. Estimated capacity is 70 % more traffic in VFR conditions and 60 % more traffic in IFR conditions than single runways. The two runways should be spaced at least 100 ft apart. They provide an increase in IFR capacity with minimum land acquisition.

In many airports there are more than one runways in different directions which cross each other. These are named as "intersecting runways" and they are necessary if there are strong winds from different directions, and simultaneous use may happen in light wind conditions. " The capacity of two intersecting runways depends a great deal on the location of the intersection (i.e., midway or near the ends); the manner in which runways are operated for takeoffs and landings, referred to as the runway-use-strategy; and the aircraft mix"(2). According to the intersection point capacity ranges from 70-175 to 50-100 operations per hour under VFR conditions and from 60-70 to 40-60 operations per hour under IFR conditions. The position of the intersection is important and the farther it is from the takeoff end of the runway and the landing threshold, the lower the capacity.

When the winds are strong from more than one direction and when the runways in different directions do not intersect each other they are called as open-V-runways and they are also used simultaneously in light wind conditions. Highest capacity can be achieved when operations are away from the V which is called as diverging pattern. The capacity changes between 60 to 180 operations per hour in VFR conditions and 50 to 80 operations per hour in IFR conditions. In converging pattern 50 to 100 operations per hour in VFR conditions and 50 to 60 operations per hour in IFR conditions.

> "From the standpoint of capacity and air traffic control, a single direction runway configuration is most desirable. All other things being equal, this configuration will yield the highest capacity compared with other configurations. For air traffic control, the routing of aircraft in a single direction is less complex than routing in multiple directions"(2).

Taxiway facilities provides efficient use of runways by allowing the maximum capacity. Taxiway capacities may increase by a set of factors such as, creation of parallel taxiways, by taxiway turnarounds at both ends of runway and a stub taxiway to the apron, by exit taxiways at the ends and adequate number of exits between, by holding bays and by-pass taxiways. Taxiways are used for the movement of aircraft on ground in order to provide linkage between different parts of the airfield. Dual parallel taxiways provide movement of aircraft in opposite directions. An apron taxiway is located on the periphery of an apron, and a taxilane is part of the aircraft parking area which provides access between taxiways and the aircraft parking positions. Minimum seperations between taxiways and taxilanes are important for providing safe maneuvering of aircraft (2).

It is desirable to provide the shortest taxiing distances from the terminal area to the takeoff ends of the runway and to shorten the taxiing distance for landing aircraft as much as possible (fig.4.2). If there are more than one runway in different directions it is desirable to locate terminal area centrally. If there are four parallel runways, it is necessary to reserve two of them for landings and two for takeoffs which are adjacent to terminal area.

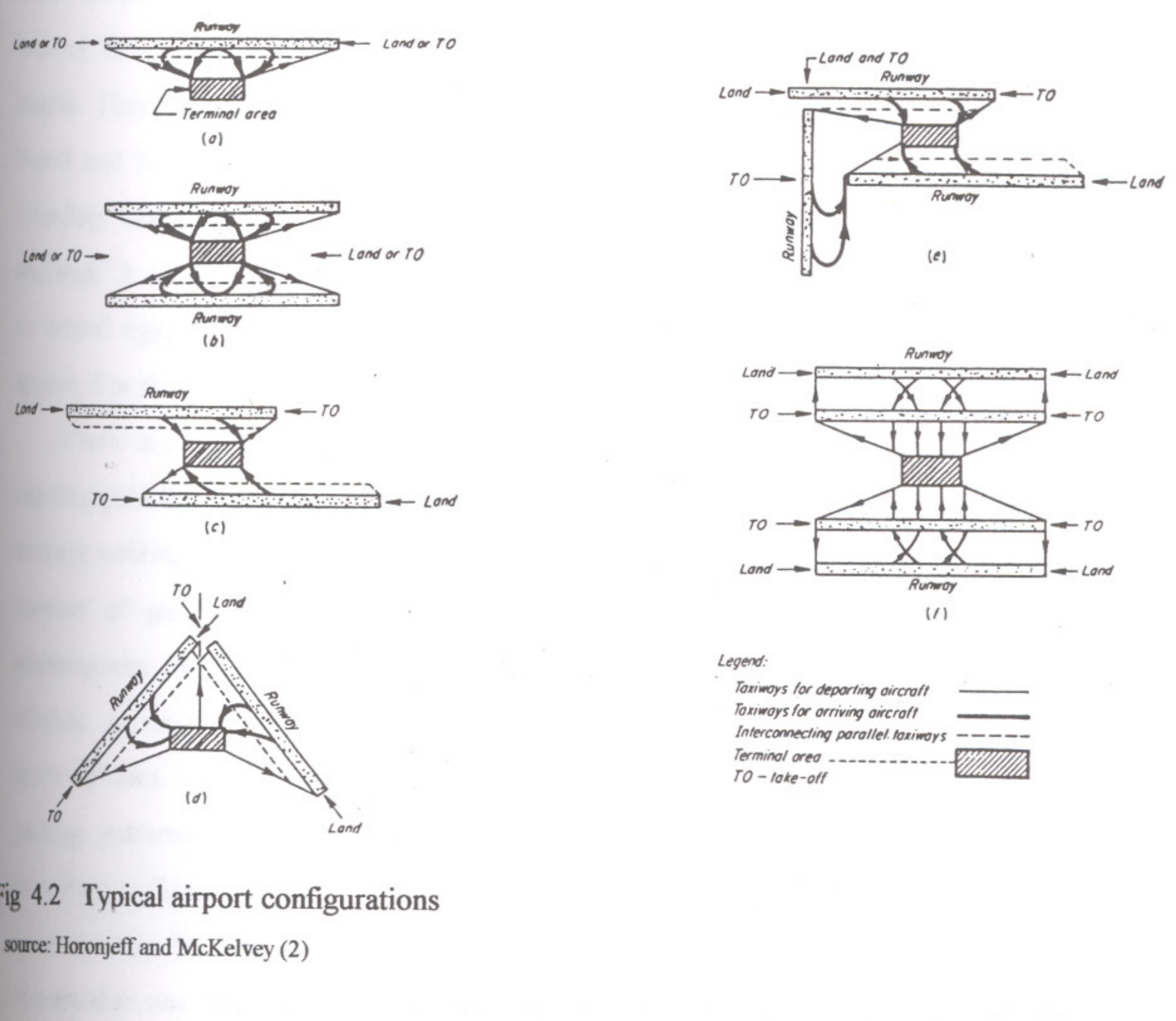


Fig 4.2 Typical airport configurations

source: Horonjeff and McKelvey (2)

4.1.2. Aprons

We can classify aprons according to their main purposes and functions. We don't need every type of apron for every airport, their need and their size should be estimated based on the type and volume of forecast traffic at the airport. Aircraft stands, the associated apron taxiways, apron service roads and parking for ground service equipment are all parts of apron system.

Minimizing adverse effects such as engine blast, noise, air pollution, etc., on the apron and the surrounding environment, is one of the objectives which should be considered in siting aprons in the master plan. While sizing an apron; aircraft mix and number of aircraft stands required at present and in the future, aircraft dimensions (table 4.1) and maneuvering capabilities, aircraft parking configuration, its clearance requirements and its ground servicing requirements (vehicles and fixed installations), taxiways and service roads are all parameters which should be considered. (fig. 4.3). Aircraft aprons should be located in a position which is minimizing the distance between runways and aircraft stands. They should provide ease of aircraft movement and facilities; for passengers to board and leave aircraft, for cargo loading and unloading, for aircraft servicing and refueling. There is a need for parking and accommodation of aircraft servicing equipment and staff. A circulatory road is necessary for airside servicing vehicles. Possible sabotage or armed aggression should be considered while planning the location and design of aprons. For this aim, direct access of public to aprons should be prevented.

There are some configurations for aircraft parking systems. Up to four gate requirements frontal system is logical. After this point, finger system is necessary and average walking distance between ticket counter and aircraft should be 300 m. When the number of gates exceeds 12 in one finger, a second finger system should be advantageous. Sometimes Y and T fingers are used but simple finger systems are more efficient. As the number of gates increases to 30 or more, multiple finger systems become more efficient. Satellite and tunnel systems were developed to create more compact parking patterns and decrease obstructions, but they have a negative effect with increasing walking distance, and also satellite systems decrease number of aircraft at the same distance. In open apron system, aircraft parked adjacent to the passenger building in more than one row. Access should be provided by walking or by using motor vehicles.

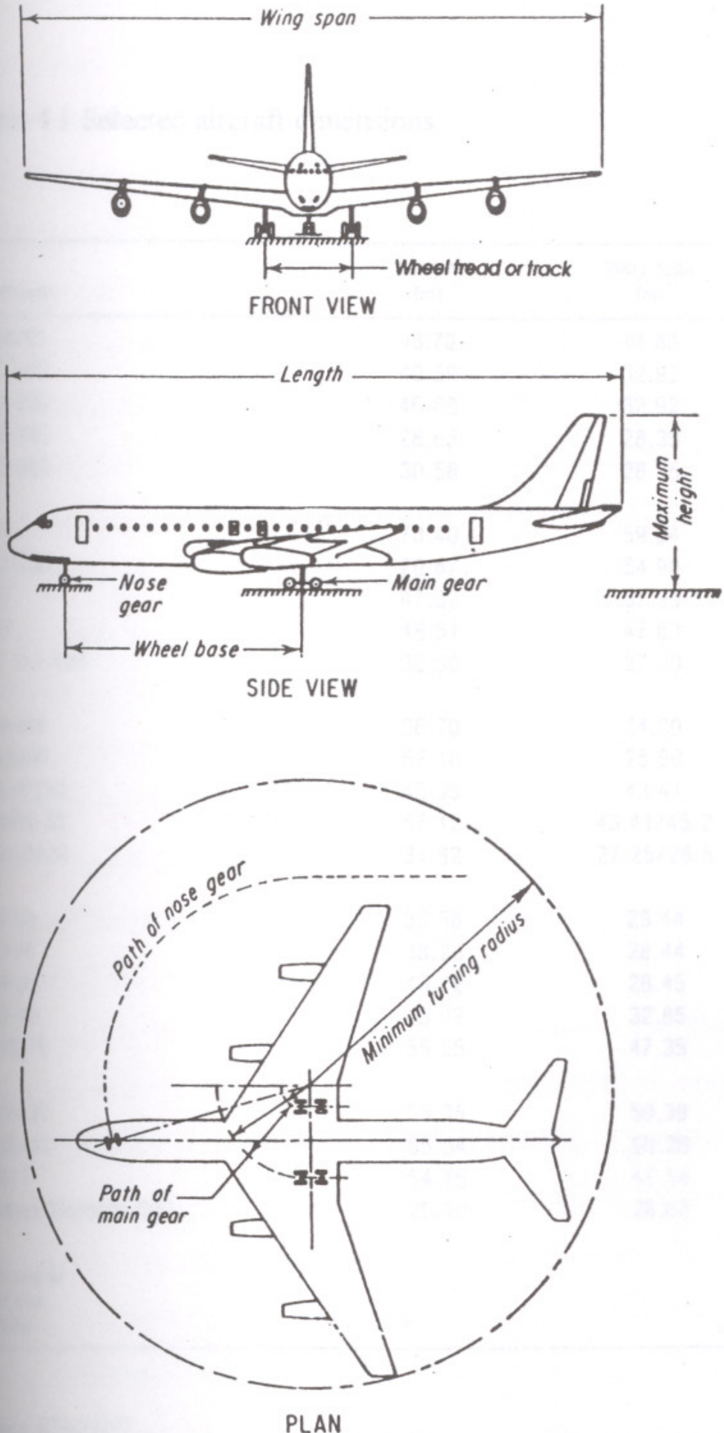


Fig 4.3 Definition of terms related to aircraft dimensions

source: Horonjeff and McKelvey (2)

Table 4.1 Selected aircraft dimensions

Aircraft type	Length (m)	Wing span (m)	Nose wheel angle	Turning radius (m)
A300B-B2	46.70	44.80	50°	38.80[a]
B727-100	40.59	32.92	75°	21.90[c]
B727-200	46.68	32.92	75°	25.00[c]
B737-100	28.65	28.35	70°	18.40[a]
B737-200	30.58	28.35	70°	18.70[a]
B747	70.40	59.64	60°	60.20[a]
B747-400	70.67	64.90		
B757	47.32	37.95	60°	27.90[a]
B767	48.51	47.63	60°	36.00[a]
BAC 111-400	28.50	27.00	65°	21.30[a]
Caravelle	36.70	34.30	45°	29.00[a]
Concorde	62.10	25.50	50°	30.10[c]
DC8-40/50	45.95	43.41	70°	29.20[a]
DC8-61/63	57.12	43.41/45.2	70°	32.70[c]
DC9-10/20	31.82	27.25/28.5	75°	17.80[c]
DC9-30	36.36	28.44	75°	20.40[c]
DC9-40	38.28	28.44	75°	21.40[c]
DC9-50	40.72	28.45	75°	22.50[c]
DC9-80	45.02	32.85	75°	25.10[b]
DC10-10	55.55	47.35	65°	35.60[a]
DC10-30	55.35	50.39	65°	37.30[a]
DC10-40	55.54	50.39	65°	36.00[a]
L1011	54.15	47.34	60°	35.59[a]
Vickers Viscount 800	26.10	28.60	50°	21.60[a]

a To wing tip
b To nose
c To tail

source: ICAO (10)

Walking is unsafe at this system. In this system, most of the airports are using a special 'mobile lounge' which have a carrying capacity of 90 passenger. Aircraft are parked at a minimum distance to the terminal and with "mobile lounge" the walking distance can be minimized. This system is also provides protection from noise and fumes and loading at the same level. Open apron system used generally together with other systems which is called as hybrid concept. Aircraft stands located at remote areas from terminal are called as remote aprons or remote stands (fig. 4.4).

Parking system choice of aircraft is directly related with the method by which it will leave the aircraft stand; either under its own power (self maneuvering) or pushed out by tractor. Nose in, angled nose in, angled nose out and parallel parking are configurations. The different aircraft parking configurations are shown in fig.4.5. Nose in system necessitates pushed out operation which is costly (towing tractors and skilled operators are required), but preferred at high activity airports with minimum space requirements. Parallel parking is the best from passenger flow point of view. In this system, all the doors of the aircraft are at equal distances from the buildings, but space requirement of this system is higher than others and blast and noise are towards the adjacent gates. Adequate clearance of aircraft parking areas from other operational locations on the airport must be considered in order to assure efficiency in the use of the airport. While designing operating areas expansion of the area should be considered. The minimum clearances between any part of an aircraft and other aircraft or structures in the apron area are recommended by FAA and ICAO (2).

The aprons necessary at conventional airports and their design criteria will be mentioned below, additionally if general aviation and helicopter operations are excessive there is a need for separate apron and terminal building facilities for each of them.

In the terminal aprons if the passengers are not protected and the aircraft uses its own power to maneuver, the positive and negative effects of parking positions should be considered. The passenger connection, blast or noise created, loading door distance and turning with heavy load are all the factors effecting this situation. Slopes of terminal aprons should never exceed 2 percent for utility airports and 1 percent for transport airports, for ease of towing, for fueling and aircraft taxiing (2).

At master planning stage based on the estimations made for short, medium and long-term development scheme prepared. Number of aircraft stands are important in the sizing

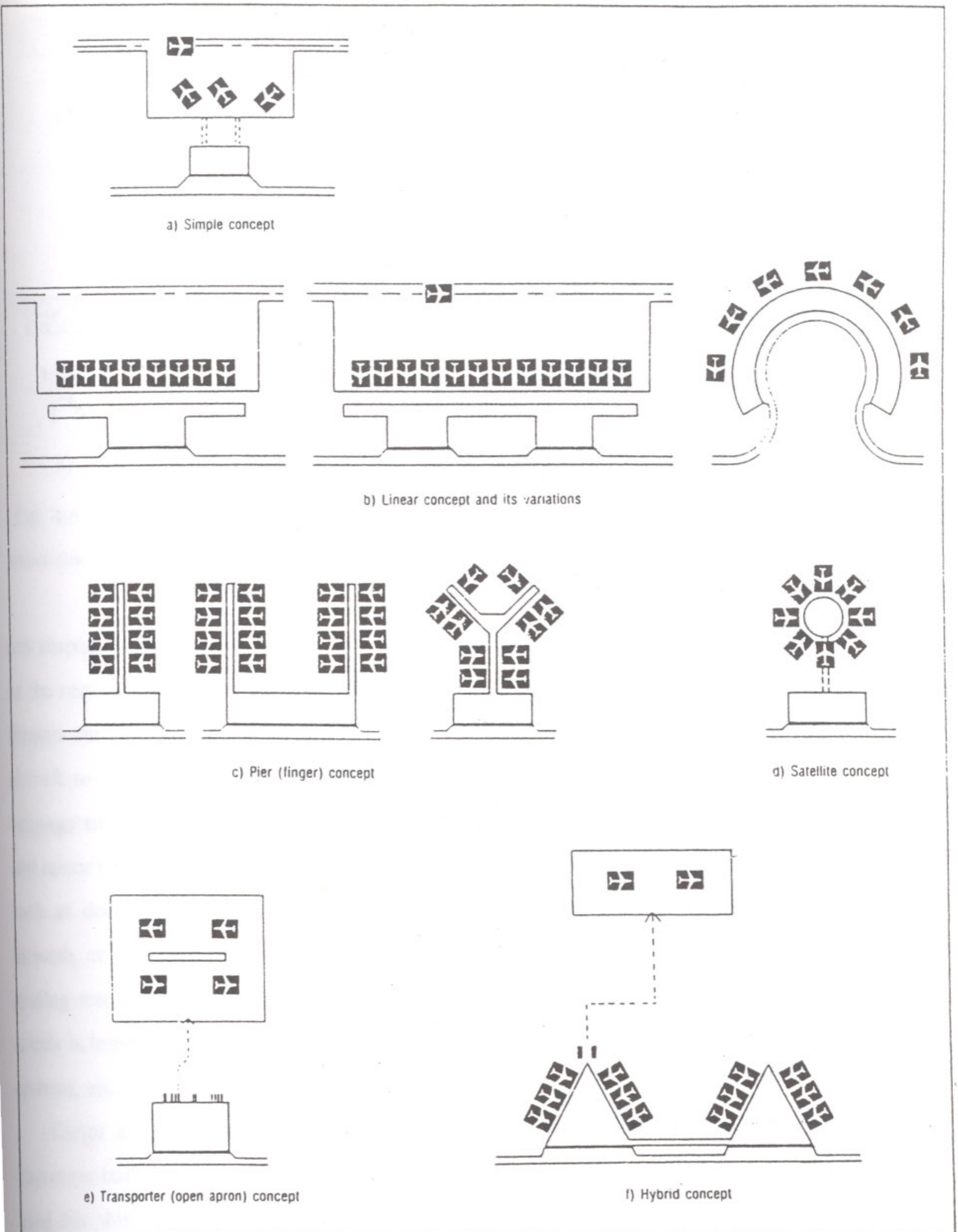


Fig. 4.4. Passenger terminal apron concepts

source: ICAO (10)

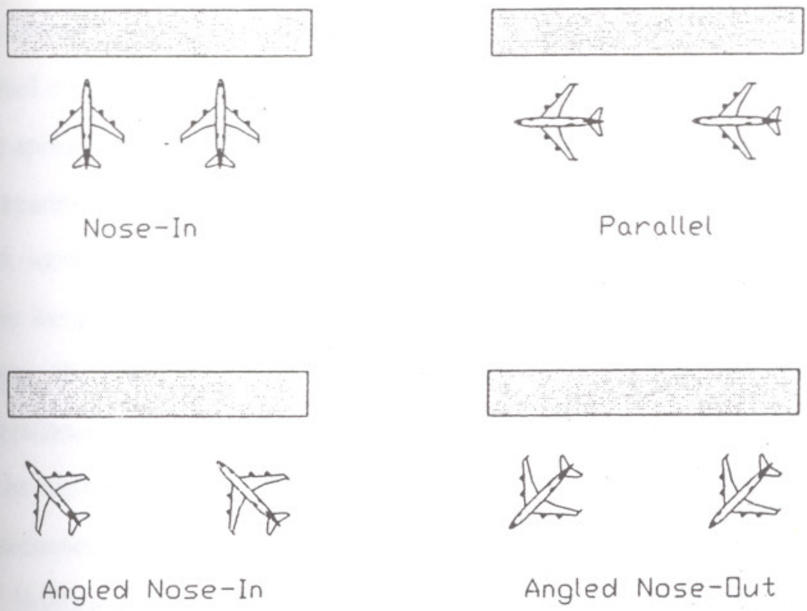


Fig. 4.5 Aircraft parking types

source: Horonjeff and McKelvey (2)

and shaping of apron and terminal building. In addition, seasonal peaks by tourists, etc., or the requirements for domestic and international passenger traffic, or for national and foreign carriers should be considered. "The gate occupancy time is the time for an aircraft to maneuver in and out of an aircraft stand and 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 and international, and station type such as originating/terminating, through, or transfer/transit stations"(10). When planning the apron layout the passenger loading method to be used must be taken into account. Categorization of aircraft using stands is important for fixed apron facilities such as passenger loading bridges, hydrant systems, etc..

Cargo aprons are located near the cargo building and at some distance from passenger building. If the cargo operations are small, passenger building apron should be used for this aim, as being far from any passenger activity in order not to create intermingling cargo and passenger traffic. In recent years parallel to the increase of air cargo traffic, many airports have all cargo aircraft operations. The need for a cargo apron based on air cargo forecast. Generally all cargo aircraft parked either parallel or nose-in but it depends on the volume and type of cargo handling system.

If aircraft should remain at an airport six to eight hours overnight, a parking apron may be justified. Parking aprons at airports with air cargo or air carrier service, should be located close to the loading position with the safe distance from maneuvering aircraft. This apron is also used for servicing and light maintenance purposes. These areas should be separate so as not to interfere with the air-cargo and air-carrier activities.

A service apron is used for performing light services to aircraft and located near repair hangar and hangar apron is an area from which aircraft move into and out of the hangar. We can categorize maintenance activities such as; line maintenance, air frame maintenance, power plant maintenance, and component maintenance. Line maintenance can be carried out on terminal apron and it is not necessary for all airports to provide all maintenance facilities.

Holding aprons, holding bays, holding pads, run-up or warm-up pads as they are mostly called are necessary at or very near the ends of runways for piston aircraft to make final checks prior to takeoff and for all types of aircraft to await takeoff clearance. (2) (fig.4.6). When a delay occurred because of weather conditions or an aircraft becomes unable to take off because of some malfunction, holding bays are useful for providing by passing of another aircraft. Holding bays should accommodate two to four aircraft and connection to the runway should be less than 90 degree. A by pass taxiway parallel to the taxiway sometimes be an alternative to holding bays.

Some accommodations should be provided at aprons. In normal stay, aircraft necessitates minor repairs, services and supplies. For this purpose accommodations may be necessary adjacent to the aircraft stands for storing equipment and for aircraft servicing personnel. Apron vehicles are also necessitates connection with these services, and therefore be considered in conjunction with the planning of apron equipment and vehicle parks and air side road systems. A motor vehicle fuel station and fresh water supply points are necessary. They should be located not farther than necessary from aircraft stands. At busy movement periods, tanker vehicles serve for aircraft sewage disposal and water supply for ease. Aircraft guidance system on aircraft stands for safe maneuvering of aircraft on the stand and positioning of aircraft is necessary. Apron markings and at some airports additional inset pavement lights are used for this purpose. Fixed aircraft servicing installations reduce apron congestion by providing less service times. They are; hydrant fueling, fixed ground power, potable/non-potable water supply, compress air and air conditioning. For hydrant fueling system; a large volume of traffic is

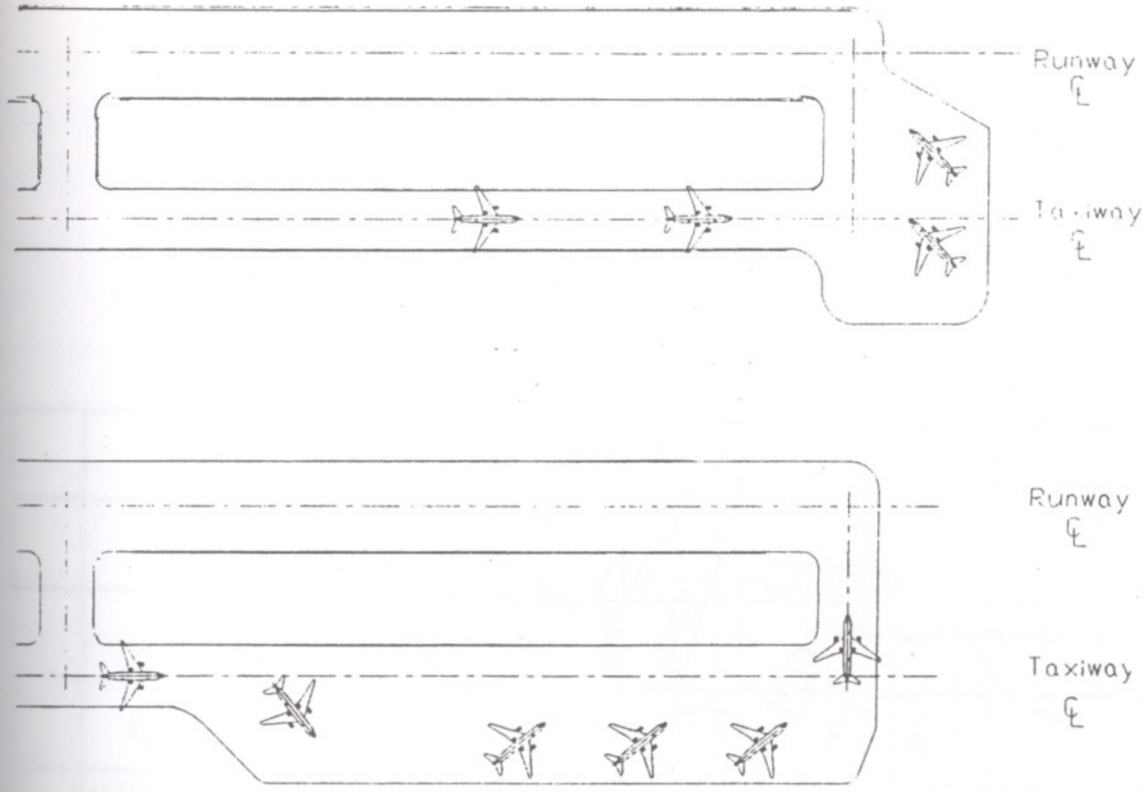


Fig. 4.6. Typical holding pad configurations

source: Horonjeff and McKelvey (2)

necessary for being economically justifiable, but this is not so for fixed water supply. "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 neighboring communities, particularly at night. Thus a decision to install any fixed servicing system requires both economic and environmental justification"(10) (fig. 4.7). Provision of apron service roads directly related with service areas and with minimum interference with maneuvering aircraft and terminal functions is important. In addition to service roads it is necessary to provide enough space for ground servicing equipment on the apron.

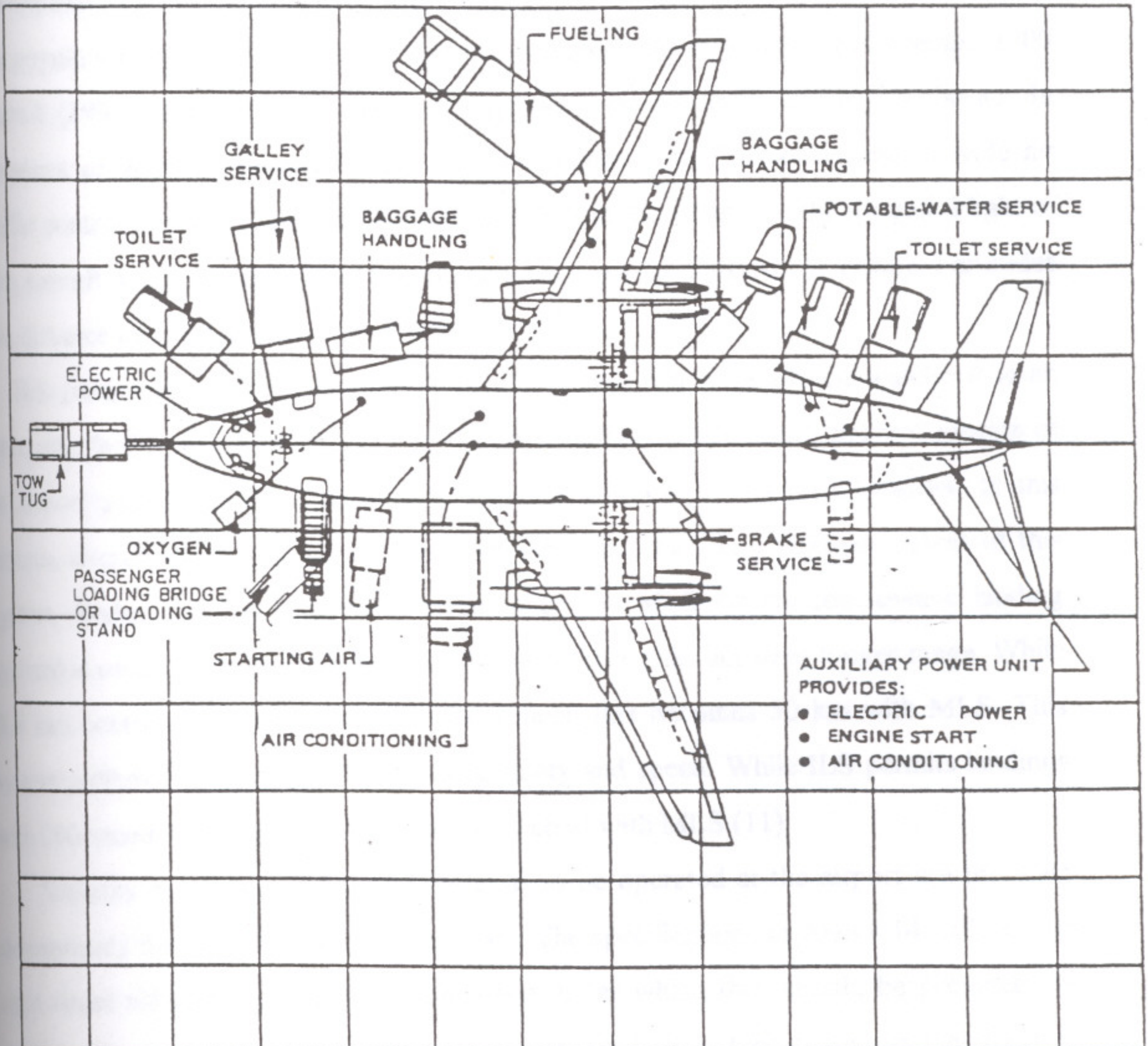


Fig. 4.7 Typical ground equipment service layout

source: ICAO (10)

4.1.3. Navigational and Air Traffic Control Aids

Airports should have air traffic control systems for controlling aircraft on the surface of airport and for refering them during their flight in the vicinity of airport.

At Atatürk Airport, number of aircraft movements in peak day in 1996 is 729, this means that in less than every two minutes (average) an aircraft takeoff or land. When we thought all the airports, this number will at least twofold in Turkey. We should add the overflights in order to understand the traffic in the airchannels. Of course these numbers are not important when compared with the worldwide bussiest airports. In France, where the population is nearer to Turkey, it was calculated that in normal days average 2700 aircraft (1993) and in bussiest days average 6000 aircraft were cruising in the air. In airspaces of airports, this traffic becomes more intensive. Control towers provide air traffic control in order to prevent aircraft accidents in the air and on the ground. Flight of two aircraft at the same altitude nearer than 7 km was prohibited. At different altitudes this distance become minimum 600 metres.

ILS (instrument landing system) is an old system which have used widely. It is an electronic facility which provides three-dimensional information about the final portion of an airport approach, to permit an aircraft to land safely in inclement weather. In this system, aircraft must wait 10 km apart for landings which is a negative aspect of this system. Today at large airports generally the new MLS system (microwave landing system) is used. This system work with the same principles but have longer range. While ILS can control 30 km farther from the airport, this becomes 50 km with MLS. This system preferred because of its increasing safety and speed. While ILS permits landings with 200 second intervals, this becomes 90 second with MLS (11).

Visibility conditions and type of aircraft to be operated at the airport are the main determinants for the selection of visual aids. The specifications in Annex 14 indicate for each visual aid and the operating conditions under which they should be provided. In general, approach and runway lighting aids are related to the type of runway whether it is planned for non-instrument, instrument approach or precision approach category I, II or III so it should be decided beforehand for planning visual aids. At the initial planning process, the type of visual aids for initial and future requirements should be determined and during initial construction process more than adequate duct capacity should be provided.

Most modern airports have all or some of the navigational aids such as ILS (Instrument Landing Systems), VOR (VHF Omni-directional Radio Ranges), DME (Distance Measuring Equipment Facilities generally co-located with VOR or ILS, VORTAC (Co-located Tactical Air Navigation Systems and VOR) and radars (approach, secondary and surveillance type). After the determination of the types of navigational aids needed at the airport , at the site selection stage the assistance of the individual expert associated with the aid is necessary. Site clearing and grading is necessary if the site is not flat. If the selected site isn't ideal, the choice of most economical configuration of required navigational aid can be determined by means of a flight check. By means of numerous navigational aids and rapid developments in electronic technology it is not easy to specify the exact sizes of buildings. Some parts of the ILS are usually outside the airport but the control and power are usually provided from the airport. Although ILS is usually planned for bad weather conditions, fair weather use is common, so some runways have planned with ILS at both ends. The properties of terrain such as slope is important because the reflectiveness affect the radio signals. When planning buildings for radio navigation aids; size, power supply, drainage, access roads and safety are important factors which should be taken into account.

Air traffic services vary according to the plans developed by the appropriate air traffic services authority prepared for air traffic services organization, but the minimum requirement for all airports is an airport control tower to accommodate a unit providing airport control service and a reporting office. Reporting office is not necessarily be a separate unit. At airports where ILS system is used there is a need for an approach control office and it is generally located in control tower. An area control center or a flight information center is also needed at some airports. It is important to determine the requirements at the early stages of planning and expandability should be taken into account.

Effective airport control service primarily requires a clear and unobstructed view of entire movement area of airport and the air traffic in the vicinity of airport. Therefore, location and height of airport control tower is important in order to have a clear visibility of aprons, taxiways, runways, and airspace especially the approach and departure areas. There is need to avoid sun glare in control towers. Cable requirements should be considered. In control rooms; provision of space for control desks and associated devices and personnel is necessary. Equipment rooms, office space and rest facilities take place underneath the control room. Special-lighting, noise protection, air conditioning and special accommodation of sensitive equipment should be considered

Approach control office should be located close to the control tower room, if it's a separate entity. Area control Center or flight information center if required should be close to airport control tower room and the approach control office. If air traffic services reporting office is required as a separate unit, it should be located closer to other briefing or reporting offices, such as meteorological briefing office, aeronautical information services unit, etc. It should be easily accessible to flight crews of arriving and departing aircraft and to flight operations officers of airlines.

Other services may be necessary at airports such as a rescue co-ordination center which located close to the area control or flight information center or a rescue sub-center located close to an appropriate air traffic services unit. If there is a complexity in aircraft and vehicle movements on the aprons there would be a need for apron controllers with clear visual sight lines to all parts of apron areas under their control. Communications can be provided by fixed and mobile services at an airport. Telecommunications are required to many parts of an airport. The communications center installation is relatively inflexible once it is established, so in siting it is necessary to avoid restricting the expansion of other facilities. In many cases it may not be possible to site transmitter and receiver buildings within the airport boundaries but they should be considered as part of the airport installation, as far as control and operational aspects are concerned.

4.1.4. Aircraft Characteristics Related to Airport Planning

A general knowledge of aircraft is necessary in planning facilities for their use. Passenger capacities of aircraft used in airline operations ranges from nearly 10 to 1000. There is a variety of aircraft which have different characteristics such as size, weight, capacity, and which necessitates different runway lengths. The weight and size of the aircraft directly affect the sizes of runway, taxiway and aprons, their pavement thicknesses and also the takeoff and landing runway length requirements. The wingspan and the fuselage length is important for the determination of apron sizes, width of runways and taxiways and distances between them, capacity of traffic affects the facilities within and adjacent to the passenger building so effective in terminal configuration and the area need for an airport.

It is not valid to assume that the larger the weight of an aircraft, the longer the runway length required. For large aircraft, especially, the trip length directly influence the takeoff weight and hence runway length requirements. Estimation of trip length is important in the analysis of runway length requirements. Runway length is important for the determination of land area requirements of an airport. In order to provide safety in aircraft operation; loading characteristics of aircraft and the load bearing properties of the airport pavement are also important factors. The greatest length required aircraft, should be taken into account while planning airport runways. This shouldn't be forgotten that the technological developments related to aircraft; airframe, wing, and engine makes it possible to fly greater distances with greater weights at reduced runway lengths (2).

As mentioned above aircraft characteristics have great influence on the design of airports, especially on runway lengths. The factors affecting runway length may be grouped into three general categories such as requirements imposed by the government, environment at the airport, and the operating take-off and landing gross weights of each aircraft type. Runway length influenced by some conditions at the airport such as temperature, surface wind, runway slope, altitude of the airport, and condition of the runway surface. The runway length requirement depends on several factors and computation of length at "A" is based upon the flight from "A" to "B". At a particular airport site, runway length based upon the regular longest nonstop flight of aircraft. Determination of the operating empty weight, payload, fuel reserve, take off and landing weight and the other factors such as temperature, surface wind, slope and altitude, etc., necessary for determining the requirement.. The aircraft manufacturers publish runway length diagrams for the required takeoff and landing runway for each aircraft, for planning purposes.

Engine technologies are expected to reduce fuel consumption and from piston engine to turbojet and now ultrahigh bypass-ratio (UHB) turbofan engines, there is a rapid improvement in this technology. We can see an increase not only in the speed of aircraft but also in the weight and size. Demand for travel is the principal factor for this growth but airport facilities may be a limiting factor. The heavier an aircraft, the longer it is and the greater its wingspan. The average productivity is the product of the average load and the cruising speed and while the average productivity of a DC-3 introduced in 1935, is 350 ton-miles/h it reaches 38500 ton-miles/h for the 747 introduced in 1969, and this means that in a little less than 40 years productivity has been over 100 fold.

Payload is the revenue-producing lift capability of transport aircraft and it has grown enormously over four decades. Since the piston engine transports of the middle and late 1950's, the growth in payload was gradual until the introduction of the wide-bodied aircraft in the late 1960s and 1970s, when a very large jump took place. The range is the distance that aircraft can fly without refueling and it has also greatly increased since the introduction of DC-3. Today there are several aircraft making possible nonstop flights from the west coast of the US to Europe or the Far East or from Europe to Africa (2).

Fuel costs and variations in these costs have resulted in significant changes in the operating economics of aircraft, so extensive research has been undertaken to investigate the impact of such technological factors such as drag reduction, engine efficiency, structural weight changes etc. on operating costs.

Since one of the most serious problems facing aviation is noise, there is an effort to reduce engine noise. In an engine the major sources of noise are the machinery noise and the primary jet noise. When the high-velocity exhaust gas from the engine mixed with the ambient air the primary jet noise generated. While the primary jet noise is dominant in takeoffs, machinery noise is dominant in landings (fig. 4.8).

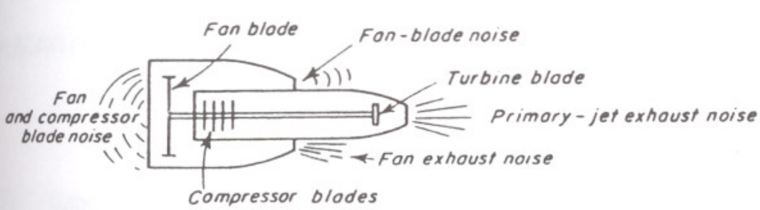


Fig. 4.8 Sources of noise in jet engines

source: Horonjeff and McKelvey (2)

The range of an aircraft is the distance it can fly. One of the most important factors effecting the range of an aircraft is the payload which refers to the total revenue-producing load, such as passengers and their baggage, mail, express, and cargo. There is an indirect relation among range and payload as payload decreases the range increases. Payload-versus-range diagrams are published by manufacturers for airport planning purposes which are useful for determining the probable weight characteristics of aircraft flying particular stage lengths between airports.

The motion of an aircraft during a 180 degree turn is important for planning purposes. For determining aircraft positions on terminal apron or the paths in the airport, it is necessary to understand the geometry of movement of an aircraft. Turning radii are the function of the nose gear steering angle and the larger the angle the smaller the radii. From the center of rotation, the distances to various parts of aircraft such as nose or tail create a number of radii. The largest radius is important for the clearances to buildings or adjacent aircraft. It was graphically shown in fig. 4.9.

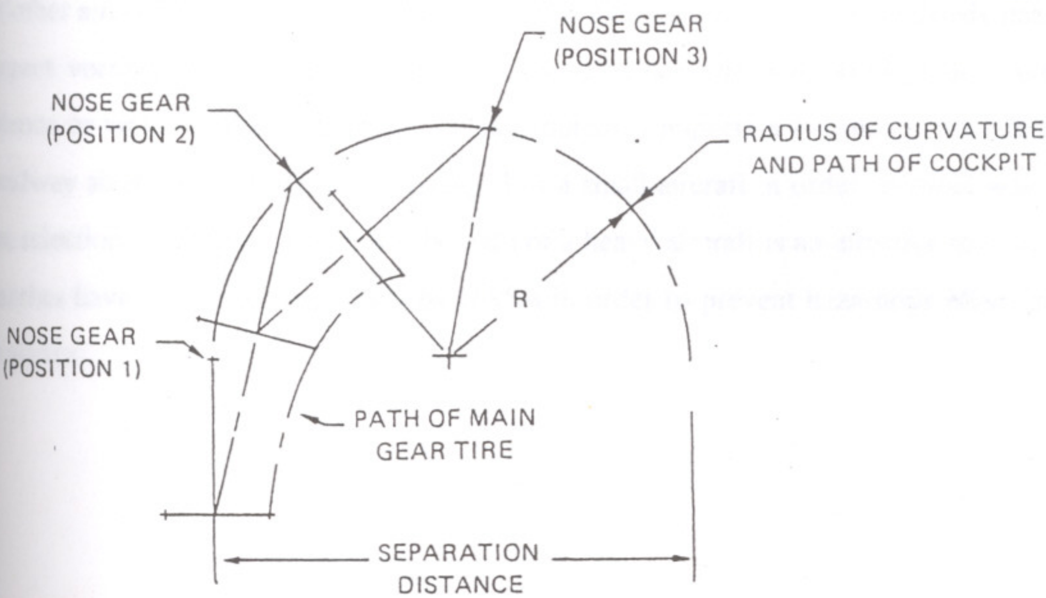


Fig. 4.9. Graphical solution of a 180° turn

source: ICAO (10)

> "The minimum turning radius corresponds to the maximum nose gear steering angle specified by the aircraft manufacturer. The maximum angles vary from 60' to 80'. The center of rotation can be easily determined by drawing a line through the axis of the nose gear at whatever steering angle is desired. The intersection of this line with a line drawn through the axes of the two main gears is the center of rotation. For aircraft with more than two main gears, such as the Boeing 747, the axis is drawn midway between the gears"(2).

Some newer large aircraft have the capability of swiveling the main gear when making sharp turns in order to reduce turning radius. Using minimum turning radius is not practical because the maneuver cause excessive tire wear and sometimes harmful to the pavement surface, so lesser angles on the order of 50 degree are more proper.

The load distribution between the main gears and the nose gear depends on the type of the aircraft and the location of its center of gravity. It is normally assumed that 5 % of the weight is supported on the nose gear and the remainder on the main gears, for the pavement design purpose.

Whenever the wings lift an aircraft, near the ends of the wings vortices appear. Vortices formed by two counterrotating cylindrical air masses about a wingspan apart, and extend along the flight path behind the aircraft. Vortices are important because, they affect other aircraft and their flight paths (fig.4.10). While an aircraft is flying slowly near an airport vortices become intense and they create winds which referred to as wake turbulence or wake vortex. The wake vortex problem is important because of its effect on headway sizes and then runway capacity. For a small aircraft in order to avoid wake vortex selection of a flight path above the path of a heavy aircraft is an effective method. Researches have been made especially by NASA in order to prevent hazardous effect of wake vortex.

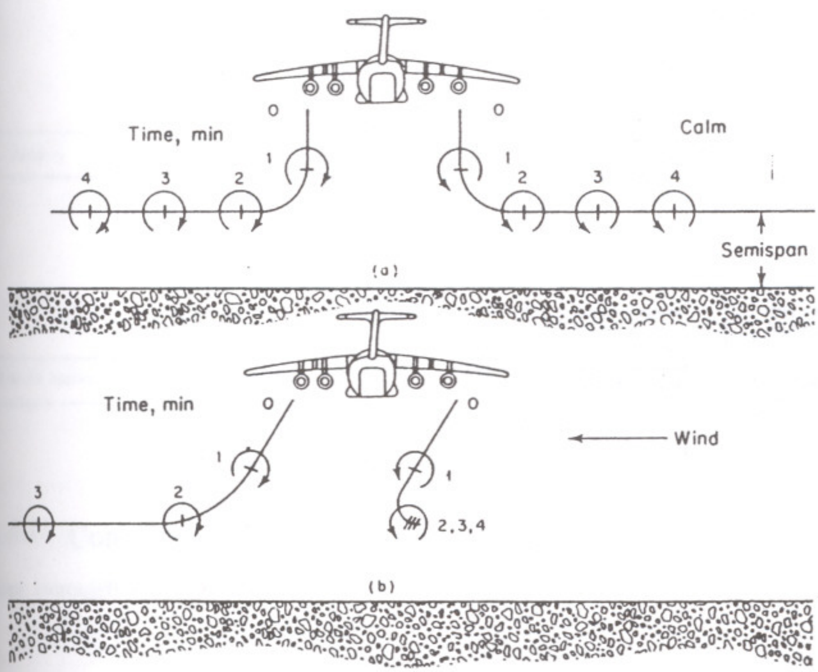


Fig. 4.10 Vortex movement near the ground showing the effect of wind.
Source. Horonjeff and Mc Kelvey (2)

4.1.5. Terminal Building

"An airport functions as a transfer point between air vehicles and ground vehicles. There are numerous types of air vehicles designed for various functions"(9). The ground vehicles are in many forms. Motor vehicles utilized as passenger cars, trucks; etc., rapid transit systems and also special loading vehicles for supplementary transfer within the airport. The transfer point is generally a building structure or structures we called as passenger terminal.

We can categorized, terminal building activities into three main groups, such as, passenger processing and servicing, cargo handling and processing and aircraft servicing. We can see each of the important functions and their interrelationships in fig. 4.11. In the design, natural movement and servicing patterns of each is important in order to minimize passenger walking distances, airline servicing and processing times, and congestion caused by intermingling of nonrelated activities.

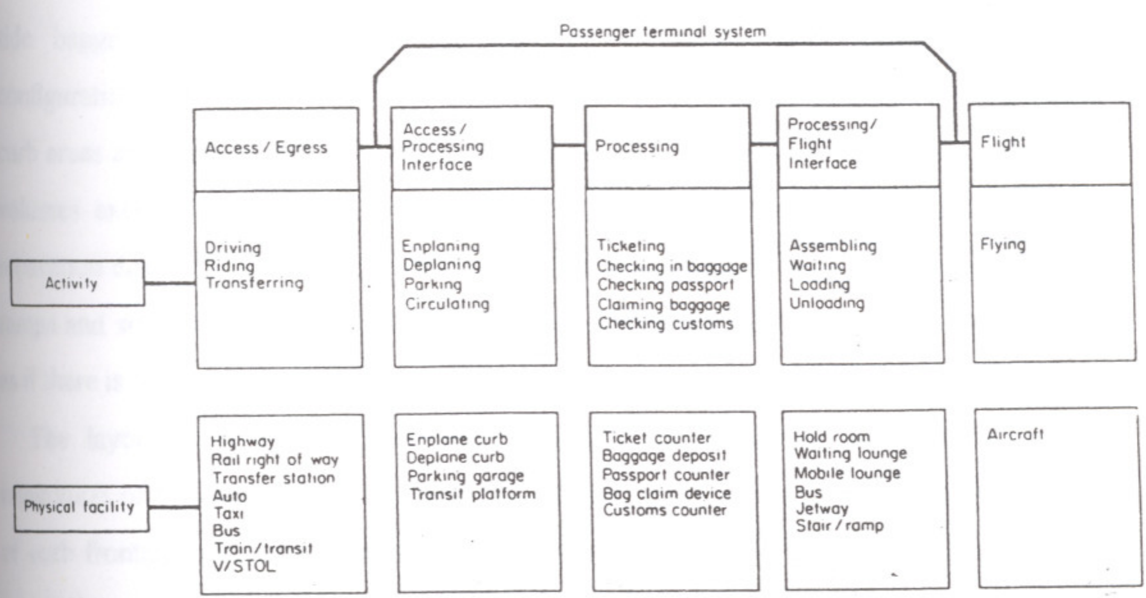


Fig. 4.11 Components of the passenger terminal system

source: Horonjeff and McKelvey (2)

The passenger terminal system provides the interface between the airport access mode and aircraft. It has three major components such as; access interface, processing, and flight interface.

- The access interface provides passage from access mode to processing component by means of circulation, parking, and curbside activities.
- Processing component provides passenger preparation for a starting, ending or continuing trip with activities such as; ticketing, baggage check-in, baggage claim, seat assignment, inspection services, and security.
- The flight interface provides passage from the processing component to the aircraft by means of assembly, conveyance to and from aircraft, and aircraft loading and unloading activities (2).

4.1.5.1. Access Interface

Passenger building connection with access system is an important part of airport system and composed by; vehicular traffic lanes, through lanes, by-pass lanes, and curb/maneuvering lanes, and also pedestrian crossings, signs, sidewalk platform, curb side baggage check-in points, and building openings. The passenger building configuration greatly influenced by the curb lengths and vehicular traffic lanes. Vehicular curb areas are required for efficient loading of baggages of passengers. When passenger volumes exceed one million enplanements and when physical limitations make curb separation desirable, multilevel curb construction considered at multilevel terminals with ramps and structural roads. They are costly constructions so they should be considered as if there is no single level alternative.

The layout and types of terminal concepts are important in determining the integration of the components to form the ground transportation access system. Design of curb frontage and road system to it is important, in order not to cause confusion, congestion, or being flight missing for passengers and insecure for pedestrians. Separation of enplaning and deplaning road system is a practice but generally pedestrian cross couldn't be eliminated. All forms of vehicular movements; private vehicles, rental cars, taxis, valet-driven cars, busses, etc., should be considered at the design stage.

The numbers, average size and characteristics of vehicles, average time requirements for vehicles, peak period requirements, etc., can help to determine the curb length requirement. Public transport systems may influence individual car usage. The distribution of passengers by travel modes and the numbers and types of vehicles can be determined by economic and operational forecasts. While waiting period of vehicles depend on several factors, many airport authorities have found that a waiting period of three minutes for cars is sufficient for unloading. Curb space is utilized by buses, private cars, taxis, etc. Curb maneuvering lanes are provided for loading and unloading passengers and their bags and should only be used for this aim, not for waiting. Each vehicle should occupy this space as the total time it takes for loading and unloading and maneuvering, which is named as "dwell time / vehicle".

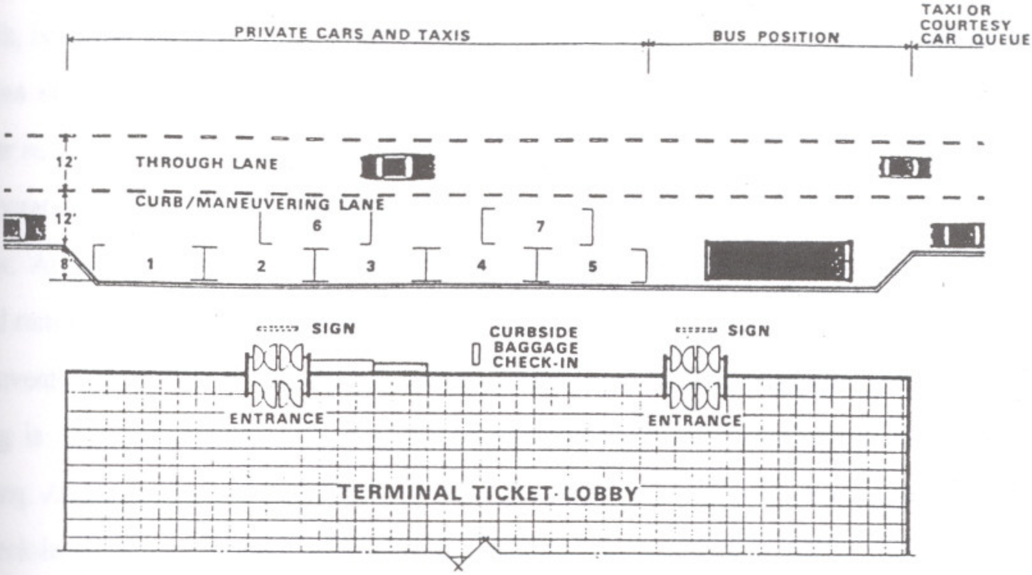
The width of curb lane should be approximately 1.6 of a regular traffic lane. Required curb length can be determined by the impact of some factors such as; design hour enplaning, deplaning passengers, transfer passenger percentage, modal preference by vehicular type, percentage of passengers who go directly to parking area without using curb system, passenger / visitor ratio, percentage of private car users, occupants per vehicle, etc. Calculated curb length should be related to terminal layouts for both enplaning and deplaning (fig.4.12).

In passenger building planning, the shape and size for vehicle unloading and number of vehicles to be accommodated is important factors. The unloading area should be on the same level with the passenger departure floor and a direct flow should be provided to the first processing area in the passenger building. Entrances and exits, of passenger buildings should be considered as potential vehicular traffic accumulation points so number and and location of terminal openings and the terminal functions with which they connect are important.

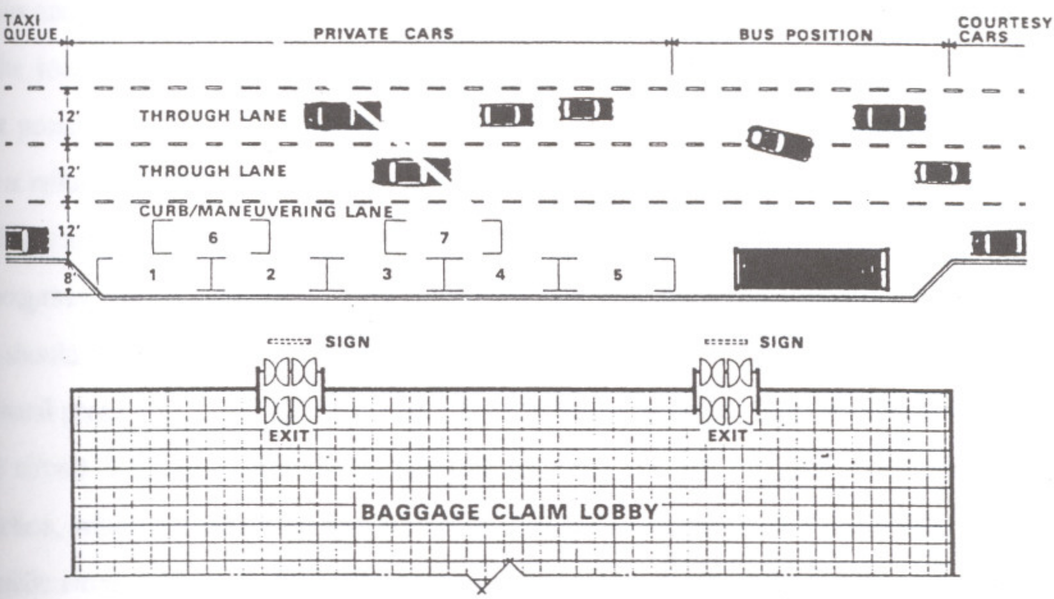
4.1.5.2. Processing

We can divide processing activity in passenger buildings into two, such as passenger processing and baggage processing. Entryways and foyers, check-in concourse, public lobby areas and security inspection stations are all elements of passenger processing system.

First areas of processing for deplaning passengers are entryways and foyers. They are located along the curb element and their size depend upon their intended use. Entrances and exits with their relatively small size considered carefully in order to provide sheltered public waiting areas with facilities to disabled and to meet peak hour demand.



Enplaning Curb



Deplaning Curb

Fig.4.12 Terminal curb areas

source : J.de Chiara and J. Callender (9)

In check-in concourse, although baggage check-in is the primary activity a number of related activities such as aircraft operators' ticket sales, stand-by passenger registrations, aircraft operators' information and currency exchange facilities may take place there. Mostly, ticket counter areas are leased by an airline so the planning, design, and sizing of these areas should be closely coordinated with individual airlines.

Different ticket counter or check-in counter configurations such as linear, flow through, island are in general use. Airline ticket counter should be in relation with office activities such as accounting and safekeeping of receipts, communications, personnel area for rest, agent supervision,etc.. At low activity locations all company administrative and operational functions, including outbound baggage may be provided at the ticket counter. At high activity locations, ticket counter and airline support activities may be located remotely.

Conventional check-in system of manual ticket control and baggage weighing and labeling is changing today with the use of computer and the elimination of baggage weighing. All these changes have influence on planning with different space requirements for check-in positions. The time required to process one passenger and the rate of flow to the check-in positions can be determined in consultation with aircraft operators and necessary for determining the number of check-in positions. Landside vehicle unloading positions and building entrances should be related with check-in positions.

The location of check-in facilities should provide passengers to check-in at the earliest possible moment and relieve their baggage at the earliest opportunity and the layout is influenced by two considerations; providing minimum distance to the airside and providing a straight forward connection of parallel flows to the airside across the check-in concourses. While designing, long continuos lines of check-in positions with right angles should be avoided.

Visual presentation of flight information with flight indicator boards or by means of closed circuit TV, etc., should be located so they should be seen without visual obstruction, without obstructing the flows and from all principal parts of complex.

Public circulation and access for passenger ticketing, waiting, concession areas and other passenger services and baggage claim provided by lobbies in terminal buildings.

The ticketing lobby should be arranged in a way that provides easy access and clear visibility to the individual airline ticket counters upon entering the building circulation pattern, and provision of adequate queuing space in front of counters is important.

Minimum 4-5 m queuing space and 12 to 15 m lobby depth in front of counter is required.

Waiting lobby is a centralized waiting area which provides public seating and access to amenities. Adequate number of seating should be provided. Visitor-passenger ratios can be determined by means of local surveys or with the assumption of one visitor per peak hour originating passenger.

Baggage Claim Lobby provides public circulation space for access to baggage claim facilities and connection with deplaning curb and ground transportation and also involves certain amenities such as car rental counters, telephones, etc.

Departure lounge (gate lounge) is a waiting or holding area for passengers immediately prior to boarding an aircraft and generally controlled by individual airlines. It includes space for ticket collections, baggage check-in, seating and waiting area, queuing area for aircraft boarding, and a separate corridor for aircraft deplaning. The deplaning area is a roped aisle or separate corridor directly leading passengers to a public corridor which should be separated from the rest of departure lounge.

There are three types of passenger inspection stations depending on the location of the station in relation to the aircraft boarding area, which are Boarding Gate Station, Holding Area Station and Sterile Concourse Station. It is generally located in a concourse or corridor leading to piers or satellite terminal. In linear and transporter terminal systems this is not a feasible method and several inspection stations required to control a number of holding areas or departure lounges. At low activity areas manual search may be employed and security inspection station include a minimum of one walk-through weapons detector and one x-ray device. Such a station requires 9-14 sqm area and have a capability of inspecting 500 to 600 persons per hour. The space which is leading to security inspection station should be large enough for not to interrupt circulation because of queuing people.

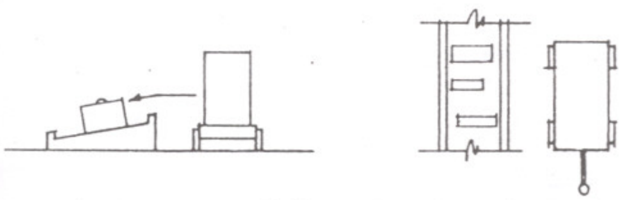
Baggage handling systems and outbound baggage facilities are elements of baggage processing system. Average baggages handled by airlines ranges from 1.6 to 1.9 bags per passenger. This is not exact and it changes due to stage lengths of airlines. Longer stage lengths causes greater number of bags than an airline with a route structure based upon short stage lengths. Therefore, a complete understanding of airline operations related to the time schedule and peak conditions is necessary for providing appropriate space for a baggage handling system.

Check-in points may be located at the central ticketing counter, at the gate lounge, at the curbside and in the parking lot in a system. The last two location provides quicker and more convenient acceptance of baggage and prevents congestion in the terminal area. Simple conveyors and/or gravity chutes can be used in this system. In large terminals fully automated cars or pallets should be used (fig.4.13). The transferred baggage is processed at the same area with the originating and terminating baggage therefore, enough space should be provided for this aim and expandability should be considered.

Baggage system is two directional. Originating passengers arrive airport over an extended period of time but terminating passengers may create a peak condition, as they arrive at the same time and expect to claim their baggage in a short time. As the larger aircraft become utilized in greater numbers this causes peaking conditions and necessity of decentralization of the baggage claim systems occur. Baggage claim devices should be manual or mechanical and in many forms. The basic aim is to provide maximum frontage so that passengers can easily identify and reach their baggage.

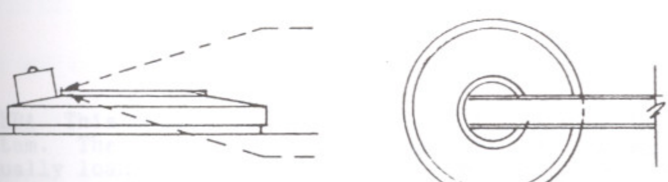
Transferring the baggage with automated systems to the building is technically feasible and a faster method. In baggage rooms, sprinkler system must be provided and careful fire cutoff must be made between terminal proper and baggage areas. Outside doors are important in baggage rooms and automation provides rapidity. Future expansion should be kept in mind. Enplaning baggage received from three points; curbside check-in, counter check-in and gate check-in. There is also transfer baggage which should be kept in mind. Deplaning baggage claim area need differs according to many factors; such as if all airlines use the same area or separate claim areas, number of passengers and amount of baggage that will be claimed within the peak condition, the type, size, capacity and frontage size of the device. The security and operation desires of airline or authority is important, so there is no exact measure for baggage claiming areas. With all the information above the decision made by the designer. Another important factor is the need for queuing space between claim device and customs inspection system for international arrivals.

"The outbound baggage facility is that area where baggage is received by mechanical conveyor from the ticket counters, online and off-line connecting flights, and curb-side check-in. It is sorted and loaded into containers or carts for subsequent delivery to aircraft. At low volume airports, bags may be manually moved through a wall

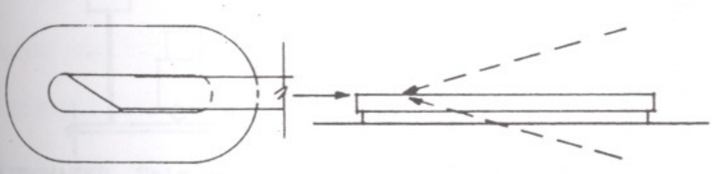


(a) The baggage is transported from the aircraft to the claiming device by a cart and is then off-loaded manually by an attendent.

(b) DIVERTER In this system the baggage is placed on a conveyor at one end. A diverter moves back and forth along the conveyor and disperses the baggage onto the claiming device.



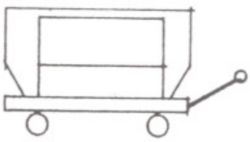
(c) CAROUSEL A conveyor, from underneath or from above, delivers the baggage to a rotating carousel.

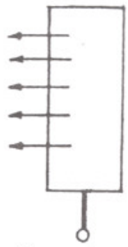


(d) RACE TRACK A conveyor from underneath or from above, delivers the baggage to a continuously circulating conveyor, the length of which will depend upon the terminal layout.

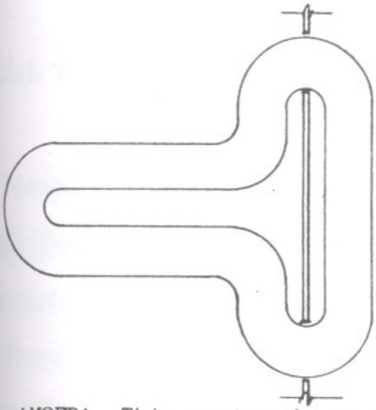
Fig. 4.13 Baggage claim systems

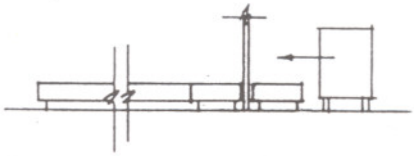
source: J.de Chiara and J. Callender (9)



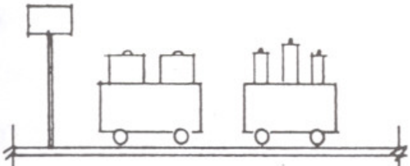


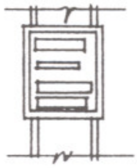
(e) POD The baggage pod is removed from the aircraft and delivered to the claim area. The passengers remove their baggage from the pod.





(f) AMOEBA This system is an extension of the race track system. The only difference being that the baggage is manually loaded directly onto the conveyor by an attendant behind a wall and out of view from the passengers.





(g) AUTOMATED This system consists of carts that are operated by a computer system. The passenger inserts his claim ticket into a call box at a desired location, the cart then delivers the baggage at that location.

Fig. 4.13 (cont.) Baggage claim systems

source: J.de Chiara and J. Callender (9)

opening"(9). Baggage processing equipment and conveyors should be provided by airlines. Outbound baggage should be in close proximity to ticket counters for providing ease in baggage movement and should be in direct relation with aircraft parking apron. For optimal use of personnel, space and equipment it should be suitable to handle all baggage at the same area. Security is an important factor.

Belt conveyors are the most common mechanized systems with average transport capacities of 26 to 50 bags per minute (fig.4.14). Inclined belts, vertical lift devices or chutes are used in multi level systems. Inclined belts necessitates more area while chutes may cause damaged bags although it is an inexpensive alternative. Vertical lift devices are preferable with capacities 18 to 45 bags per minute. Recirculating devices can be used when the number of departures processed exceeds the capabilities of raw belt and spill plate. Tilt-tray sorters are used for very high-volume stations. These are most common systems and the terminal design should allow the flexibility for future installation of different systems.

4.1.5.3. The Flight Interface

Aircraft Parking Systems and passenger loading methods are important determinants of the flight interface. Gate lounge which is a sterile area before boarding an aircraft is also part of the flight interface.

There are two type of operations for the displacement of aircraft on the aircraft apron. One is power-out which aircraft move with its own power, the other is push-out which aircraft was moved by the help of special vehicles. Power-out operation require greater apron area and they necessitate special design considerations with regard to the wall surfaces of terminal buildings. Blast protection should be considered in this system but fewer ground personnel and less equipment are required. Push-out operation requires less apron area but the use of expensive tractors and personnel to move the aircraft out of its gate position before it powers away from the terminal area.

Many systems have become available for passenger enplaning and deplaning. It changes according to the passenger volumes, economic considerations, and climatic conditions. Passengers walk up boarding stairs or along a passenger loading bridge, or conveying them in a transporter are all different methods of boarding. Second level

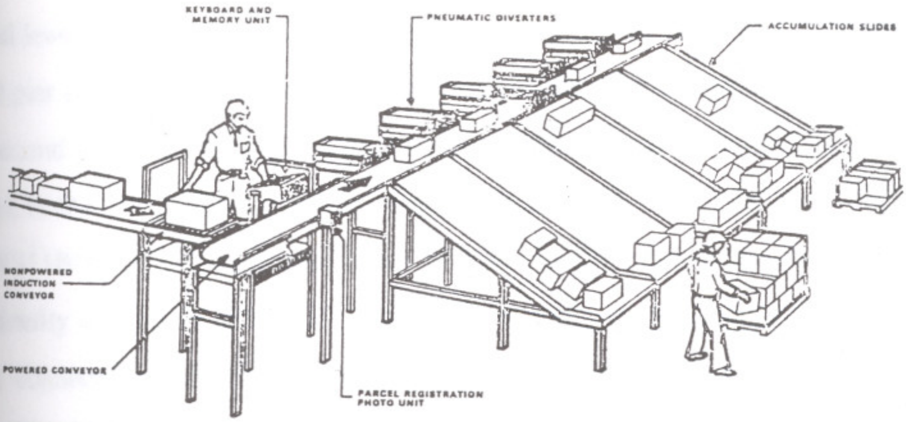


Fig. 4.14 Semiautomated linear belt sorter

source: J.de Chiara and J. Callender (9)

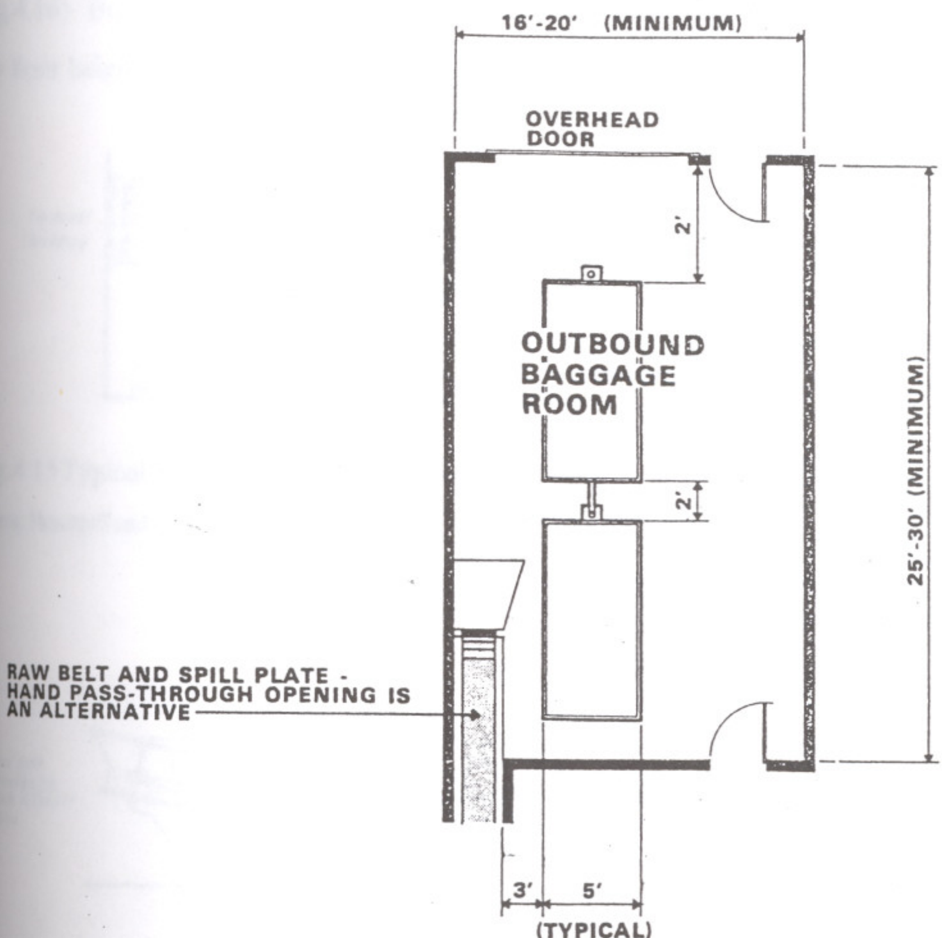


Fig.4.14 Outbound baggage room typical raw belt conveyor installation

source: J.de Chiara and J. Callender (9)

boarding and deplaning is preferable for its simplicity and efficiency at multilevel terminals. Sometimes at single level terminals because of severe weather conditions, second level boarding becomes necessary and this is provided by two storey connectors, raised pier structures or inclined loading bridges, etc. Sometimes a combination of apron and second level boarding gates may be desirable. "Integral aircraft stairs are used with aircraft in the 50-120 seat capacity range,such as B727, B737, DC-9, BAC111, CV580, and YS11B"(10). Whether integral or mobile the flow is one directional and the width and density of people effect the capacity of system. Passenger loading bridges provide faster connection and also protect passengers from weather, noise and fumes but they necessitate high traffic volumes because of their installation costs. Their size and form are important in order to provide flexibility to serve different types of aircraft (fig.4.15). Transporter vehicles may be used to serve aircraft at remote parking areas.It should be a bus in combination with stairs or a specifically designed vehicle with elevating capability (Fig.4.16). Buses are also designed specifically for this purpose with their large doors, low floor height, etc..

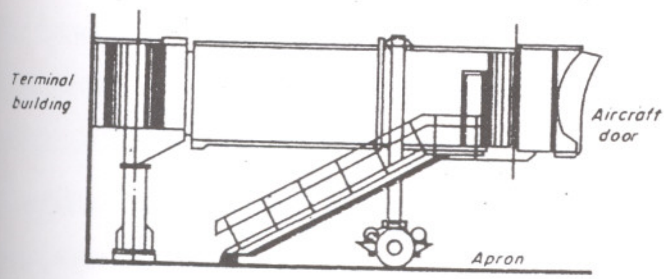


Fig.4.15 Typical aircraft loading bridges

source: Horonjeff and McKelvey (2)

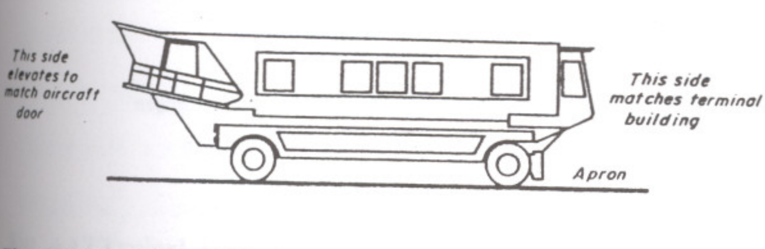


Fig. 4.16 Typical mobile lounge

source: Horonjeff and McKelvey (2)

The concept and functions of the gate lounge are basically standard throughout the airline industry and their functional requirements are a ticket counter, a secure or semisecure seating area, flight identification and last-minute baggage drop. It is also necessary to separate circulation patterns of enplaning and deplaning passengers. Gate lounge requirement changes for each aircraft type and according to the operation procedures and activity levels of airlines. Average gate lounge sizes required by each aircraft type which are approximate and for preliminary design purposes are as follows: 6 000 sq ft for B-747, 4 000 sq ft for L- 1011, DC-10, B2702, 3 500 sq ft for DC-8 and B-707, 2 000 sq ft for B-737 and B-727 and 1 500 sq ft for DC-9. Airlines' preferences related with ticket counter or seating area and type of loading bridge directly affects circulation pattern and the plan layout of the lounge (fig.4.17).

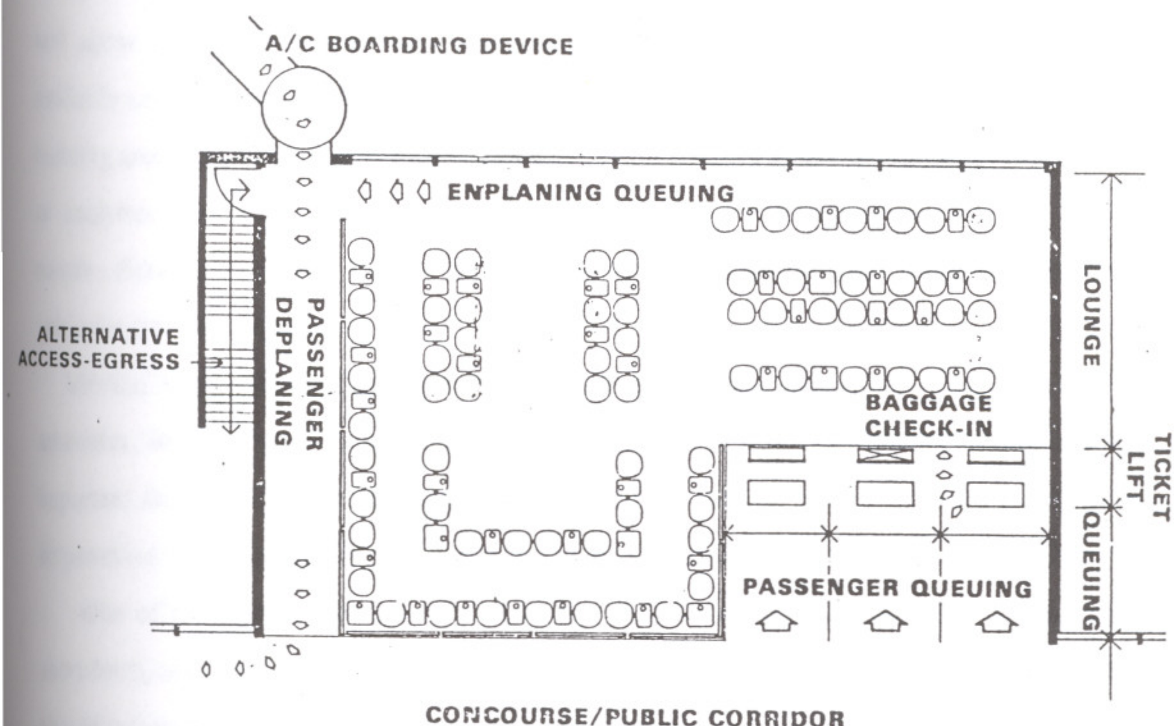


Fig. 4.17 Typical departure lounge layout

source: J.de Chiara and J. Callender (9)

4.1.5.4. General Design Considerations

For passenger buildings being closer to runways for more efficient and less costly aircraft operations; by minimizing taxiing distance, fuel consumption and time spend by aircraft for ground movement, is one of the primary considerations for locational choice.

Passenger buildings should provide a comfortable, convenient and speedy transition for passengers and baggage between two transport modes, with lowest cost and can provide future expansion without extensive modification.

Parking lots, public transportation systems, curb frontage, baggage claim areas, check-in areas, gate lounge areas, aircraft positions should have the capability of independent growth to meet the changing demands of the future, because improvements in aircraft technology and changes in the preestablished schedules may cause congestion at almost any point in the terminal system (9). Airports and terminal buildings based on traffic forecasts and guestimate of schedules developed from these forecasts. It would be wrong to design a structure with fixed parameters based on this information. For good design and economy flexibility should be maintained.

By means of computer maximum number of aircraft movements that air saturation will allow can be simulated and correlation of this with the maximum ground area available can be made. This data can serve as a guide for the master plan of the terminal building area. Role of specialists is important at this stage. Either by computer simulation or analytical methods "average peak hours" should be determined in order to create simple, direct and logical routes for all passengers, including their baggage and their vehicular transportation.

Method of operation of different airlines such as handling passengers, baggage, cargo, amenities, food service, ramp operations, maintenance, and their own personnel is an important determinant. Minimum space requirements related with the time frame should be provided. While providing these spaces, ICAO requirements should be established.

One of the basic concepts related to terminal building is parking lots. Long-term, short-term, and valet parking areas with different tariffs and parking areas for employees should be provided.

In developing the passenger terminal, the architect must recognize in the early phase of planning that: "The new wide-body type of aircraft carries vast amount of cargo. The economics of the new aircraft require that a sizable portion of its cargo-carrying capacity be utilized in the transportation of passengers"(9). Therefore the passenger terminal, must have the capacity to store cargo for loading into passenger aircraft. This is true for all types and sizes of passenger terminal and with the greater use of the wide-bodied aircraft, this is becoming standard practice.

Since the passenger terminal is the transfer point between land and air, geometry of the aircraft apron is important in order to be flexible for different sizes of aircraft, to provide space for ground equipment, the storage of cargo, and for different loading techniques for people from building to aircraft.

In small terminals secondary functions generally take place in the terminal buildings, such as, in-flight feeding, line-maintenance, and general office use.

While designing; the baggage carrying passenger should be considered and conveniences such as automated doors, wide escalators, moving sidewalks…etc., should be provided. The terminal must provide amenities for public such as banks, barbershops, duty free shops, car rental agencies, gift shops, restrooms, restaurant, telephones, television lounge, hotel, etc. Nursery facilities, medical and first-aid facilities should be provided. Fire safety is an important factor which should be considered at the design stage.

Engineering considerations are also important. Boiler plants, air conditioning, electrical distribution, communication systems, waste removal and maintenance areas are considered at the early stages of design and also every mechanical system should have an alternate or redundant system in order to guarantee the operation at the airport.

Careful attention must be given to directional and identification signs on roadways and in the passenger building complex in order to facilitate an orderly flow of passengers to their desired locations. There should be a simple and effective information system at the terminal buildings for guiding people there. Language is a problem. The ICAO document 8881-C/992, International Signs to Facilitate Passengers Using Airports, contains a set of signs which facilitates air travelers access to facilities and services such as; telephones, check-in counter, post offices, toilets, banks, etc..

We should know the activity systems in order to understand the operation of this building. The activity is divided into public and nonpublic functions (Fig.4.18-20)

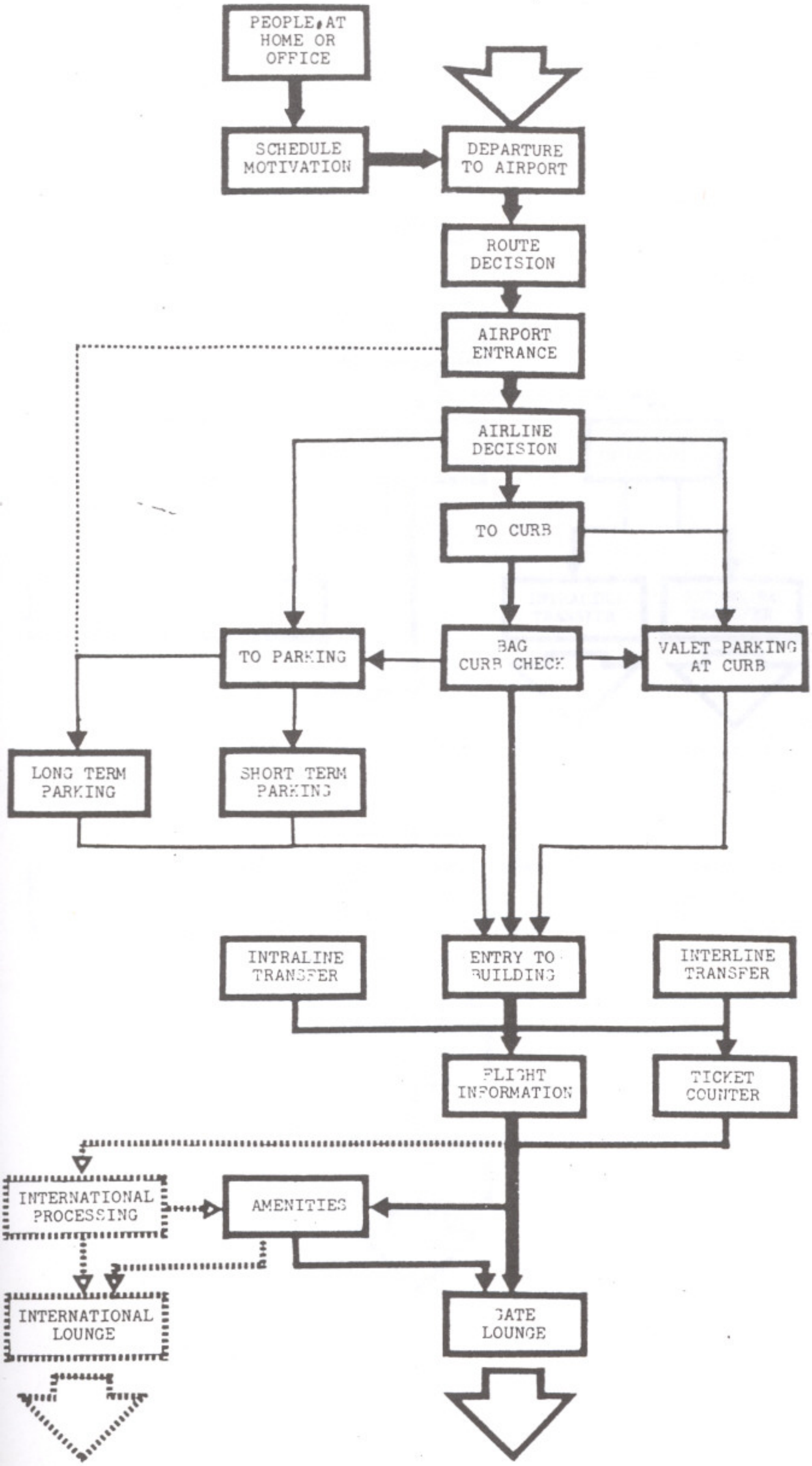


Fig. 4. 18 Enplaining passenger flow

source: J de Chiara and J. Callender (9)

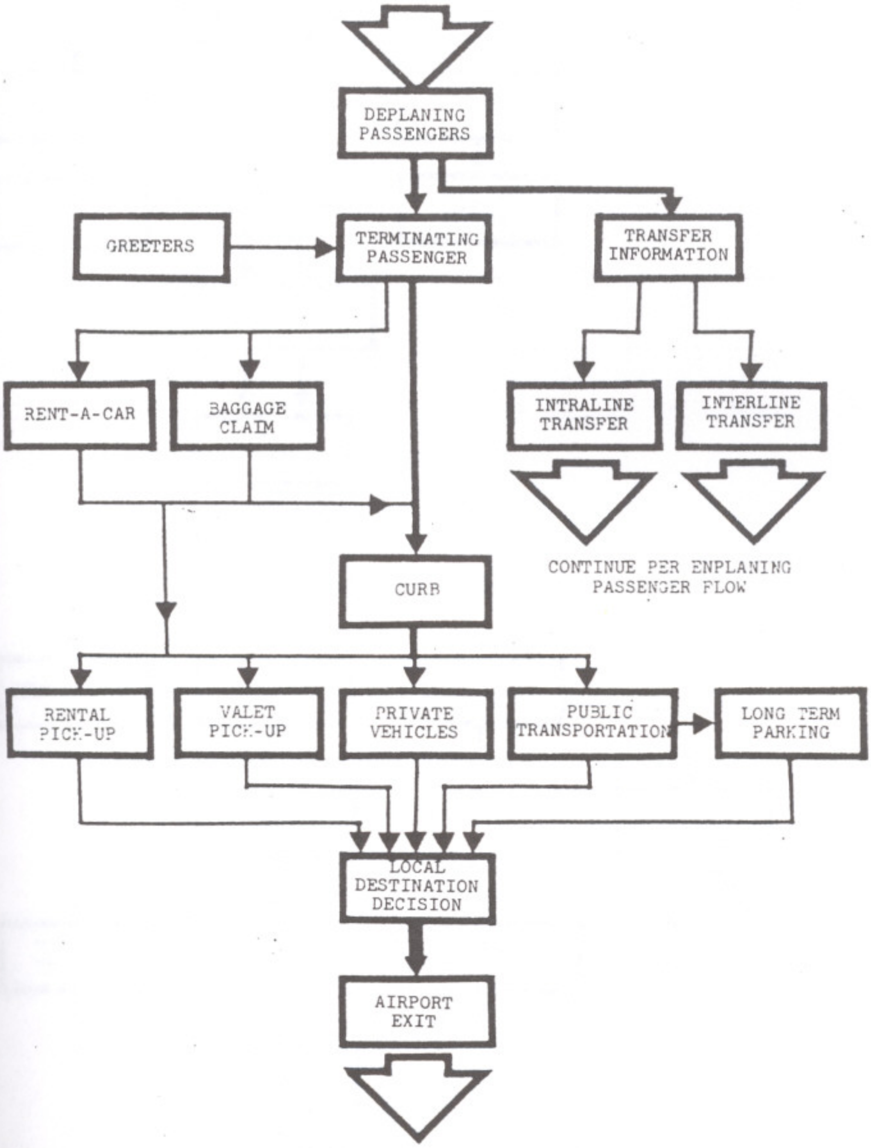


Fig. 4.19 Domestic Deplaining passenger flow

source: J de Chiara and J. Callender (9)

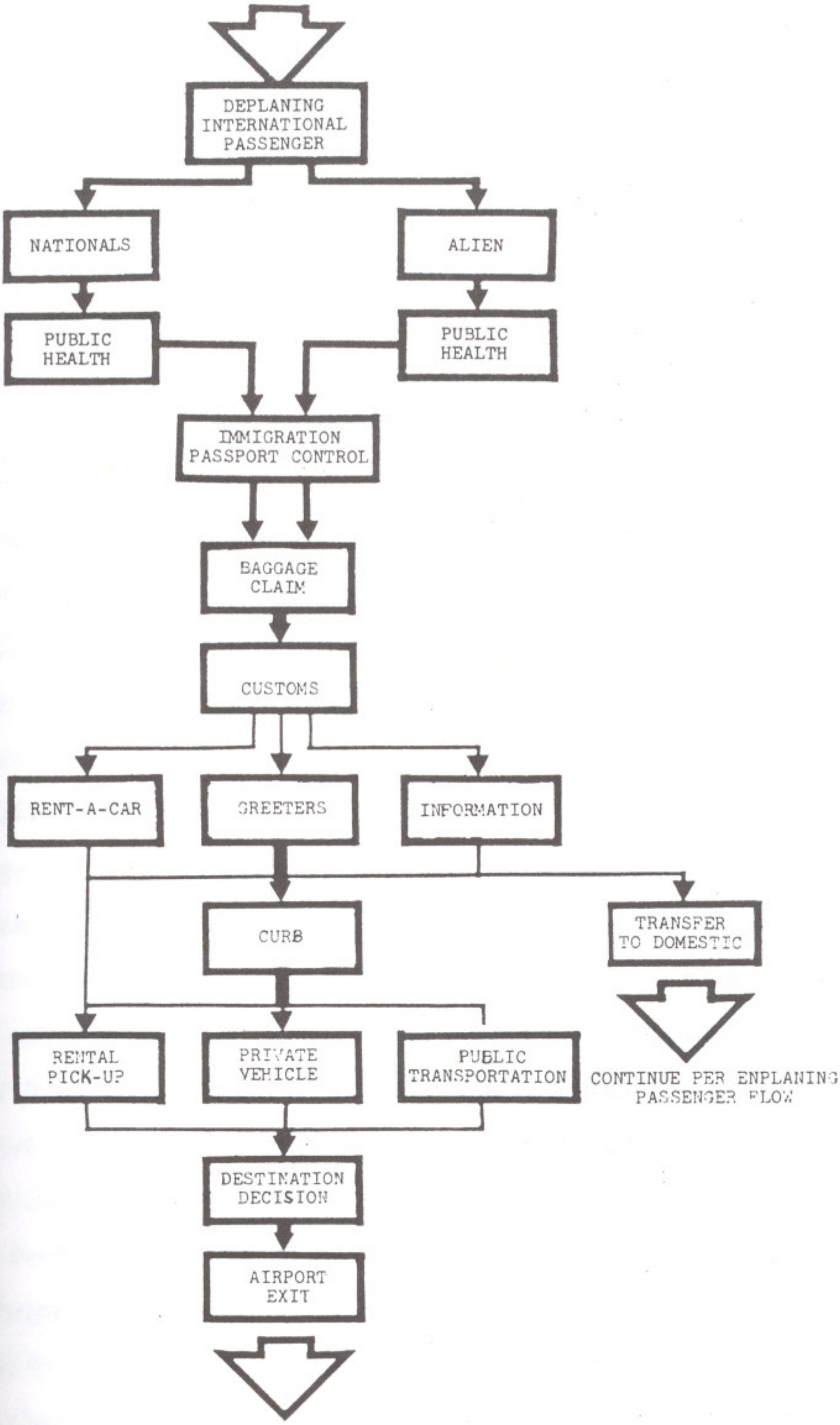


Fig. 4.20 International deplaining passenger flow

source: J de Chiara and J. Callender (9)

4.1.5.5. Passenger Characteristics

There are two main categories of passengers; one who travel for business purposes the other for non-business purposes as tourist, personal or religious reasons. While the business passenger is a more experienced traveler, non-business traveler generally less familiar with airline procedures or passenger building service and concessions. Passengers can also be categorized as international and domestic, and these two flow routes should be separated while passengers traveling between countries have to subject to inspection by government frontier control agencies domestic passengers have not. The other categorization can be made such as departures, arrivals, transit and transferring passengers.

It's necessary to understand passenger behavior and flow principles in order to achieve a successful design. Passengers show a homogenous flow, whether constant or intermittent, they require clear indications of what they are expected to do and the routes they should follow and they have different needs, preferences and sometimes disabilities. With all these factors, a system should attract passengers to the routes required by the flow pattern while giving freedom for individual requirements. The key is simplicity while achieving planning objectives and it can be provided by separating functions.

A large area in the passenger building should be broken down into units or modules which is sized according to the physical limitations of passengers and the economics of construction and operation of this building and apron. 300 m from the center of the airside of passenger building to the farthest aircraft parking position is accepted as a reasonable limit. It is essential to provide most compact arrangement in order to minimize transfer distances while planning the passenger building. For creating an easily comprehensible environment facilitating for free flow of vehicles and people and for providing flexible and expandable layout these units should be arranged in the simplest manner. Separation of functions as a determinant in hand, flow pattern is mainly determined by passenger flow although baggage flow has an equal importance but its inanimate character makes it easily compatible with the best passenger flow.

Passenger flow routes should be short, direct and do not cross other flow routes, should be one directional and should provide maximum visual continuity, should not necessitate guidance. Level changes and hesitancy caused by directional signs and multidirectional junctions on flow routes should be avoided. Passengers should get rid of their baggage at the earliest possible point. Random movement areas should be adjacent, but not part of flow routes. Interruption by means of controls should be minimized and passengers should not have to pass through the same type of control more than once in order not to cause delays and irritation.

The general planning principles also apply to baggage systems planning and we should know that baggage system influenced by passenger flow at points where passenger and baggage flow come together.

4.1.5.6. Passenger Amenities

We can classify passenger amenities such as food and beverage services, concessionaires and building services.

At small airports food and beverage services may be only a coffee shop and a separate restaurant depending on the surrounding community, but at larger airports these services include sometimes more than one snack bars, coffee shops, restaurants and bar lounges, etc. The number and size of these services depend on the terminal concept and airport size. Based on available data 3.3 to 3.7 sqm ranges used for space per seat for coffee shop/restaurant seat, including support space. 15 to 25 percent of coffee shop/restaurant over-all space requirement for snack-bars and 25 to 35 percent for bar-lounges is suitable.

Concessionaires may be news, tobacco, gift and apparel shops, drugstore, barber and shoeshine operations and each of them may become separate or combined according to the enplanement level. Auto rental counters vary according to the number of companies, florist shop, displays, insurance, public lockers, public telephones, automated post offices are some of the other services. Vending machines, if provided should be grouped or recessed in order not to affect circulation. Public toilets sized according to the local codes and building occupancy. Airport Management Offices and Airport Police / Security Offices space needs vary especially according to the size of staff. Medical Aid Facilities space requirements mostly determined by first-aid services, for branch operations, off airport clinics used. Nursery Facilities have been provided at airports over annual one million enplanements. A private toilet room of 4.7 to 5.6 sqm for changing and feeding facilities which has a number of two or up depending on the terminal size and configuration (9). "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 sqm per 500 peak-hour passengers (in and out) down to 120 sqm per million annual enplanements at large hub airports"(10). Facilities for elderly and disabled people should also be provided in passenger buildings.

Building maintenance and storage varies according to the types of maintenance either contracted or authority operated and storage facilities available in other authority owned buildings. Building mechanical systems (HVAC) space requirement ranges from 12 to 15 percent of the gross total space of all other terminal functions. Some other space need may be for information services, government offices, contract service facilities, etc..

4.1.5.7. Traffic and Service Characteristics

It is necessary to investigate the specific needs of individual carriers. The level of passenger and cargo, the operational growth or the potential of changing route structures, and an initial and future projected flight schedule are part of necessary information. Airlines' demand for distinctive visual character for being identifiable to the public is also important and should be considered at design stage. Airline service characteristics can be categorized into three basic types; originating/terminating, through station and transfer/transit station.

The characteristic of airport change according to airlines' route structures, and an airport may serve as one of these different types or all types can be observed at one airport. Depending on the type served mainly; the space requirements for different services may change, such as curb frontage, ticketing, baggage check-in, baggage claim, concessions and public services, security control etc.

Airlines operate charter flights, group tour flights and other types of non-scheduled passenger services, in addition to their scheduled operations, there are also a number of certificated carriers operating similarly. Air Taxi is also another class of non-scheduled / charter service and aircraft are smaller than those operated by airlines and at many airports this service is provided outside the passenger building complex. Air taxis may create problems at large airports but this is not so at smaller or medium sized airports. At some airports a relatively high volume of airline charter operations may necessitate a separate and modest passenger building facilities for supplemental carriers. There may be a demand for general aviation and careful analysis should be made to determine whether intermixing this traffic with commercial aviation or not.

The facility requirement vary according to the number of aircraft operators to be accommodated, their traffic share proportions, aircraft type and the nature of operations. Minimum cost for an airport can be achieved by the most efficient use of facilities. Developing criteria for passenger building plan related to demand and capacity should be developed for the above factors and for the major components of passenger building which are affecting the scale of facilities to be provided. The criteria should be analyzed and agreed upon by all parties involved such as, the airlines, general aviation interests, concessionaires, airport management, technical advisors, etc., before it is incorporated in the master plan.

4.1.5.8. Passenger Building Concepts

There are certain passenger building concepts and for a particular airport, applicability of all concepts should be considered by the planner. Aircraft parking system is effective in this choice and also compatibility with the planned airfield configuration is important. Before the final selection, in order to prevent future rejection, the most desirable concepts should be evaluated with interested parties. Passenger building concepts are as follows:

There are two basic concepts for the arrangement of terminal area. One is centralized, where all passengers and baggage processed in one building, the other is unit (decentralized) where each airline or several airlines together located in a separate terminal building. A single centralized terminal building with its compact operation have no problem of transferring passengers and baggage between buildings and have lower maintenance and operating costs. This type provides a simple transfer stage for ground vehicles and air vehicles with a consolidated single structure involving several airlines. It has a simple airstrip with only a few aircraft positions which may be increased by using different concepts and also multiples of this small group can be used in major terminal complexes. Convenience to passengers and efficiency of operation to airlines are measures of effectiveness. "A unit terminal concept can be justified only at the very high activity airports, particularly where the percentage of airline transfer passengers is