AIRPORT PLANNING AND OPERATIONS(A82127)

COURSE FILE

IV B. Tech II Semester

(2017-2018)

Prepared By

Mr. Yugender, Asst. Prof

Department of Aeronautical Engineering

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

(Autonomous Institution – UGC, Govt. of India)

Affiliated to JNTU, Hyderabad, Approved by AICTE - Accredited by NBA & NAAC – 'A' Grade - ISO 9001:2015 Certified)
Maisammaguda, Dhulapally (Post Via. Kompally), Secunderabad – 500100, Telangana State, India.

MRCET VISION

- To become a model institution in the fields of Engineering, Technology and Management.
- To have a perfect synchronization of the ideologies of MRCET with challenging demands of International Pioneering Organizations.

MRCET MISSION

To establish a pedestal for the integral innovation, team spirit, originality and competence in the students, expose them to face the global challenges and become pioneers of Indian vision of modern society.

MRCET QUALITY POLICY

- To pursue continual improvement of teaching learning process of Undergraduate and Post Graduate programs in Engineering & Management vigorously.
- To provide state of art infrastructure and expertise to impart the quality education

PROGRAM OUTCOMES
(PO's)

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design / development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multi disciplinary environments.
12. **Life- long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

DEPARTMENT OF AERONAUTICAL ENGINEERING

VISION

Department of Aeronautical Engineering aims to be indispensable source in Aeronautical Engineering which has a zeal to provide the value driven platform for the students to acquire knowledge and empower themselves to shoulder higher responsibility in building a strong nation.

MISSION

The primary mission of the department is to promote engineering education and research. To strive consistently to provide quality education, keeping in pace with time and technology. Department passions to integrate the intellectual, spiritual, ethical and social development of the students for shaping them into dynamic engineers.

QUALITY POLICY STATEMENT

Impart up-to-date knowledge to the students in Aeronautical area to make them quality engineers. Make the students experience the applications on quality equipment and tools. Provide systems, resources and training opportunities to achieve continuous improvement. Maintain global standards in education, training and services.

PROGRAM EDUCATIONAL OBJECTIVES – Aeronautical Engineering

1. **PEO1 (PROFESSIONALISM & CITIZENSHIP):** To create and sustain a community of learning in which students acquire knowledge and learn to apply it professionally with due consideration for ethical, ecological and economic issues.
2. **PEO2 (TECHNICAL ACCOMPLISHMENTS):** To provide knowledge based services to satisfy the needs of society and the industry by providing hands on experience in various technologies in core field.
3. **PEO3 (INVENTION, INNOVATION AND CREATIVITY):** To make the students to design, experiment, analyze, and interpret in the core field with the help of other multi disciplinary concepts wherever applicable.
4. **PEO4 (PROFESSIONAL DEVELOPMENT):** To educate the students to disseminate research findings with good soft skills and become a successful entrepreneur.
5. **PEO5 (HUMAN RESOURCE DEVELOPMENT):** To graduate the students in building national capabilities in technology, education and research

PROGRAM SPECIFIC OUTCOMES – Aeronautical Engineering

1. To mould students to become a professional with all necessary skills, personality and sound knowledge in basic and advance technological areas.
2. To promote understanding of concepts and develop ability in design manufacture and maintenance of aircraft, aerospace vehicles and associated equipment and develop application capability of the concepts sciences to engineering design and processes.
3. Understanding the current scenario in the field of aeronautics and acquire ability to apply knowledge of engineering, science and mathematics to design and conduct experiments in the field of Aeronautical Engineering.
4. To develop leadership skills in our students necessary to shape the social, intellectual, business and technical worlds.

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

	L	T/P/D	C
IV Year B. Tech, ANE-II Sem	**4**	**1/-/-**	**3**

AIRPORT PLANNING AND OPERATIONS (A82127)

Objective: To Introduce To The Students About Various Components Of The Airport And Its Operations

UNIT-1

Airport As An Operational System: Private Airports And Public Use Airports, Commercial Service Airports And Primary Commercial Service Airports, General Aviation Airports, Reliever Airports. Hub Classification –Large Hubs, Medium Hubs ,Small Hubs, Non-Hubs. Components Of An Airports- Airside,L And Side. Airport As A System-Function Of Airport –Complexity of airport operation.

UNIT-II

Airport Planning: Airport System Planning, Airport Master Plan ,Airport Layout Plan – Forecasting, Facilities Requirements, Design Alternatives .Financial Plans, Land Use Planning, Environmental Planning.

UNIT-III

Ground Handling: Passenger Handling , Ramp Handling-Aircraft Ramp Servicing ,Ramp Lay Out. Departure Control. Division Of Ground Handling Responsibility. Control Of Groundling Handling Efficiency. Baggage Handling Baggage Operations –Operating Characteristics Of Baggage Handling Systems-Inbound Baggage Systems , Outbound Baggage System-Operating Performance-Organizing For The Task.

UNIT-IV

Passenger Terminal Operations And Cargo Operations: Function Of The Passenger Terminal, Philosophies Of Terminal Management. Direct Passenger Services, Airline Related Passenger Services .Airline Related Operations Functions. Governmental Requirements-Non-Passenger Related Airport Authority Functions, Processing Very Important Persons .Passenger Information System. Space Components Adjacencies-Aids To Circulation Hubbing Considerations.

Air Cargo Market –Expanding The Movement. Flow Through The Cargo Terminal Unit Loading Devices. Handling Within The Terminal-Cargo Apron Operations-Computerization Of Facilitation-Example Of Modern Cargo Design-Freight Operations For The Integrated Carrier.

UNIT-V

Airport Technical Services And Access: Scope Of Technical Services-Airtraffic Control-Telecommunications-Metrology-Aeronautical Information. Access As Part Of Airport System-Access Users And Model Choice, Access Interaction with Passenger Terminal Operation, Access –Modes-In-Town And Off-Airport Terminals. Factor Effecting Access Mode Choice.

TEXT BOOK

1. Wells, A.T. and Young, S.B., *Airport Planning and Management*, 5th edn, McGraw-Hill, 2004.

REFERENCES

1. Ashford, N., Stanton, H.P.M. and Moore, C.A., *Airport Operations*, McGraw-hill, 1997.
2. Kazda, A. and Caves, R.E., *Airport Design and Operation*, 2nd edn., Elsevier, 2007.
3. *Horonjeff, R., McKelvey, F.X., Sproule, W.J. and Young*, S.B., *Planning and Design of Airport*, 5th edn., McGraw-Hill, 2010.

Outcomes: The student would gain an understanding of the basic planning and operations involved in airport.

MALLA REDDY COLLEGE OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF AERONAUTICAL ENGINEERING
AIRPORT PLANNING & OPERATIONS
MODEL PAPER -I

PART –A
Answer all the questions

1. Describe about ground airports? [3]
2. Define Hub classification? [2]
3. What is hub classification? [2]
4. What is called as air side and land side? [2]
5. What is airport master plan? [3]
6. What is meant complexity of airport operation? [3]
7. What is role of relieve airport? [2]
8. Define small hubs? [2]
9. What are facility requirements of airport? [3]
10. Write about land in of planning? [3]

PART-B

1. Describe about private airport in detail? [10]

OR

2. Differentiate between public and commercial service airport? [10]
3. Draw airport loyal plow with neat sketch with components? [10]

OR

4. Discuss in detail about financial plans in construction of airport? [10]
5. What are role of an airport and discuss the various types of aircraft? [10]

OR

6. Discuss about passenger and ramp handling? [10]
7. What are the functions of passenger terminal? [10]

OR

8. What are the different types of cargo loading devices? [10]
9. Discuss about air traffic control in detail? [10]

OR

10. What are the factors effecting access mode choice? [10]

MALLA REDDY COLLEGE OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF AERONAUTICAL ENGINEERING
AIRPORT PLANNING & OPERATIONS
MODEL PAPER -II

PART –A
Answer all the questions

1. Define hub classification? [2]
2. Differentiate between long hub and medium hub? [3]
3. Write the components of airport? [3]
4. What is an airport planning system? [2]
5. Differentiate land side and air side? [3]
6. Write functions of airport? [2]
7. Draw airport layout? [3]
8. What is financial planning? [2]
9. Define forecasting of airport planning? [2]
10. What are design alternatives? [3]

PART-B

1. Discuss about private and general airport in detail? [10]

OR

2. Write function of airport in detail? [10]
3. Describe financial planning of airport? [10]

OR

4. Discuss in detail diverse alternatives? [10]
5. Explain departure control and achieved in airport? [10]

OR

6. What are the non-passenger related airport functions? [10]
7. What are characteristics of baggage handling system? [10]

OR

8. Describe about art band baggage system in detail? [10]
9. What is requirement of aeronautical information system in airport operations? [10]

OR

10. Discuss about access modes in town and off airport terminals? [10]

MALLA REDDY COLLEGE OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF AERONAUTICAL ENGINEERING
AIRPORT PLANNING & OPERATIONS
MODEL PAPER -III

PART –A
Answer all the questions

1. What is function of airport? [2]
2. Discuss primary role of commercial service airport? [2]
3. Draw airport layout? [2]
4. What is land use planning [3]
5. Explain baggage load planning? [2]
6. What is meant by environmental planning? [3]
7. What is medium hub? [2]
8. Discuss about general aviation airport? [3]
9. Discuss any two design alternatives? [3]
10. What are financial plans of an aircraft? [3]

PART-B

1. Differentiate long, small and medium hubs? [10]

OR

2. Write in detail functions of an aircraft? [10]
3. Discuss about financial planning of airport? [10]

OR

4. Discuss about master plan of airport? [10]
5. What are responsibilities of ground handling? [10]

OR

6. Discuss about ramp handling and services? [10]
7. What are airline related operational functions? [10]

OR

8. How do you process VIP in Airport terminal building? [10]
9. What is role of metrology department in airport operation? [10]

OR

10. Discuss about access any part of airport systems? [10]

MALLA REDDY COLLEGE OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF AERONAUTICAL ENGINEERING
AIRPORT PLANNING & OPERATIONS
MODEL PAPER -IV

PART –A
Answer all the questions

1. Distinguish between public and private airport? [3]
2. Describe about commercial service airport? [2]
3. Define small hub? [2]
4. What is an airside? [2]
5. Write about relieve airport? [3]
6. What are complexities of airport operations? [3]
7. What is meant by environmental planning? [3]
8. What are the facility requirements of airport? [2]
9. Write components of airport? [3]
10. Write about land use planning? [2]

PART-B

1. Draw the components of airside and landside of an airport? [10]

OR

2. Describe functions of airport? [10]
3. What are design alternatives of airport? [10]

OR

4. Discuss about environmental planning of airport? [10]
5. What are the operating characteristics of baggage handling systems? [10]

OR

6. Discuss about out bound baggage system? [10]
7. Write about
   i. Direct passenger services [5]
   ii. Airline related passenger services [5]

OR

8. What are government requirements of airport operations? [10]
9. Discuss about aeronautical information system? [10]

OR

10. What are requirements of technical services in airport ATC? [10]

MALLA REDDY COLLEGE OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF AERONAUTICAL ENGINEERING
AIRPORT PLANNING & OPERATIONS
MODEL PAPER -V

PART –A
Answer all the questions

1. What is meant by giant airports? [2]
2. Write the components of airport? [2]
3. Define medium hubs? [2]
4. What is land side? [2]
5. What do you understand by airport planning? [3]
6. What is airport master plan? [3]
7. What is forecasting of airport planning? [3]
8. Write components of airport [2]
9. Define airport plan layout? [3]
10. What are the facilities of print airport? [3]

PART-B

1. Discuss in detail the general aviation airport? [10]

OR

2. Write about relive airport and general airport? [10]
3. Discuss in detail about airport planning system? [10]

OR

4. What are facility requirements of an airport? Discuss in detail about terminal/parking of an aircraft? [10]
5. Differentiate between general and relieve airport? [10]

OR

6. Draw layout of an airport and its components? [10]
7. What are the duties of ground handling departments? [10]

OR

8. Explain about baggage handling procedure? [10]
9. Explain about cargo airport operation in detail? [10]

OR

10. What is the function of passenger related airport authority? [10]

UNIT-1
AIRPORT AS AN OPERATIONAL SYSTEM

It is often said that managing an airport is like being mayor of a city. Similar to a city, an airport is comprised of a huge variety of facilities, systems, users, workers, rules, and regulations. Also, just as cities thrive on trade and commerce with other cities, airports are successful in part by their ability to successfully be the location where passengers and cargo travel to and from other airports. Furthermore, just as cities find their place as part of its county's, state's, and country's economy, airports, too, must operate successfully as part of the nation's system of airports.

The airport forms an essential part of the air transport system because it is the physical site at which a modal Transfer is made from the air mode to the land mode or vice versa It is the point of interaction of the three major components of the air transport system. The airport, including its commercial & operational concessionaires, tenants and partners, plus. These discussion purposes, the airways control system.

- The airline
- The user

The interaction among these three major components must be made to have successful rate and planning and operation is also must. To operate well, each should reach some form of equilibrium with the other two.

Function of the airport:

An airport is either an intermediate or terminal point for an aircraft on the air portion of a trip. In simple functional terms the facility must be designed to enable an a/c to land & take off In b/w their two operations, the aircraft may, if required, unload and load payload & crew & be serviced Airport operations are divided into airside & land side functions. After approach and landing an aircraft uses the runway, taxiway and apron prior to docking at a Packing position, where its payload is processed through the terminal to the access system. The airport passenger and freight terminals are themselves facilities that have three distinct functions.

Change of mode: To provide linkage b/w the air vehicle of the surface vehicle designed to accommodate the operating characteristics of the vehicles on landside & airside respectively.

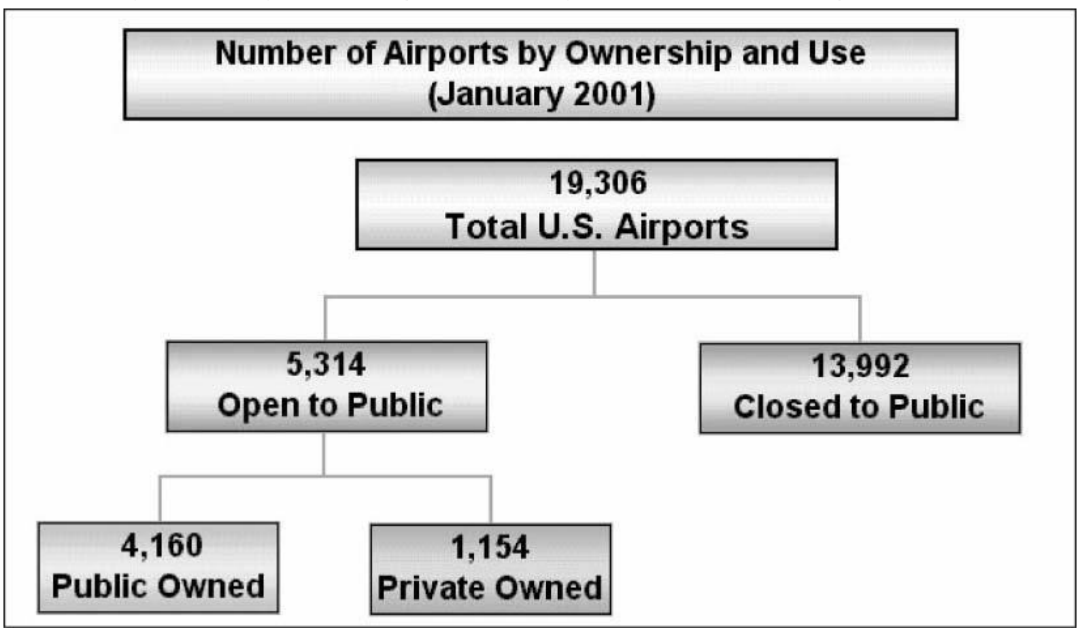
Processing: To provide the necessary facilities for ticketing, documentation and control of passengers and freight.

Change of movement type: To convert continual shipments of freight by trucks of departing passengers by car, bus, taxi & train to aircraft sized batches that generally depart according to a preplanned schedule or to reverse this process for arriving aircraft. Airports of a significant size must have an organization that can either supply or administer the following Faculties

Airports in the United States—An overview

The United States has by far the greatest number of airports in the world. More than half the world's airports and more than two-thirds of the world's 400 busiest airports are located in the United States. There are more than 19,000 civil landing areas in the United States, including heliports, seaplane bases, and "fixed-wing" landing facilities. Most of these facilities are privately owned, and for private use only. Such facilities include helipads operated at hospitals and office buildings, private lakes for seaplane operations, and, most common, small private airstrips that accommodate the local owners of small aircraft operations. Many of these facilities are nothing more than a cleared area known as a "grass strip."

There are approximately 5,400 airports that are open for use to the general public. Of these, approximately 4,150 are equipped with at least one paved and lighted runway. Of the 5,400 public-use airports in the United States, approximately 4,200 are publicly owned, either by the local municipality, county, state, or by an "authority" made up of municipal, county, and/or state officials. The remaining 1,200 are privately owned, either by individuals, corporations, or private airport management companies, see below. Fig.



Airports are often described by their levels of activity.

The activities,

1. services,
2. investment levels vary greatly among the nation's airports.

3. The most common measures used to describe the level of activity at an airport are the number of passengers served, the amount of cargo carried, and the number of operations performed at the airport.

Specifically, the term **enplanements** (or *enplaned passengers*) is used to describe the number of passengers that board an aircraft at an airport. Annual enplanements are often used to measure the amount of airport activity, and even evaluate the amount of funding to be provided for improvement projects. The term **deplanements** (or *deplaned passengers*) is used to describe the number of passengers that deplane an aircraft at an airport. The term *total passengers* is used to describe the number of passengers that either board or deplane an aircraft at an airport. At many airports, the number of total passengers is roughly double the number of annual enplanements.

Cargo activity is typically used to measure the level of activity at airports that handle freight and mail. Airports located near major seaports, railroad hubs, and large metropolitan areas, as well as airports served by the nation's cargo carriers (such as FedEx and UPS) accommodate thousands of tons of cargo annually.

The number of **aircraft operations** is used as a measure of activity at all airports, but is the primary measure of activity at general aviation airports. An aircraft operation is defined as a takeoff or a landing. When an aircraft makes a landing and then immediately takes off again, it is known as a "touch and go" and is counted as two operations. This activity is common at many general aviation airports where there is a significant amount of flight training. When an aircraft takes off and lands at an airport without landing at any other airport, the aircraft is said to be performing **local operations.** An **itinerant operation** is a flight that takes off from one airport and lands at another.

Another, albeit, indirect measure of airport activity is identified by the number of aircraft "based" at the airport. A **based aircraft** is an aircraft that is registered as a "resident" of the airport. The number of based aircraft is used to indirectly measure activity primarily at smaller airports where private "general" aviation is dominant. At airports that primarily handle the air carriers, relatively few aircraft are actually based. In general, airport management measure the activity levels of their airports on the basis of all levels of passenger, cargo, operations, and based aircraft activity; virtually all airports, especially the largest airports in the nation, accommodate passengers and cargo, as well as air carrier and private aircraft operations.

Airport as an Operational system

1. **Private airports and public use airports.**

Airport planning is a systematic process used to establish guidelines for the efficient development of airports that is consistent with local, state & national goals. Key object of airport planning is to assure the effective use of airport resources in order to satisfy aviation demand in a financially feasible manner.

1. National system planning.
2. State airport system planning
3. Metropolitan airport system planning
4. Airport Master planning

Limitations of use:

FAA policies are applicable such as Usc, united state code, public law (PL), code of federal regulations of official FAA policies.

Public & Private use airport

When we think of public airports, it is usually commercial service we think. How ever, Oregon's system of more than 100 public use airports includes a half dozen commercial service airports.

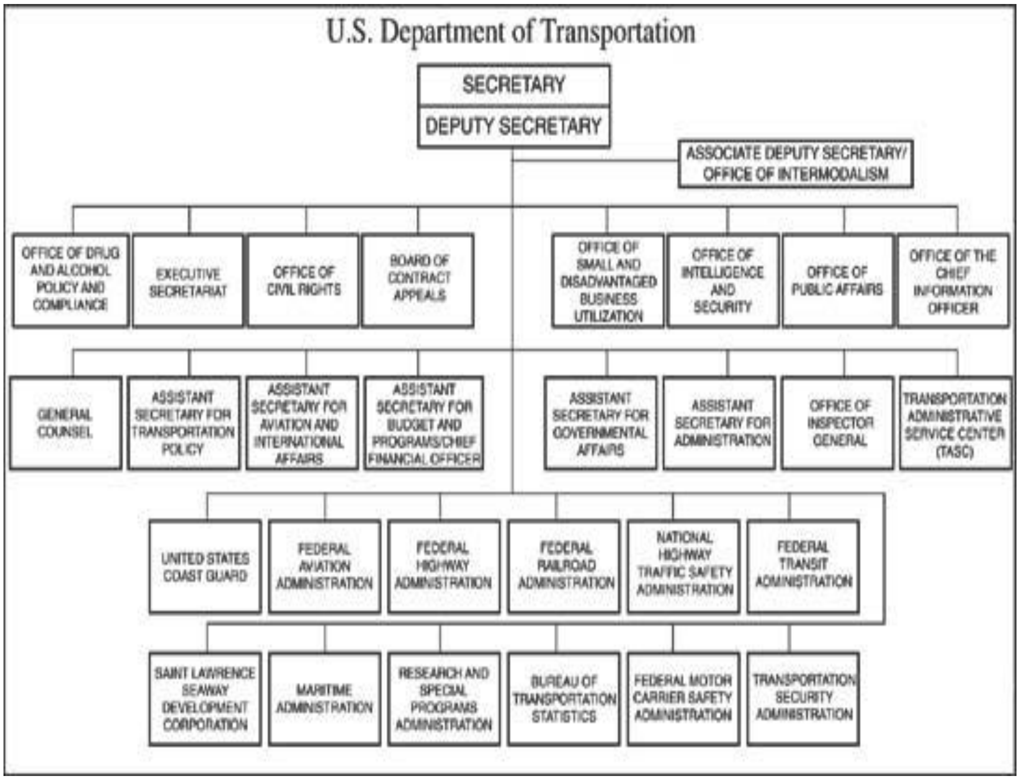
All public categories for purpose of oregano aviation plan.

Private air charter services, one advantage to use a private airport is the privacy factor. Travelling

Details are kept confidentially including the destination, members of travelling paity & Potential rerurn dates.

The national administrative structure of airports

All civil-use airports, large and small, in one way or another, utilize the United States' Civil Aviation System. The civil aviation system is an integral part of the United States' transportation infrastructure. This vital infrastructure is administered through the United States **Department of Transportation (DOT),** led by the secretary of transportation.



U.S Department of Transportation organization chart.

The DOT is divided into several administrations that oversee the various modes of national and regional transportation in the United States. Such administrations include:

FHWA—The Federal Highway Administration
FMCSA—The Federal Motor Carrier Safety Administration
FRA—The Federal Railroad Administration
FRA—The Federal Transit Administration
MARAD—The Maritime Administration
NHTSA—The National Highway Traffic Safety Administration
USCG—The United States Coast Guard

The administration that oversees civil aviation is the **Federal Aviation Administration (FAA).** The FAA's primary mission is to oversee the safety of civil aviation. The FAA is responsible for the rating and certification of pilots and for the certification of airports, particularly those serving commercial air carriers. The FAA operates the nation's air traffic control system, including most air traffic control towers found at airports, and owns, installs, and maintains visual and electronic navigational aids found on and around airports. In addition, the FAA administers the majority of the rules that govern civil aviation and airport operations, as well as plays a large role in the funding of airports for improvement and expansion. The FAA is led by an administrator who is appointed by the secretary of transportation for a 5-year term. The FAA is headquartered in Washington, D.C. Headquarter offices within the FAA include the offices of Air Traffic Services (ATS), Office of Security and Hazardous Matericals (ASH), Commercial Space Transportation (AST), Regulation and Certification (AVR), Research and Acquisitions (ARA), and Airports (ARP). Within the Office of Airports lies the Office of Airport Safety and Standards (AAS) and the Office of Planning and Programming (APP). It is in these offices where Federal Aviation Regulations and policies specific to airports are administered. The FAA is also divided into nine geographic regions, as illustrated in Fig.

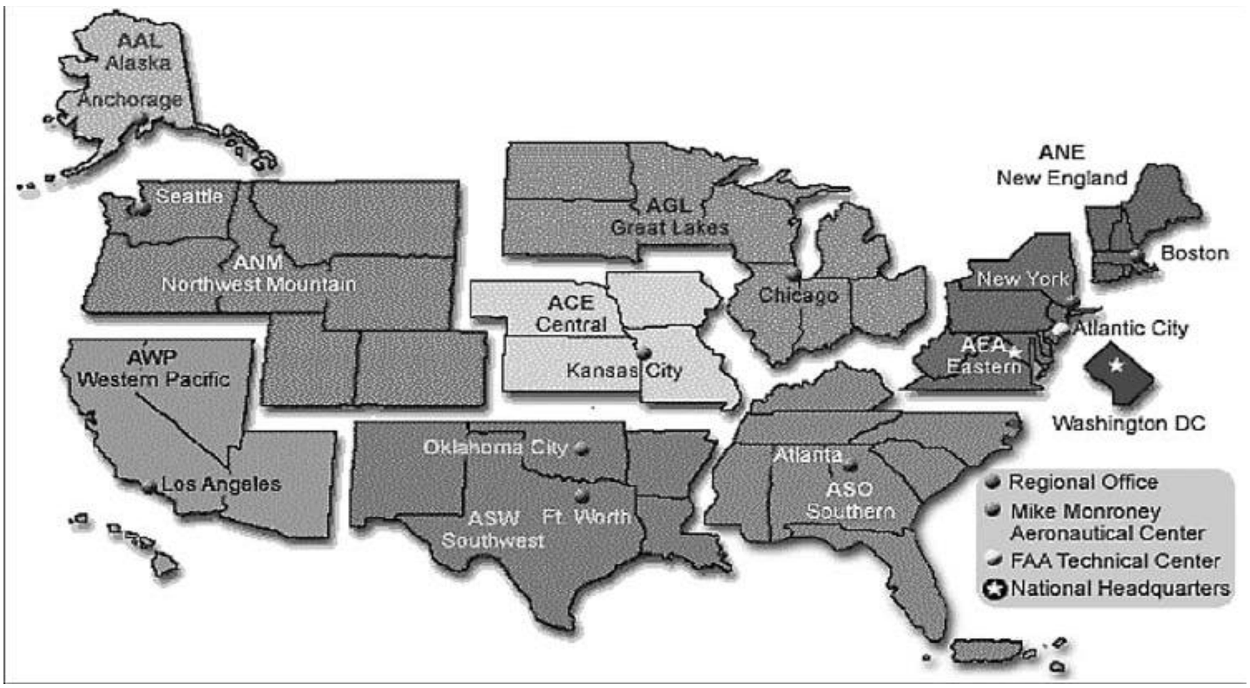


Figure *FAA regions.*

Within each region are two or more **Airport District Offices (ADOs).** ADOs keep in contact with airports within their respective regions to ensure compliance with federal regulations and to assist airport management in safe and efficient airport operations as well as in airport planning. Many civil-use airports, including those that are not directly administered by the FAA, may be under the administrative control of their individual states, which in turn have their own departments of transportation and associated offices and regions. Airport management at individual airports should be familiar with all federal, state, and even local levels of administration that govern their facilities.

Airport management on an international level

Internationally, the recommended standards for the operation and management of civil-use airports are provided by the **International Civil Aviation Organization (ICAO).** ICAO, headquartered in Montreal, Quebec, Canada, is a membership-based organization, comprised of 188 contracting states that span the world. ICAO came into existence as a part of the 1944 Chicago Convention on International Civil Aviation for the purpose of providing a source of communication and standardization among participating states with respect to civil aviation operations. ICAO publishes a series of recommended policies and regulations to be applied by individual states in the management of their airports and civil aviation systems.

The National Plan of Integrated Airport Systems

Since 1970, the Federal Aviation Administration has recognized a subset of the 5,400 public-use airports in the United States as being vital to serving the public needs for air transportation, either directly or indirectly, and may be made eligible for federal funding to maintain their facilities. The **National Airport System Plan (NASP)** was the first such plan, which recognized approximately 3,200 such airports. In addition, the NASP categorized these airports on the basis of each airport's number of annual enplanements and the type of service provided. The NASP categorized airports as being "commercial service airports" if the airport enplaned at least 2,500 passengers annually on commercial air carriers or charter aircraft. Commercial service airports were subcategorized as "air carrier" airports and "commuter" airports, depending on the type of service dominant at a given airport. Airports that enplaned less than 2,500 passengers annually were classified as "general aviation airports." In 1983, the final year of the NASP, a total of 780 commercial service airports (635 air carrier airports and 145 commuter airports) and 2,423 general aviation airports were recognized under the NASP.

With the passage of the Airport and Airway Act of 1982, the FAA was charged with preparing a new version of the NASP, to be called the **National Plan of Integrated Airport Systems (NPIAS).** The NPIAS revised the method of classifying airports, primarily to reflect the extreme growth in annual enplanements that a relative few of the largest airports were experiencing at the time. As of 2002, a total of 3,364 airports in the United States were included in the NPIAS.

The categories of airports listed in the NPIAS are:

1. Primary commercial service airports
2. Commercial service airports
3. General aviation airports
4. Reliever airports

Commercial service airports

Commercial service airports are those airports that accommodate scheduled air carrier service, provided by the world's certificated air carriers. Virtually all of the 650 million passengers that boarded commercial aircraft in 2001 began, transferred through, and ended their trips at commercial service airports. Commercial service airports operate under very specific regulations enforced by the Federal Aviation Administration, Transportation Security Administration, as well as state and local governments. In addition, other federal and local administrations, such as the Environmental Protection Agency, and local economic development organizations, indirectly affect how commercial service airports operate. The goal of commercial service airports, of course, is to provide for the safe and efficient movement of passengers and cargo between population centers through the nation's aviation system. In 2002, there were a total of 546 commercial service airports throughout the United States striving to fulfill this mission.

Primary commercial service airports are categorized in the NPIAS as those public-use airports enplaning at least 10,000 passengers annually in the United States. In 2002, there were 422 airports (less than 3 percent of the nation's total airports) categorized as primary commercial service airports. Within this exclusive group of airports, the range of airport size and activity level is very wide, and the distribution of passenger enplanements is highly skewed. About half the primary commercial service airports handle relatively little traffic; the vast majority of passengers are enplaned through relatively few very large airports. This phenomenon is a direct result of the airline routing strategy, known as the "hub and spoke. In fact, the top five airports in the United States, in terms of annual enplanements, boarded nearly 25 percent of all the passengers in the United States. The top two airports, Chicago O'Hare Field and the Hartsfield Atlanta International Airport, enplaned nearly 70 million (over 10 percent) of the nation's commercial air travelers in 2002.

Because of this wide range of size within the primary commercial service airport category, the NPIAS subcategorizes these airports into "hub" classifications. It should be noted that the term "hub" used by the FAA in the NPIAS is very different than the term used by the airline industry. Whereas the airline industry uses the term "hub" as an airport where the majority of an airline's passengers will transfer between flights to reach their ultimate destinations, the FAA defines hub strictly by the number of annual enplaned passengers to use the airport. Furthermore, if there is more than one airport in a **standard metropolitan statistical area (SMSA),** the total number of enplaned passengers of the airports within the SMSA is used to determine the airport's "hub" classification (Fig.).

Number Airports	Airport Type	Percentage of All Enplanements	Percentage of Active GA Aircraft1
31	Large-Hub Primary	69.6	1.3
37	Medium-Hub Primary	19.3	2.9
74	Small-Hub Primary	7.7	4.7
280	Nonhub Primary	3.2	11.3
124	Other Commercial Service	0.1	2.0
260	Relievers	0.0	27.1
2,558	General Aviation	0.0	37.2
3,364	Existing NPIAS Airports	100.0	86.4
15,942	Low Activity Landing Areas (Non-NPIAS)	0.0	13.6

Figure . *Airports by level of activity. (Figure courtesy FAA)*

The hub classifications used by the FAA in the NPIAS are:
1. Large hubs
2. Medium hubs
3. Small hubs
4. Nonhubs

Large hubs are those airports that account for at least 1 percent of the total annual passenger enplanements in the United States. In 2002, there were 31 large hub airports in the NPIAS. These 31 large hub airports accounted for 70 percent of all passenger enplanements in the United States.

Medium hubs are those airports that account for at least 0.25 percent but less than 1 percent of the total annual passenger enplanements. In 2002, there were 37 airports classified as medium hubs.

Small hubs are defined as those airports accommodating greater than 0.05 percent but less than 0.25 percent of annual U.S. enplanements. Seventy-four NPIAS airports were categorized asmall hubs.

Nonhubs are those airports that enplane at least 10,000 annual enplanements but less than 0.05 percent of the annual total U.S. enplanements. In 2002, 280 primary commercial service airports fell into the nonhub category.

Airports that handle at least 2,500 but less than 10,000 annual enplanements are categorized as

nonprimary commercial service airports, or simply commercial service airports. In 2002, there were 124 nonprimary commercial service airports included in the NPIAS.

General aviation airports

Those airports with fewer than 2,500 annual enplaned passengers and those used exclusively by private business aircraft not providing commercial air carrier passenger service are categorized as **general aviation (GA) airports.** Although there are over 13,000 airports that fit this category, only a subset is included in the NPIAS. There is typically at least one general aviation airport in the NPIAS for every county in the United States. In addition, any general aviation airport that has at least 10 aircraft based at the airport and is located at least 20 miles away from the next nearest NPIAS airport is usually included in the NPIAS. In 2002, a total of 2,558 general aviation airports were included in the NPIAS. General aviation airports have facilities and activity that rival their commercial service counterparts. These airports have multiple runways, at least one long enough to accommodate corporate and larger-size jet aircraft, and have a full spectrum of maintenance, fueling, and other service facilities. Many such general aviation airports even have rental car, restaurant, and hotel services to accommodate their customers. An important aspect of general aviation airports is that they serve many functions for a wide variety of airports. Some GA airports provide isolated communities with valuable links to other population centers. The principal function of general aviation airports, however, is to provide facilities for privately owned aircraft to be used for business and personal activities. In most recent years, there has been a significant increase in the amount of small business jet aircraft using general aviation airports.

A general aviation airport is generally categorized as being either a **basic utility** or **general utility facility.** Basic utility airports are designed to accommodate most single-engine and small twin-engine propeller-driven aircraft. These types of aircraft accommodate approximately 95 percent of the general aviation aircraft fleet. General utility airports can accommodate larger aircraft, as well as the lighter, smaller aircraft handled by basic utility airports.

Reliever airports

Reliever airports comprise a special category of general aviation airports. Reliever airports, generally located within a relatively short distance (less than 50 miles) of primary commercial service airports, are specifically designated by the NPIAS as "general aviation-type airports that provide relief to congested major airports." To be classified as a reliever airport, the airport must have at least 50 aircraft based at the airport or handle at least 25,000 itinerant operations or 35,000 local operations annually, either currently or within the last 2 years. Reliever airports are located within an SMSA with a population of at least 500,000 or where passenger enplanements at the nearest commercial service airport exceed 250,000 annually. As the name suggests, reliever airports are intended to encourage general aviation traffic to use the facility rather than the busier commercial service airport, In many major metropolitan areas, reliever airports account for a majority of airport operations. Of the general aviation airports recognized in the NPIAS, 260 have been classified as reliever airports. These airports are home to over 38 percent of all general aviation aircraft.

The rules that govern airport management

Ensure the safe and efficient operation of public-use airports. All airports included in the NPIAS are subject to a variety of **Federal Aviation Regulations(FAR).** FAR's are found in Title 14 of the United States **Code of Federal Regulations**(CFR) (14 CFR—Aeronautics and Space). The 14 CFR series is made up of over 100 chapters, known as parts, each of which provide regulatory mandates that govern various elements of the civil aviation system, including regulations for pilots, general aviation and commercial flight operations, and, of course, airport operations and management. Within airport management, regulations regarding airport operations, environmental policies, financial policies, administrative policies, airport planning, and other issues of direct concern to airports are covered. Although all Federal Aviation Regulations are important to airport management, the following FARs are of specific importance to airport management, operations, and planning, and will be referenced in detail in this text:

FAR Part 1 Definitions and Abbreviations
FAR Part 11 General Rulemaking Procedures
FAR Part 36 Noise Standards: Aircraft Type and Airworthiness Certification
FAR Part 71 Designation of Class A, Class B, Class C, Class D, and Class E Airspace Areas; Airways, Routes, and Reporting Points
FAR Part 73 Special Use Airspace
FAR Part 77 Objects Affecting Navigable Airspace

FAR Part 91 General Operating and Flight Rules
FAR Part 93 Special Air Traffic Rules and Airport Traffic Patterns
FAR Part 97 Standard Instrument Approach Procedures
FAR Part 121 Operating Requirements: Domestic, Flag, and Supplemental Air Carrier Operations
FAR Part 129 Operations: Foreign Air Carriers and Foreign Operators of U.S. Registered Aircraft Engaged in Common Carriage
FAR Part 139 Certification and Operations: Land Airports Serving Certain Air Carriers
FAR Part 150 Airport Noise and Compatibility Planning
FAR Part 151 Federal Aid to Airports
FAR Part 152 Airport Aid Program
FAR Part 156 State Block Grant Pilot Program
FAR Part 157 Notice of Construction, Alteration, Activation, and Deactivation of Airports
FAR Part 158 Passenger Facility Charges
FAR Part 161 Notice and Approval of Airport Noise and Access Restrictions
FAR Part 169 Expenditure of Federal Funds for Nonmilitary Airports or Air Navigation Facilities Thereon (for airports not operated under Federal Aviation Administration regulations)

In addition to the 14 CFR series, regulations regarding the security of airport and other civil aviation operations are published under Title 49 of the Code of Federal Regulations (49 CFR—Transportation) and are known as **Transportation Security Regulations (TSRs).** TSRs are enforced by the Transportation Security Administration (TSA). TSRs of specific importance to airport management include

49 CFR Part 1500 Applicability, Terms, and Abbreviations
49 CFR Part 1502 Organization, Functions, and Procedures
49 CFR Part 1503 Investigative and Enforcement Procedures
49 CFR Part 1510 Passenger Civil Aviation Security Service Fees
49 CFR Part 1511 Aviation Security Infrastructure Fee
49 CFR Part 1520 Protection of Security Information (replaced FAR Part 191)
49 CFR Part 1540 Civil Aviation Security: General Rules
49 CFR Part 1542 Airport Security (replaced FAR Part 107)
49 CFR Part 1544 Aircraft Operator Security: Air Carriers and Commercial Operators (replaced FAR Part 108)
49 CFR Part 1546 Foreign Air Carrier Security (replaced parts of FAR Part 129)
49 CFR Part 1549 Indirect Air Carrier Security (replaced FAR Part 109)
49 CFR Part 1550 Aircraft Security Under General Operating and Flight Rules (replaced parts of FAR Part 91)

To assist airport management and other aviation operations in understanding and applying procedures dictated by federal regulations, the FAA makes available a series of **advisory circulars (ACs)** associated with each regulation and policies. The advisory circulars specific to airports are compiled into the 150 Series of Advisory Circulars. There are over 100 current and historical advisory circulars in the 150 series available to airport management. Those advisory circulars of particular general interest to airport management are referenced throughout this text. Some of these include:

AC 150/5000-5C Designated U.S. International Airports
AC 150/5020-1 Noise Control and Compatibility Planning for Airports
AC 150/5060-5 Airport Capacity and Delay
AC 150/5070-6A Airport Master Plans
AC 150/5190-5 Exclusive Rights and Minimum Standards for Commercial Aeronautical Activities
AC 150/5200-28B Notices to Airmen (NOTAMS) for Airport Operators
AC 150/5200-30A Airport Winter Safety and Operations
AC 150/5200-31A Airport Emergency Plan
AC 150/5300-13 Airport Design
AC 150/5325-4A Runway Length Requirements for Airport Design
AC 150/5340-1H Standards for Airport Markings
AC 150/5360-12C Airport Signing and Graphics
AC 150/5360-13 Planning and Design Guidelines for Airport Terminal Facilities
AC 150/5360-14 Access to Airports by Individuals with Disabilities

Airports are also subject to state and local civil regulations specific to the airport's metropolitan area. In addition, airport management itself may impose regulations and policies governing the operation and administration of the airport. Each airport is encouraged to have a published set of rules and regulations covering all the applicable federal, state, local, and individual airport policies to be made available for all employees and airport users on an as-needed basis.

The components of the airport

An airport is a complex transportation facility, designed to serve aircraft, passengers, cargo, and surface vehicles. Each of these users is served by different components of an airport. The components of an airport are typically placed into two categories
The Airside
The landside

The **airside** of an airport is planned and managed to accommodate the movement of aircraft around the airport as well as to and from the air. The airside components of an airport are further categorized as being part of the local airspace or the airfield. The airport's **airfield** component includes all the facilities located on the physical property of the airport to facilitate aircraft operations. The **airspace** surrounding an airport is simply the area, off the ground, surrounding the airport, where aircraft maneuver, after takeoff, prior to landing, or even merely to pass through on the way to another airport.

The **landside** components of an airport are planned and managed to accommodate the movement of ground-based vehicles, passengers, and cargo. These components are further categorized to reflect the specific users being served. The airport **terminal** component is primarily designed to facilitate the movement of passengers and luggage from the landside to aircraft on the airside. The airport's **ground access** component accommodates the movement of ground-based vehicles to and from the surrounding metropolitan area, as well as between the various buildings found on the airport property.

No matter what the size or category of an airport, each of the above components is necessary to properly move people from one metropolitan area to another using air transportation. The components of an airport are planned in a manner that allows for the proper "flow" from one component to another. An example of a typical "flow" between components is illustrated in Fig. In Figure further identifies some of the facilities located on the airfield and ground access components of the airport.

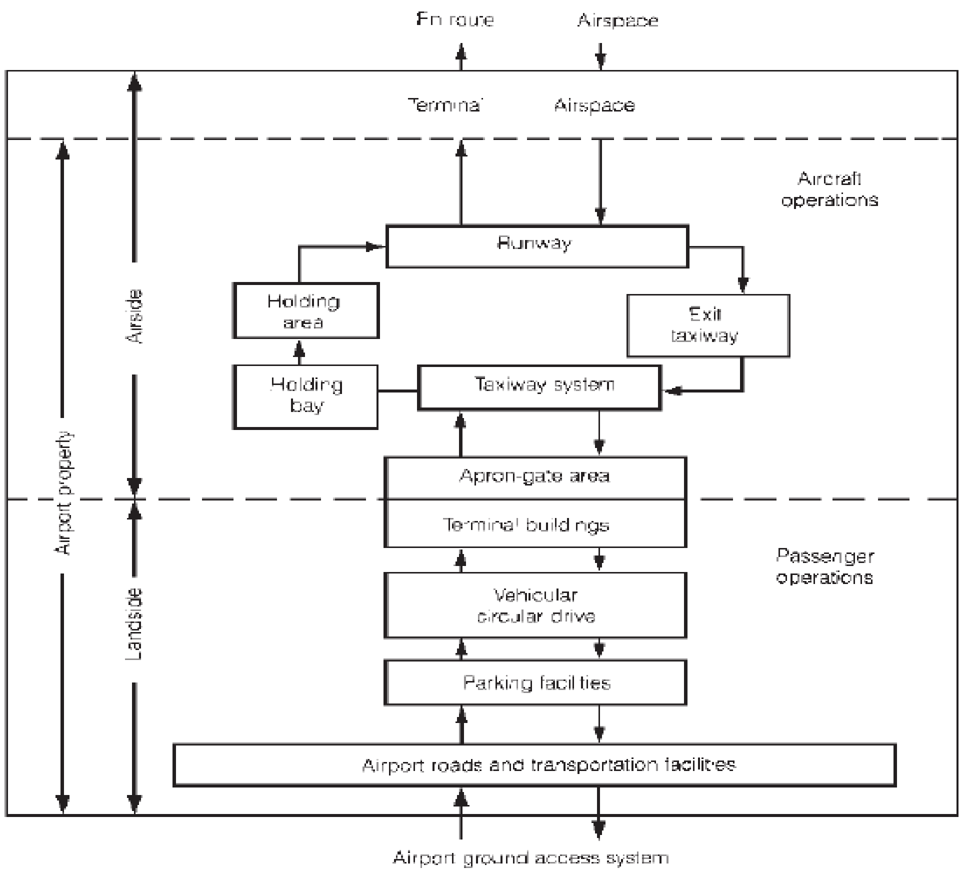


Fig. The components of an airport

The complexity of the Airport operation:

Until the deregulation & privatization of the air transport industry in the late 1970s & 1980s, it had been seen in many countries almost as a public service industry that required support from the Public purpose.

Airports such as Shannon in republic & Amsterdam in Netherlands, were among the first to develop income from commercial activities. By 1970s commercial revenues had become very inplerns of total income. The larger airports became complex business with functions that extended well beyond the airfield or "traffic" side of operations. It is also clear that in most countries, airports maintain economic viability by developing a broadly based revere capability As the relative and alxobute sizes of the non traffic element of the airports revenue increase, much more attention must be paid to developing commercial expertise, some of the largest airports have developed considerable in-house expertise in maximizing commercial revenues.

The non aeronautical activities found at airports are (ICA0) 2006;
Aviation fuel suppliers
Food & beverage sales (i.e restaurants, bars cafeterias etc)
Duty paid shopping
Banks / Foreign exchange
Airline catering services
Taxi services
Car rentals
Advertising
Airport /City transport services (i.e buses, limousines etc.
Duty free shopping (eg alcohol, tobacco, perfume, watches, optical)
Petrol/automobile service stations
Hair dressing/barber shop
Internet services
Casinos/gaming machines
Cinema
Vending machines for other than food
Freight consolidators
Art concerts
Music concerts
Souvenir shops

The degree to which airports go to a non aeronautical activity is likely to depend on the destination of the revenges generated from such activities. These go directly to the airport and add to the airports profitability. There are number of situations that can act as disincentive to the airport company. Where income from non aeronautical sources goes directly to the national treasury. Where the government gives the dut-free franchise to the government-owned airline. Where the U. S airport is operated on a residual cost basis, and income from non aero sources is used to reduce landing fear for the airlines 5 does not accrue to the airport.

UNIT-2
AIRPORT PLANNING

Airport planning may be defined as the employment of an organized strategy for the future management of airport operations, facilities designs, airfield configurations, financial allocations and revenues, environmental impacts, and organizational structures. There are various types of airport planning studies, including:

- Facilities planning
- Financial planning
- Economic planning
- Environmental planning
- Organizational planning
- Strategic planning

Defining the planning horizon

The planning of airport operations, or any activities for that matter, is defined in part by the length of time into the future management considers in its planning. The length of time into the future that is considered is termed the **planning horizon.** Different planning efforts require different planning horizons. For example, the organizational planning of staffing levels per shift for airport operations may require a 3-month planning horizon, but certainly not a 20-year planning horizon. On the other hand, facilities planning of an airfield which may include runway construction, requires at least a 5-year planning horizon, and certainly not a planning horizon of less than 1 year.

Airport system planning

Airport **system planning** is a planning effort that considers a collection of airports, either on a local, state, regional, or national level, expected to compliment each other as part of a coordinated air transportation system. Through airport system planning, the objectives of individual airports are set in accordance with the needs of the community by, for example, setting the mission of each airport to serve certain segments of the demand for aviation, such as targeting one airport in a region to handle international commercial air travelers and another airport to handle primarily smaller general aviation aircraft operations.

The airport master plan

At the local level, the centerpiece of airport planning is the airport **master plan,** a document that charts the proposed evolution of the airport to meet future needs. The magnitude and sophistication of the master planning effort depends on the size of the airport. At the largest commercial service airports, master planning is a formal and complex process that has evolved to coordinate large construction projects (or perhaps several such projects simultaneously) that can be carried out over a period of up to 20 years. At smaller airports, master planning might be the responsibility of a few staff members with other responsibilities, who depend on outside consultants for expertise and support. At very small airports, where capital improvements are minimal or are made infrequently, the master plan might be a very simple document, perhaps prepared locally but usually with the help of consultants.

An airport master plan presents the planner's conception of the ultimate development of a specific airport. It effectively presents the research and logic from which the plan was evolved and artfully displays the plan in a graphic and written report. Master plans are applied to the modernization and expansion of existing airports and to the construction of new airports, regardless of their size or functional role. The typical airport master plan has a planning horizon of 20 years. The Federal Aviation Administration notes that for a master plan to be considered valid it must be updated every 20 years or when changes in the airport or surrounding environment occur, or when moderate and major construction may require federal funding.

Objectives of the airport master plan

- To provide an effective graphic presentation of the ultimate development of the airport and of anticipated land uses adjacent to the airport
- To establish a schedule of priorities and phasing for the various improvements proposed in the plan
- To present the pertinent backup information and data that were essential to the development of the master plan
- To describe the various concepts and alternatives that were considered in the establishment of the proposed plan
- To provide a concise and descriptive report so that the impact and logic of its recommendations can be clearly understood by the community the airport serves and by those authorities and public agencies that are charged with the approval, promotion, and funding of the improvements proposed in the airport master plan

Elements of the master plan

An airport master plan typically consists of the following elements: inventory, activity forecasts, demand/capacity analysis, facilities requirements, design alternatives, and financial plans. These elements provide a recipe for the airport in its effort to meet the demands of its users and the surrounding community over the airport's master plan. In addition, some master plans include environmental and economic assessments of plans associated with the future plans for the airport.

The airport layout plan

Even though a narrative description of the airport environment is a necessary part of an airport master plan inventory, a graphical representation is also required. This graphical representation is known as the **airport layout plan,** or **ALP.**

The airport layout plan is a graphic presentation to scale of existing and proposed airport facilities and land uses, their locations, and the pertinent clearance and dimensional information required to show conformance with applicable standards. It shows the airport location, clear zones, approach areas, and other environmental features that might influence airport usage and expansion capabilities

The airport layout plan also identifies facilities that are no longer needed and describes a plan for their removal or phase out. Some areas might be leased, sold, or otherwise used for commercial and industrial purposes. The plan is always updated with any changes in property lines; airfield configuration involving runways, taxiways, and aircraft parking apron size and location; buildings; auto parking; cargo areas; navigational aids; obstructions; and entrance roads. The airport layout plan drawing includes the following items: the airport layout, location map, vicinity map, basic data table, and wind information.

The airport layout is the main portion of the drawing. It depicts the existing and ultimate airport development and land uses drawn to scale and includes as a minimum the following information

- Prominent airport facilities such as runways, taxiways, aprons, blast pads, extended runway safety areas, buildings, NAVAIDs, parking areas, roads, lighting, runway marking, pipelines, fences, major drainage facilities, segmented circle, wind indicators, and beacons.
- Prominent natural and man-made features such as trees, streams, ponds, rock outcrops, ditches, railroads, power lines, and towers.
- Outline of revenue-producing non-aviation-related property, surplus or otherwise, with current status and use specified.
- Areas reserved for existing and future aviation development and services such as for general aviation fixed-base operations, heliports, cargo facilities, airport maintenance, and so forth.
- Areas reserved for non aviation development, such as industrial areas, motels, and so forth
- Existing topographic contours
- Fueling facilities and tiedown areas
- Facilities that are to be phased out
- Airport boundaries and areas owned or controlled by the sponsor, including avigation easements

- Airport reference point with latitude and longitude given on the basis of the U.S. Geological Survey grid system
- Elevation of runway ends, high and low points, and runway intersections
- True azimuth of runways (measured from true north)
- North point—true and magnetic
- Pertinent dimensional data—runway and taxiway widths and runway lengths, taxiway-runway-apron clearances, apron dimensions, building clearance lines, clear zones, and parallel runway separation

The **location map** shown in the lower-left-hand side of the airport layout plan drawing is drawn to scale and depicts the airport, cities, railroads, major highways, and roads within 25 to 50 miles of the airport. The **vicinity map** shown in the upper-left-hand side of the airport layout plan drawing shows the relationship of the airport to the city or cities, nearby airports, roads, railroads, and built-up areas

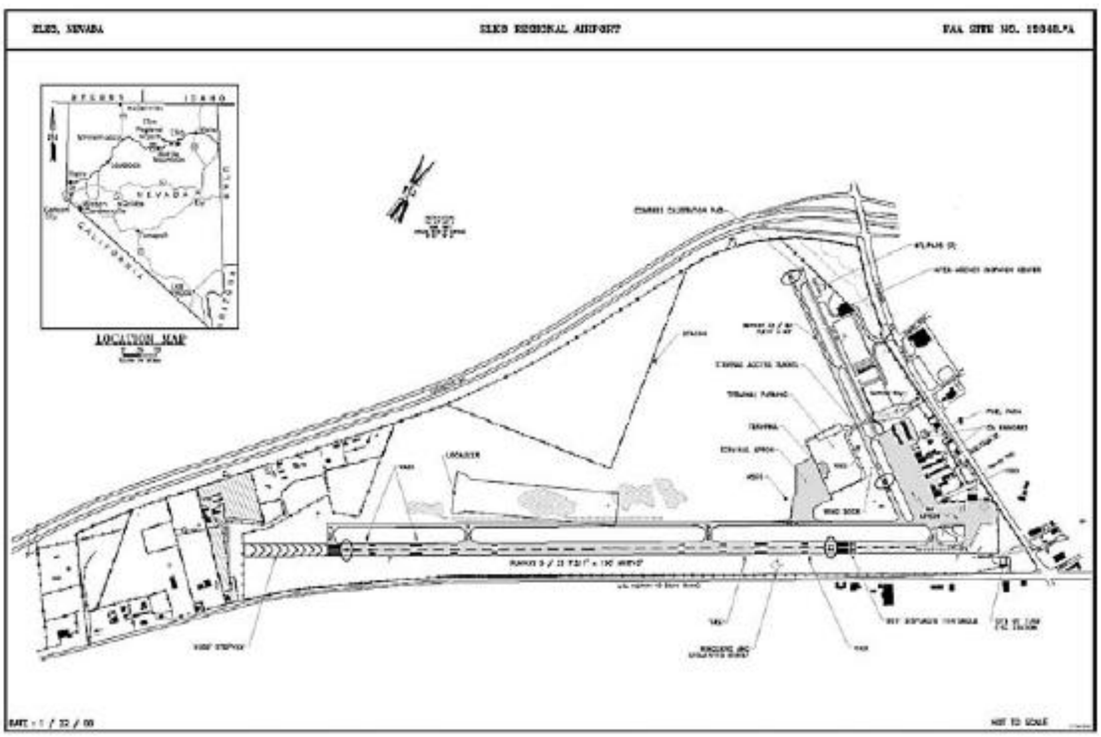


Fig. Example of ALP layout of airfield and facilities.

The **basic data table** contains the following information on existing and ultimate conditions where applicable:

- Airport elevation (highest point of the landing areas)
- Runway identifications
- Percent effective runway gradient for each existing and proposed runway

- Instrument landing system (ILS) runway when designated, dominant runway otherwise, existing and proposed
- Normal or mean maximum daily temperature of the hottest month
- Pavement strength of each runway in gross weight and type of main gear (single, dual, and dual tandem) as appropriate
- Plan for obstruction removal, relocation of facilities, and so forth

In addition, a wind rose (described in detail later in this chapter) is always included in the airport layout plan drawing with the runway orientation superimposed. Crosswind coverage and the source and period of data are also given. Wind information is given in terms of all-weather conditions, supplemented by IFR weather conditions where IFR operations are expected.

Airport layout plans also include to scale diagrams of all FAR Part 77 surfaces, noise impacted areas, and detailed-to scale drawings of major facilities at the airport, including terminal buildings, aircraft and automobile parking facilities, ground access roads, and public transit infrastructure, such as rail systems

Forecasting

Airport master plans are developed on the basis of forecasts. From forecasts, the relationships between demand and the capacity of an airport's various facilities can be established and airport requirements can be determined. Short-, intermediate-, and long-range (approximately 5-, 10-, and 20-year) forecasts are made to enable the planner to establish a schedule of development for improvements proposed in the master plan.

Two types of forecasting methods are available to assist planners in the decision- making process: qualitative and quantitative.

Qualitative forecasting methods

Qualitative forecasting methods rely primarily on the judgment of forecasters based on their expertise and experience with the airport and surrounding environment. Judgmental predictions of future airport activity tend not to be based on historical data, but by the foresight that certain experts have, based on their knowledge of the current and potential future environment. Qualitative forecasts may almost be thought of as "educated guesses," opinions, or "hunches" of future activity, although they tend to be just as accurate as quantitative methods. Despite this, qualitative forecasts tend to require the support of some quantitative analysis to justify the forecasts to the public. Four of the more popular qualitative methods include: Jury of Executive Opinion, Sales Force Composite, consumer market survey, and the Delphi method.

Quantitative methods

Quantitative forecasting methods are those that use numerical data and mathematical models to derive numerical forecasts. In contrast to qualitative methods, quantitative methods are strictly objective. Because only numerical data are used, quantitative methods do not directly consider any judgment on the part of the forecaster. Quantitative methods are either used as stand-alone forecasting methods, or used to support forecasts made under qualitative methods.

Quantitative methods include *time-series* or *trend analysis models,* which forecast future values strictly on the basis of historical data collected over time, and *causal models,* which attempt to make accurate predictions of the future on the basis of how one area of historical data affects another.

A **causal model** is constructed by finding variables that explain, statistically, the changes in the variable to be forecasted. The availability of data on the variables, or more specifically their specific values, is largely determined by the time and resources the planner has available. For example, the number of aircraft operations forecast to occur at a general aviation airport may be statistically correlated to the strength of the economy, perhaps measured by the average income of residents in the area surrounding the airport.

Another reasonably sophisticated statistical method of forecasting is time-series or trend analysis, the oldest and in many cases still the most widely used method of forecasting air transportation demand. **Time-series** models are based on a measure of time (months, quarters, years, etc.) as the independent or explanatory variable. This method is used quite frequently where both time and data are limited, such as in forecasting a single variable, for example, cargo tonnage, where historical data are obtained for that particular variable.

Regression analysis

The most widely used mathematical method for performing both time-series and causal quantitative forecasts is regression analysis. **Regression analysis** applies specific mathematical formulas to estimate forecast equations. These equations may then be used to forecast future activity by applying the equations to independent variables that may occur in the future. Regression equations come in many forms. The most common regression equation is one that represents a straight line. The method used to estimate the equation of a straight line that best represents either historical trends or causal relationships is known as ordinary least-squares (OLS) linear regression analysis. Although based in sophisticated theories of statistics and calculus, OLS linear regression analysis tools are readily available on most personal computer spreadsheet software such as Microsoft Excel, Corel Quattro Pro, or IBM's mLotus 1-2-3. Other common statistical software tools available for personal computers include SPSS, SAS, and a variety programming languages that may be used to create custom regression models. All that is required of the forecaster is to collect appropriate data, enter the data into a software program, and apply the regression tool. Although applying data to today's regression tools is quite simple, proper interpretation and use of regression results require at least a fundamental knowledge of regression modeling from a theoretical perspective. It is suggested that anyone who will actively participate in performing or interpreting quantitative forecast results, such as those found from regression analysis, seek additional knowledge in statistical modeling.

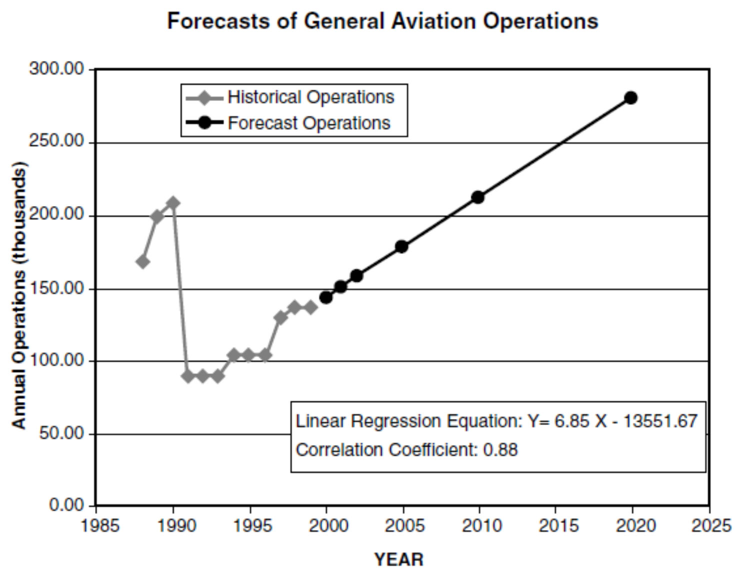


Fig. Example of time-series forecast using OLS linear regression.

Forecasts of aviation demand

Forecasts of aviation demand form the basis for facilities planning. There is a need to know the types of civil airport users, certificated air carriers, commuters, general aviation, and military services where applicable; the types and volume of operational activity, aircraft operations, passengers and cargo, based aircraft, and so forth; and the aircraft fleet mix, jet and large-capacity prop transport aircraft, smaller commercial, corporate, business, and pleasure aircraft, future vertical/short takeoff and landing (V/STOL) aircraft, and so forth.

Civil airport users

The FAA defines the various types of civil airport users as follows. ***Air carriers*** These airline aircraft operators holding Certificates of Public Convenience and Necessity issued by the former Civil Aeronautics Board and based on authorization from the Department of Transportation to perform passenger and cargo services. This general air carrier grouping includes the major, national, large, and medium regional air carriers. ***Commuters*** are non certificated small regionals that perform scheduled service to smaller cities and serve as feeders to the major hub airports. They generally operate aircraft of less than 12,500 pounds maximum gross takeoff weight.

General aviation: General aviation is the segment of civil aviation that encompasses all facets of aviation except air carriers and commuters. General aviation includes air taxi operators, corporate-executive transportation, flight instruction, aircraft rental, aerial application, aerial observation, business, pleasure, and other special users.
Military This category encompasses the operators of all military (Air Force, Army, Navy, U.S. Coast Guard, Air National Guard, and military reserve organizations) aircraft using civil airports.

Operational activity: Six major types of operational activity forecasts are considered necessary to determine future facility requirements.

Enplaning passengers: This activity includes the total number of passengers (air carrier, commuter, and general aviation) departing on aircraft at the airport. Originating, stopover, and transfer passengers are identified separately.

Enplaning air cargo: Enplaning air cargo includes the total tonnage of priority, nonpriority, and foreign mail, express shipments, and freight (property other than baggage accompanying passengers) departing on aircraft at an airport, including originations, stopover, and transfer cargo. Where applicable, domestic and international are identified separately.

Aircraft operations: Aircraft operations include the total number of landings (arrivals) at and takeoffs (departures) from an airport. Two types of operations— local and itinerant—are separately identified: *local operations,* performed by aircraft that operate in the local traffic pattern or within sight of the tower and are known to be departing for or arriving from flight in local practice and flight test areas located within a 20-mile radius of the airport and/or control tower and execute simulated instrument approaches or low passes at the airport; and *itinerant operations,* all aircraft arrivals and departures other than local operations described above. Where applicable, domestic and international itinerant operations should be identified separately. Except for local training flights at some airports, air carrier aircraft movements are itinerant operations. The basic premise underlying the methodology for forecasting air carrier operations by an airport is that a relationship exists between the number of enplaned passengers and cargo shipments and the level of service provided. It is assumed that the number of aircraft seats for transiting and enplaning passengers and the number of flights by type of aircraft have been a function of the traffic demand and traffic characteristics of the communit as well as the route structure and operating policies and practices of the individual carriers. It is also assumed that these same factors will continue to determine the level of operations in the future.

Based aircraft: Based aircraft is the total number of active general aviation aircraft that use or might be expected to use an airport as "home base." General aviation–based aircraft are separately identified as single-engine, multiengine, piston, or turbine, or vertical/short takeoff and landing (V/STOL) aircraft.

Busy-hour operations: Busy-hour operations is the total number of aircraft operations expected to occur at an airport at its busiest hour, computed by averaging the two adjacent busiest hours of a typically high-activity day. One definition of a typically high-activity day would be the average day of the busiest month of the year. The operations are identified by major user category, as applicable.

Aircraft fleet mix: **Fleet mix** is defined as the percentage of aircraft, by type or category,that operate or are based at the airport. Aircraft fleet mix is typically summarized as seating capacity groups for air carrier aircraft and operational characteristics groups for all four of the major airport user categories. By performing a comprehensive forecast of the above measures of airport activity, using both quantitative and qualitative methods, the airport planner has the ability to incorporate into the master plan airport facilities that will accommodate forecast activity.

Facilities requirements

After an inventory of current facilities has been compiled and future aviation activity has been forecast, the next step in the airport master planning process is the assessment of facility requirements. The study of the demand/capacity relationship involves an estimation of the need to expand facilities and the cost of these improvements. This type of analysis is done in consultation with the airlines and the general aviation community. The analysis is applied to aircraft operations versus airfield improvements, passenger enplanements versus terminal building improvements, cargo tonnage versus cargo facility development, airport access traffic versus access roads and rapid transit facilities, and other improvements as might be appropriate. Airspace in the vicinity of the master plan airport is also analyzed.

Demand/capacity analysis is normally applied to short-, intermediate-, and long-range developments (approximately 5, 10, and 20 years). The analysis is only an approximation of facility requirements, their costs, and savings that will result from reduced delays to airport users as well as anticipated revenues that might be obtained from proposed improvements;

thus, demand/capacity analysis will yield preliminary estimates of the number and configuration of runways, areas of apron, number of vehicle parking spaces, and capacities of airport access facilities. Preliminary estimates of economic feasibility may also be obtained. These approximations will provide a basis for developing the details of the airport master plan and for determining the feasibility of improvements considered in the plan.

Aircraft operational requirements

The forecasts of aviation activity will indicate the kinds of aircraft anticipated to use the master plan airport. The frequency of use, passenger/cargo load factors, and lengths of outbound nonstop flights will also be indicated. From this demand data, the planner can ascertain the required physical dimensions of the aircraft operational areas. Although a capacity analysis provides requirements in terms of numbers of runways/taxiways and so forth, the analysis of aircraft operational requirements allows the determination of runway/taxiway/apron dimensions, strengths, and lateral clearances between airport areas. Of course, both of these analyses are interrelated and are accomplished simultaneously in order to determine system requirements.

Capacity analysis

An analysis of the existing air traffic capacity of the area the master plan airport is to serve will help determine how much additional capacity will be required at the master plan airport. Four distinct elements require investigation, namely, airfield and airspace capacity, terminal area capacity, and ground access capacity.

Airfield capacity is the practical maximum rate of aircraft movements on the runway/taxiway system. Levels of demand that exceed capacity will result in a given level of delay on the airfield (see Chap. 12 for a detailed analysis of airfield capacity). The proximity of airports to one another, the relationship of runway alignments, and the nature of operations [IFR or visual flight rules (VFR)] are the principal inter airport considerations that will affect *airspace capacity* of the master plan airport. For example, it is not uncommon in a large metropolitan area to have major or secondary airports spaced so closely that they share one discrete parcel of airspace. In such cases there may be a reduction in the IFR capacity for the airports involved because of the intermixing of traffic within the common parcel of airspace. When this occurs, aircraft, regardless of destination, must be sequenced with the proper separation standards. This reduces the IFR capacity for a specific airport.

Terminal area capacity is the ability of the terminal area to accept the passengers, cargo, and aircraft that the airfield generates. Individual elements within terminal areas must be evaluated to determine overall terminal capacity. Terminal elements included in the analysis are airline gate positions, airline apron areas, cargo apron areas, general aviation apron areas, airline passenger terminals, general aviation terminals, cargo buildings, automobile parking, and aircraft maintenance facilities. The establishment of capacity requirements for the master plan airport will determine the capacity required for airport ground access. A preliminary examination of existing and planned highway and mass transit systems allows a judgment as to the availability of ground access capacity. In determining the volume of people, it is necessary for the planner to establish the percentage relationship between passengers, visitors, and airport employees. This can vary from one urban area to another and from one site to another.

Facility requirements are developed from information obtained in demand/capacity analysis and from FAA advisory circulars and regulations that provide criteria for design of airport components. Demand/capacity analysis yields the approximate number and configuration of runways, number of gates, square footage of terminal buildings, cargo facilities, number of public and employee parking spaces, types of airport access roads, and the overall land area required for the airport. From the mix of aircraft and the number of aircraft operations, general requirements for length, strength, and number of runways; spacing of taxiways; layout and spacing of gates; and apron area requirements can be determined.

Design alternatives

When planning for an airport's future, airport planners develop a series of design alternatives to accommodate forecast levels of demand. These design alternatives are then brought to airport management, the local government, the surrounding community, and often the Federal Aviation Administration to reach a consensus on the recommended design alternative.

- The design alternatives for airports may include:
- The selection of an airport on a new yet undeveloped site
- The plans for design and operation of the airfield and local airspace
- The plans for design and operation of the terminal and ground access Systems

Site selection

One of the design alternatives for the future of an airport may be to design a new airport on an open, or *greenfield,* site. If this is the case, the first and perhaps most important step in this process is that of proper site selection. The major factors that require careful analysis in the final evaluation of airport sites include runway orientation and wind analysis, airspace analysis, surrounding obstructions, availability for expansion, availability of utilities, meteorological conditions, noise impacts, and cost comparisons of alternative sites.

Runway orientation and wind analysis

Planning an airfield with respect to runway orientation is a nontrivial task. Runway orientation planning consists of three tasks:

1. Identifying the Airport Reference Code (ARC) on the basis of an airport's critical aircraft.
2. Analyze historical wind data for the airfield.
3. Apply the Airport Reference Code and historical wind data using a wind rose to find the appropriate orientation of the primary runway and any necessary crosswind runways.

Analyzing historical wind data for the airfield

At airports, wind is typically measured by its velocity (in knots), and direction (in degrees from north). Wind direction and velocity data have historically been recorded on an hourly basis at airports and other areas of interest by the National Oceanic and Atmospheric Administration.

Historical wind data are compiled, categorized, and illustrated by means of a graphical tool called a **wind rose.** A wind rose graphically represents wind speed, and direction by a series of concentric rings, which represent wind speed, and spokes, which represent direction. The center of the wind rose represents calm winds. Rings further out from the center of the wind rose represent winds of increasingly stronger velocity. The spokes represent direction from North. The percentage of time that the wind blows between certain directions and between certain speeds is placed in the cells created from the rings and spokes of the wind rose.

A wind rose is designed to provide the airport planner and manager a visual guide to the appropriate direction of the primary runway and any necessary crosswind runways. By overlaying a proposed runway direction over the wind rose, an airport planner can visually identify the direction of the prevailing winds and assess the approximate percentage of time that the runway orientation will provide less-than-maximum tolerable crosswinds. This is performed by adding up the percentages found within the "runway template." The "width" of the runway template is associated with the maximum crosswind component associated with the Airport Reference Code for the airport.

Airspace analysis

In major metropolitan areas, it is not uncommon for two or more airports to share common airspace. This factor might restrict the capability of any one airport to accept IFR traffic under adverse weather conditions. Airports too close to each other can degrade their respective capabilities and create a serious traffic control problem. It is important to analyze the requirements and future needs of existing airports before considering construction sites for a new airport.

Surrounding obstructions

Obstructions in the vicinity of the airport sites, whether natural, existing, or proposed man-made structures, must meet the criteria set forth in Federal Aviation Regulations .The FAA requires that clear zones at the ends of runways be provided by the airport operator. **Runway clear zones** are areas comprising the innermost portions of the runway approach areas. The FAA requires that the airport owner have "an adequate property interest" in the clear zone area in order that the requirements of FAR Part 77 can be met and the area protected from future encroachments. Adequate property interest might be in the form of ownership or a long-term lease or other demonstration of legal ability to prevent future obstructions in the runway clear zone.

Availability for expansion

Available land for expansion of the airport is a major factor in site selection; however, it is not always necessary to purchase the entire tract at the start because adjacent land needed for future expansion could be protected by lease or option to buy. The Airport and Airway Development Act of 1970 first established funding for communities to acquire land for future airport development.

Noise

Noise is the most predominant objection raised by opponents to new airports and airport expansion projects. Numerous efforts are being made by industry and government to seek new and better ways to reduce aircraft sound levels. Many of the older jet aircraft are now being retrofitted with noise kits that are designed to reduce noise. Engine manufacturers are exploring new engineering concepts and designs that will reduce this source of noise to an absolute minimum. Pilots of airliners are required to maintain certain power settings and to fly prescribed routes that reduce noise levels in the vicinity of takeoff and landing areas. Noise certification standards have been established by the FAA for new aircraft.

Terminal area plans

The primary objective of the terminal area plans is to achieve an acceptable balance between passenger convenience, operating efficiency, facility investment, and aesthetics. The physical and psychological comfort characteristics of the terminal area should afford the passenger orderly and convenient progress from automobile or public transportation through the terminal to the aircraft and back again. A detailed description of airport terminal geometries, along with the facilities that are found in airport terminals, is provided in Chap. 6 of this text. One of the most important factors affecting the air traveler is walking distance. It begins when the passenger leaves the ground transportation vehicle and continues on to the ticket counter and to the point at which he or she boards the aircraft. Consequently, terminals are planned to minimize the walking distance by developing convenient auto parking facilities, convenient movements of passengers through the terminal complex, and conveyances that will permit fast and efficient handling of baggage. The planner normally establishes objectives for average walking distances from terminal points to parked aircraft. Conveyances for passengers such as moving walks and baggage handling systems are also considered.

Airport access plans

The airport access plans are an integral part of the master planning process. These plans indicate proposed routing of airport access to the central business district and to points of connection with existing or planned ground transportation arteries. All modes of access are considered, including highways, rapid transit, and access by vertical and short takeoff and landing (V/STOL) aircraft. The estimated capacity requirement for the various modes considered is determined from forecasts of passengers, cargo, and aircraft operations. The airport access plans normally are general in nature because detailed plans of access outside the boundaries of the airport will be developed by highway departments, transit authorities, and comprehensive planning bodies

Financial plans

The financial plan is an economic evaluation of the entire plan of development. It looks at the master plan activity forecasts from the point of view of revenues and expenditures, analyzing the airport’s balance sheet over the planning period to ensure that the airport sponsor can afford to proceed. A corollary activity in this phase is the consideration of funding sources and financing methods for the proposed development.

Economic evaluation

Although the primary objective of the airport master plan is to develop a design concept for the entire airport, it is essential to test the economic feasibility of the plan from the standpoints of airport operation and individual facilities and services. Economic feasibility will depend on whether the users of the airport improvements programmed under the plan can produce the revenues (as might be supplemented by federal, state, or local subsidies) required to cover annual cost for administration, operation, and maintenance. This must be determined for each stage of development scheduled in the master plan. This consideration includes the cost of capital to be employed in financing the improvement, the annual operating costs of facilities, and prospective annual revenues.

This preliminary cost estimate for each of the proposed improvements provides the basic capital investment information needed for evaluating the feasibility of the various facilities. Estimated construction costs are adjusted to include allowance for architect and engineering fees for preparation of detailed plans and specifications, overhead for construction administration, allowance for contingencies, and allowance for interest expenses during construction. Estimated costs of land acquisitions as well as the costs of easements required to protect approach and departure areas are included. If the master plan provides for the expansion of an existing airport, the cost of the existing capital investment might be required to be added to the new capital costs. The airport layout plan also indicates the stage development of the proposed facilities. The drawings are normally written with appropriate legends to indicate staging shown on the plan, either on single or separate sheets. Charts that show the schedule of development for various items of the master plan are developed for inclusion in the master plan report.

Land use planning

The airport land use plan shows on-airport land uses as developed by the airport sponsor under the master plan effort and off-airport land uses as developed by surrounding communities. The work of airport, city, regional, and state planners must be carefully coordinated. The configuration of airfield runways, taxiways, and approach zones established in an airport layout plan provides the basis for development of the land use plan for areas on and adjacent to the airport. The land use plan for the airport and its environment in turn is an integral part of an area wide comprehensive planning program. The location, size, and configuration of the airport need to be coordinated with patterns of residential and other major land uses in the area, as well as with other transportation facilities and public services. Within the comprehensive planning framework, airport planning, policies, and programs must be coordinated with the objectives, policies, and programs for the area that the master plan airport is to serve.

Land uses on the airport

The amount of acreage within the airport's boundaries will have a major impact on the types of land uses to be found on the airport. For airports with limited acreage, most land uses will be aviation oriented. Large airports with a great deal of land in excess of what is needed for aeronautical purposes might be utilized for other uses. For example, many airports lease land to industrial users, particularly those who employ business aircraft or whose personnel travel extensively by air carrier or charter. In many cases, taxiway access is provided directly to the company's facility. In some instances, railroad tracks serving the company's area, company parking lots, or low-level warehousing can be located directly under runway approaches (but free of clear zones). Companies that might produce electronic disturbances that would interfere with aircraft navigation or communications equipment or cause visibility problems because of smoke are not compatible airport tenants.

Some commercial activities are suitable for location within the airport's boundaries. Recreational uses such as golf courses and picnicking areas are quite suitable for airport land and might in effect serve as good buffer areas. Certain agricultural uses are appropriate for airport lands, but grain fields that attract birds are avoided. Although lakes, reservoirs, rivers, and streams might be appropriate for inclusion within the airport's boundaries, especially from the standpoints of noise or flood control, care is normally taken to avoid those water bodies that have in the past attracted large numbers of waterfowl. Dumps and landfills that might attract birds are also avoided.

Land uses around the airport

The responsibility for developing land around the airport so as to maximize the compatibility between airport activity and surrounding activities, and minimize the impact of noise and other environmental problems, lies with the local governmental bodies. The more political entities that are involved, the more complicated the coordination process becomes. In the past, the most common approach to controlling land uses around the airport was zoning. Airports and their surrounding areas become involved in two types of zoning. The first type of zoning is height and hazard zoning, which protects the airport and its approaches from obstructions to aviation while restricting certain elements of community growth.

The second type of zoning is land use zoning. This type of zoning has several shortcomings. First, it is not retroactive and does not affect preexisting uses that might conflict with airport operations. Second, jurisdictions with zoning powers (usually cities, towns, or counties) might not take effective zoning action. This is partly because the airport might affect several jurisdictions and coordination of zoning is difficult. Or the airport might be located in a rural area where the county lacks zoning powers and the sponsoring city might not be able to zone outside its political boundaries. Another problem is that the interest of the community is not always consistent with the needs and interests of the aviation industry. The locality might want more tax base, population growth, and rising land values, all of which are not often consistent with the need to preserve the land around the airport for other than residential uses.

Another approach to land use planning around the airport is subdivision regulations. Provisions can be written into the regulations prohibiting residential construction in intense noise-exposure areas. These areas can be determined by acoustical studies prior to development. Insulation requirements can be made a part of the local building codes, without which the building permits cannot be issued.

Finally, another alternative in controlling land use around the airport is the relocation of residences and other incompatible uses. Often urban renewal funds are available for this purpose.

Environmental planning

For any proposed airport planning project, a review of how such expansion would affect the surrounding environment must be performed. This requirement was first established in the Airport and Airway Development Act of 1970 and the Environmental Policy Act of 1969. The National Environmental Policy Act of 1969 requires the preparation of detailed environmental statements for all major federal airport development actions significantly affecting the quality of the environment. The Airport and Airway Development Act of 1970 directed that no airport development project may be approved by the Secretary of Transportation unless he or she is satisfied that fair consideration has been given to the communities in or near which the project may be located.

For every proposed project, an **Environmental Impact Review (EIR)** is performed. The results of the review may find that there will be no significant impact to the surrounding environment as a result of the project. If this finding is realized then a **Finding of No Significant Impact (FONSI)** statement is issued. If the EIR reveals that there is the potential for significant environmental impact as a result of the project, then a more comprehensive **Environmental Impact Statement (EIS)** must be developed. The EIS states specifically the areas of the environment that will be impacted and the degree of impact on the environment, and, most important, requires a plan on the part of the airport to mitigate those impacts.

Studies of the impact of construction and operation of the airport or airport expansion upon accepted standards of air and water quality, ambient noise levels, ecological processes, and natural environmental values are conducted to determine how the airport requirements can best be accomplished. An airport is an obvious stimulus to society from the standpoints of economic growth and the services it offers to the public; however, this generation of productivity and employment might be negated by noise and air pollution and ecological compromises if compatibility between an airport and its environs is not achieved; thus, the airport master plan must directly contend with these problems identified in the studies of environmental qualities so that the engineering of airport facilities will minimize or overcome those operations that contribute to environmental pollution.

In line with the above guidelines and policy, an airport master plan (including site selection) must be evaluated factually in terms of any proposed development that is likely to:

- Noticeably affect the ambient noise level for a significant number of people
- Displace significant numbers of people
- Have a significant aesthetic or visual effect
- Divide or disrupt an established community or divide existing uses (e.g., cutting off residential areas from recreation or shopping areas)
- Have any effect on areas of unique interest or scenic beauty
- Destroy or detract from important recreational areas
- Substantially alter the pattern of behavior for a species
- Interfere with important wildlife breeding, nesting, or feeding grounds
- Significantly increase air or water pollution
- Adversely affect the water table of an area

The airport master plan is commonly thought of as a "living document" whose contents adapt to constant changes in community needs. A robust master plan is one that helps airport planners and management maintain and develop an airport that meets the needs of the community, surrounding environment, and the nation's aviation and transportation system overall.

UNIT-3
GROUND HANDLING

Introduction

The passenger and cargo terminals have been described as interface points between the air and ground modes (Ashford et al. 2011). The movement of passengers, baggage, and cargo through the terminals and the turnaround of the aircraft on the apron are achieved with the help of those involved in the ground handling activities at the airport (IATA 2012). These activities are carried out by some mix of the airport authority, the airlines, and special handling agencies depending on the size o the airport and the operational philosophy adopted by the airport operating authority. For convenience of discussion, ground handling procedures can be classified as either terminal or airside operations. Such a division, however, is only a convention in that the staff and activities involved are not necessarily restricted to these particular functional areas. Below Table lists the airport activities normally classified under ground handling operations.

Terminal
Baggage check
Baggage handling
Baggage claim
Ticketing and check-in
Passenger loading/unloading
Transit passenger handling
Elderly and disabled persons
Information systems
Government controls
Load control
Security
Cargo
Airside
Ramp services
Supervision
Marshaling
Startup
Moving/towing aircraft
Safety measures
On-ramp aircraft servicing
Repair of faults
Fueling
Wheel and tire check
Ground power supply
Deicing
Cooling/heating
Toilet servicing
Potable water
Demineralized water
Routine maintenance
Nonroutine maintenance
Cleaning of cockpit windows, wings, nacelles, and cabin windows
Onboard servicing cleaning
Catering
In-flight entertainment
Minor servicing of cabin fittings
Alteration of seat configuration
External ramp equipment
Passenger steps
Catering loaders
Cargo loaders
Mail and equipment loading
Crew steps on all freight aircraft

TABLE 1 .The Scope of Ground Handling Operations

Passenger Handling

Passenger handling in the terminal is almost universally entirely an airline function or the function of a handling agent operating on behalf of the airline. In most countries of the world, certainly at the major air transport hubs, the airlines are in mutual competition. Especially in the terminal area, the airlines wish to project a corporate image, and passenger contact is almost entirely with the airline, with the obvious exceptions of the governmental controls of health, customs, and immigration. Airline influence is perhaps seen at its extreme in the United States, where individual airlines on occasion construct facilities (e.g., the old United terminal and the new Jet Blue terminals at New York JFK). In these circumstances, the airlines play a significant role in the planning and design of physical facilities that they will operate. Even where there is no direct ownership of facilities, industry practice involves the designation of various airport facilities that are leased to the individual airlines operating these areas. Long-term designation of particular areas to an individual airline results in a strong projection of airline corporate image, particularly in the ticketing and checkin areas and even in the individual gate lounges.

A more common arrangement worldwide is for airlines to lease designated areas in the terminal, but to have a large proportion of the ground handling in the ramp area carried out by the airport authority, a special handling agency, or another airline. At a number of international airports, the airline image is considerably reduced in the checkin area when common-user terminal equipment (CUTE) is used to connect the checkin clerk to the airline computers. Use of the CUTE system can substantially reduce the requirements for numbers of checkin desks, particularly where there is a large number of airlines and some airlines have very light service schedules or the airline presence is not necessary throughout the whole day. Desks are assigned by resource managers on a need basis. Checkin areas are vacated by one airline and taken up by another based on departure demand. The airline’s presence at checkin desks is displayed on overhead logo panels that are activated when an airline logs onto the CUTE system Common Use Self Service or CUSS is a shared kiosk offering checkin facilities to passengers without the need for ground staff. The CUSS kiosks can be used by several participating airlines in a single terminal.

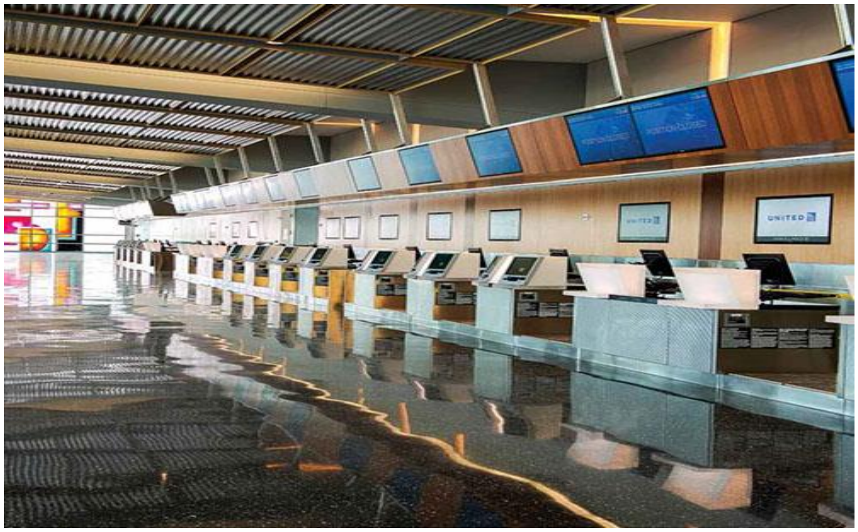


Fig. Computer-assigned CUTE passenger checkin desks

The airside passenger-transfer steps and loading bridges might be operated by the airline on a long-term leasing arrangement or by the airport authority or handling agency at a defined hiring rate to the airlines. With the advent of very large aircraft (e.g., the A380), multiple loading bridges are required to cope with passenger flows to and from a single aircraft. They require experienced handling, but even these are normally operated by the airlines.

Fig. Airline passenger steps

Fig. Elevating passenger air bridge.

Fig. Three-loading-bridge configuration serving an A380.

Apron passenger-transfer vehicles are usually of the conventional bus type. Both airline and airport ownership and operation are common, airline operation being economically feasible only where the carrier has a large number of movements below figures shows a typical airport-owned apron bus. Where a more sophisticated transfer vehicle, such as the mobile lounges also shown are used, it is usual for the operation to be entirely in the hands of the airport authority.

Fig.Apron passenger transport bus.   *Fig.Mobile lounge for passenger transport across the apron*

Ramp Handling

During the period that an aircraft is on the ground, either in transit or on turnaround, the apron is a center of considerable activity (IATA 2004). Some overall supervision of activities is required (ICAO 2010) to ensure that there is sufficient coordination of operations to avoid unnecessary ramp delays. This is normally carried out by a ramp coordinator or dispatcher who monitors departure control. Marshaling is provided to guide the pilot for the initial and final maneuvering of the aircraft in the vicinity of its parking stand position. In the delicate process of positioning the aircraft, the pilot is guided by internationally recognized hand signals from a signalperson positioned on the apron. Where nose-in docking is used next to a building, self-docking guides such as the Aircraft Parking and Information System (APIS) using optical moiré technology or the Docking Guidance System (DGS) using sensor loops in the apron pavement enabling the pilot to bring the aircraft to a precise location to permit the use of loading bridges (Ashford et al. 2011). Marshaling includes the positioning and removal of wheel chocks, landing-gear locks, engine blanking covers, pitot covers, surface control locks, cockpit steps, and tail steadies. Headsets are provided to permit ground-to-cockpit communication, and all necessary electrical power for aircraft systems is provided from a ground power unit. When the aircraft is to spend an extended period on the ground, the marshaling procedure includes arranging for remote parking or hangar space.

The ramp handling process also includes the provision, positioning, and removal of the appropriate equipment for engine starting purposes. Below Figure shows an engine air-start power unit suitable for providing for a large passenger aircraft.

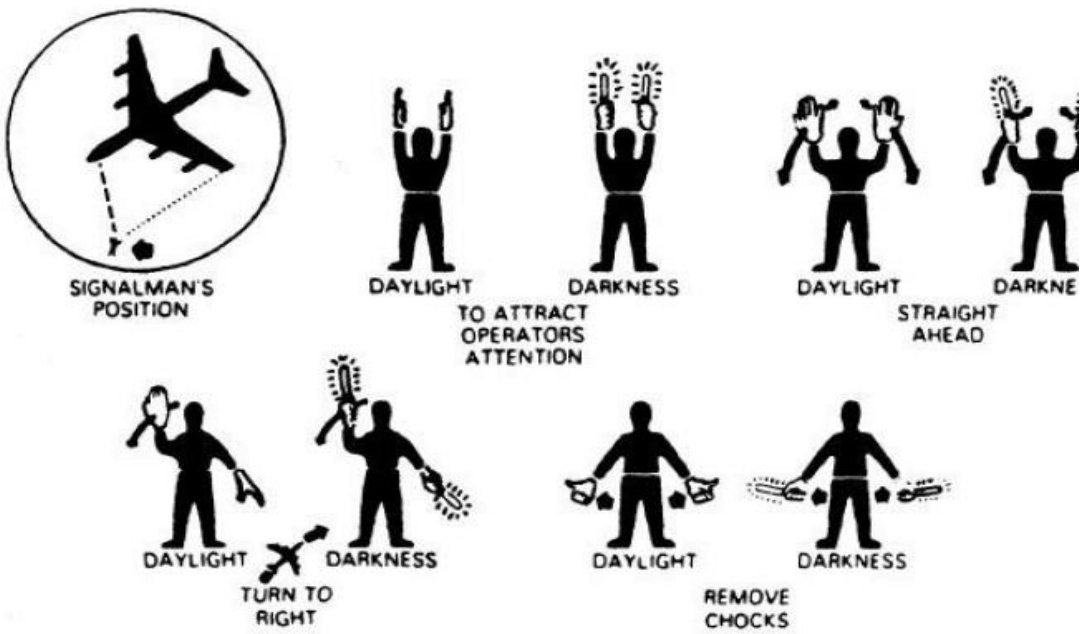


Fig. Ground signalman marshalling an aircraft. (Courtesy: IATA.)

Fig. Mobile apron engine air-start vehicle.

Safety measures on the apron include the provision of suitable firefighting equipment and other necessary protective equipment, the provision of security personnel where required, and notification of the carrier of all damage to the aircraft that is noticed during the period that the aircraft is on the apron. Frequently there is a necessity for moving an aircraft, requiring the provision and operation of suitable towing equipment. Tow tractors might be needed simply for pushing out an aircraft parked in a nose-in position or for more extensive tows to remote stands or maintenance areas. Below figure shows a tractor suitable for moving a large passenger aircraft. It is normal aircraft-design practice to ensure that undercarriages are sufficiently strong to sustain towing forces without structural damage. Tow tractors must be capable of moving aircraft at a reasonable speed [12 mi/h (20 km/h) approximately] over considerable taxiway distances. As airports grow larger and more decentralized in layout, high-speed towing vehicles capable of operating in excess of 30 mi/h (48 km/h) have been developed, although speeds of 20 mi/h (32 km/h) are more common. Usually aircraft that are being towed have taxiway priority once towing has started. Therefore, reasonable tow speeds are necessary to avoid general taxiing delays.

FIGURE .Aircraft tow tractor.

Aircraft Ramp Servicing

Most arriving or departing aircraft require some ramp services, a number of which are the responsibility of the airline station engineer. When extensive servicing is required, many of the activities must be carried out simultaneously.

Fault Servicing

Minor faults that have been reported in the technical log by the aircraft captain and that do not necessitate withdrawal of the aircraft from service are fixed under supervision of the station engineer.

Fueling

The engineer, who is responsible for the availability and provision of adequate fuel supplies, supervises the fueling of the aircraft, ensuring that the correct quantity of uncontaminated fuel is supplied in a safe manner. Supply is either by mobile truck or from the apron hydrant system. Many airports use both systems to ensure competitive pricing from suppliers and to give maximum flexibility of apron operation. Oils and other necessary equipment fluids are replenished during the fueling process.

FIG.Mobile apron fuel tanker (bowser).

FIG.Mobile aircraft fuel dispenser for fueling from apron hydrant system.

Wheels and Tires

A visual physical check of the aircraft wheels and tires is made to ensure that no damage has been incurred during the last takeoff/ landing cycle and that the tires are still serviceable.

Ground Power Supply

Although many aircraft have auxiliary power units (APUs) that can provide power while the aircraft is on the ground, there is a tendency for airlines to prefer to use ground electrical supply to reduce fuel costs and to cut down apron noise. At some airports, the use of APUs is severely restricted on environmental grounds. Typically, ground power is supplied under the supervision of the station engineer by a mobile unit. Many airports also can supply power from central power supplies that connect to the aircraft either by apron cable or by cable in the air-bridge structure.

Fig. Apron cable electrical supply

Deicing and Washing

Below fig shows a typical multiuse vehicle suitable for spraying the fuselage and wings with deicing fluid and for washing the aircraft, especially the cockpit windows, wings, nacelles, and cabin windows. This self-propelled tanker unit provides a stable lift platform for spraying or for various maintenance tasks on conventional and wide-bodied aircraft. Apron drainage facilities must permit the recapture and recycling of deicing fluid (ICAO 2000)

FIG. Deicing/washer vehicle.

Cooling/Heating

In many climates where an aircraft is on the apron for some time without operation of the APU, auxiliary mobile heating or cooling units are necessary to maintain a suitable internal temperature in the aircraft interior. The airline station engineer is responsible for ensuring mthe availability of such units. With increasing fuel costs and environmental concern, much interest has been focused on centralized compressed-air units delivering air to the aircraft gate positions (usually called fixed air supply or preconditioned air,) and to mobile compressors at the gates (known simply as compressed-air systems). Pneumatic systems can deliver high pressure air for both heating and cooling and for air-starting the engines. Where fixed air systems are used, cockpit controls can ensure either internal heating or cooling on an individual aircraft basis depending on the requirement. Studies indicate that the high cost of running aircraft APUs now means that fixed air systems can completely recover capital costs from the savings of two years of normal operation. Where airlines have infrequent flights to an airport, APUs are still used.

Fig. Fixed ground cooling unit attached to an air bridge.

Other Servicing

Toilet holding tanks are serviced externally from the apron by special mobile pumping units. Demineralized water for the engines and potable water are also replenished during servicing.

Onboard Servicing

While external aircraft servicing is being carried out, there are simultaneous onboard servicing activities, principally cleaning and catering. Very high levels of cabin cleanliness are achieved by

- Exchange of blankets, pillow, and headrests
- Vacuuming and shampooing of carpets
- Clearing of ashtrays and removal of all litter
- Restocking of seatback pockets
- Cleaning and restocking of galleys and toilets
- Washing of all smooth areas, including armrests

Catering

Personnel clear the galley areas immediately after disembarkation of the incoming passengers. After the galley has been cleaned, it is restocked, and a secondary cleaning takes care of spillage during restocking. Internationally agreed standards of hygiene must be met in the handling of food and drink from their point of origin to the passenger. Where route stations are unable to meet either quality or hygiene standards, catering supplies are often brought from the main base. Below Figure shows the loading operation of a catering truck. These trucks are usually constructed from a standard truck chassis with a closed-van body that can be lifted up by a hydraulic scissor lift powered by the truck engine. Two different types of catering trucks are available: low-lift vehicles suitable for servicing narrow-bodied aircraft up to 11.5 feet (3.5 m) doorsill height and high-lift vehicles for loading wide-bodied jets.

Fig. Catering truck in loading position.

Ramp Layout

During the design phase of a commercial air transport aircraft, considerable thought is given to the matter of ramp ground handling. Modern aircraft are very large, complicated, and expensive. Therefore, the apron servicing operation is also complicated and consequently time-consuming. Unless the ramp servicing procedure can be performed efficiently, with many services being carried out concurrently, the aircraft will incur long apron turnaround times during which no productive revenue is earned. Inefficient ramp servicing can lead to low levels of aircraft and staff utilization and a generally low level of airline productivity. The complexity of the apron operation becomes obvious when below Figure is examined. This figure shows the apron positions typically designated for servicing and loading equipment for a Boeing 747. It can be seen that the aircraft door and servicing point layout has been arranged to permit simultaneous operations during the short period that the vehicle is on the ground during turnaround service. The ramp coordinator is required to ensure that suitable equipment and staff numbers are available for the period the aircraft is likely to be on the ground. Complicated as Figure is, it hardly shows the true complexity of the problem. Because the ground equipment is necessarily mobile, the neat static position shown is made less easy by problems of maneuvering equipment into place. Positioning errors can seriously affect the required free movement of cargo trains, transporters, and baggage trains. Over the last 25 years, the arrival of low-cost carriers (LCCs) has put considerable pressure on ramp efficiency with the demand for very short turnaround times. Some LCCs have negotiated contracts with the airport company that stipulate forfeiture of landing charges when a turnaround time of as low as 20 minutes is exceeded.

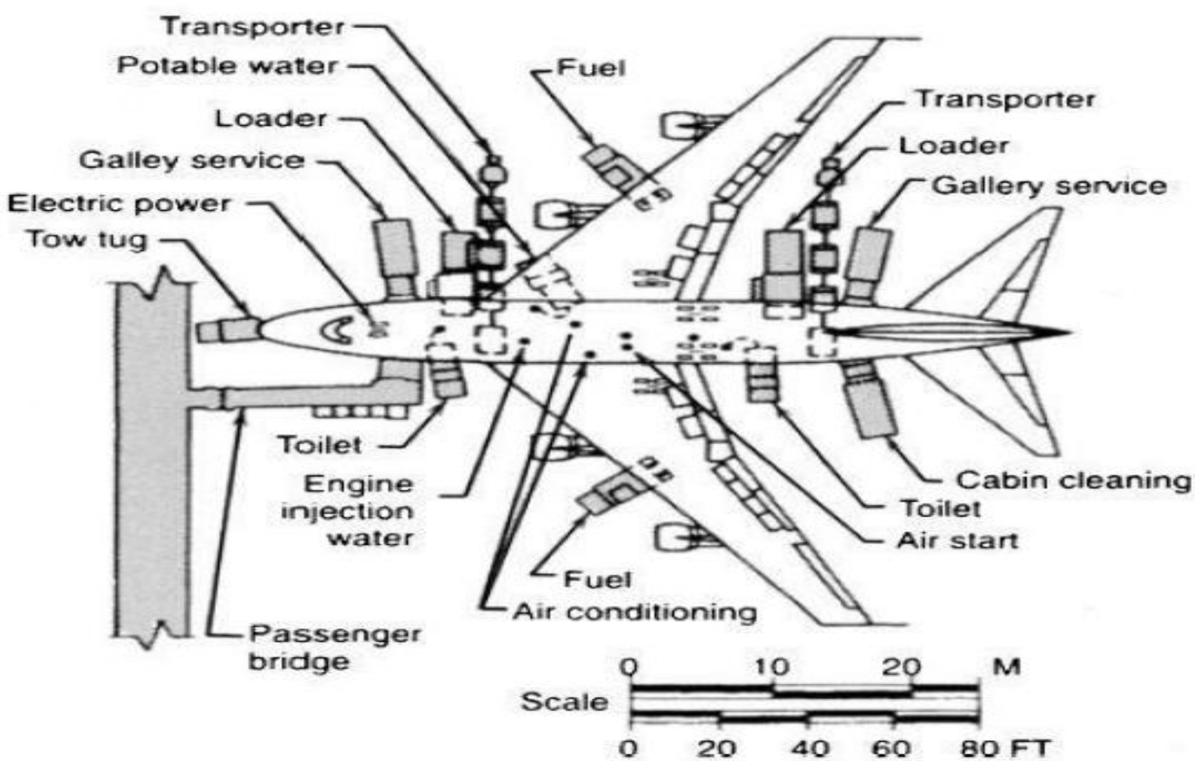


Fig. Ramp layout for servicing a B747SP.
Note: Under normal conditions, external electrical power, air-start, and air conditioning are not required when the auxiliary power unit is used. (Courtesy: Boeing Airplane Company.)

Particular attention must be paid to the compatibility of apron handling devices with the aircraft and other apron equipment. The sill height of the aircraft must be compatible with passenger and freight loading systems. In the case of freight, there is the additional directional compatibility requirement. Transporters must be able to load and unload at both the aircraft and the terminal onto beds and loading devices that are compatible with the vehicles' direction of handling. Many transporters can load or unload in the one direction only. The receiving devices must be oriented to accept this direction.

Most mobile equipment requires frequent maintenance. In addition to normal problems of wear, mobile apron equipment is subject to increased damage from minor collisions and misuse that do not occur in the same degree with static equipment. Successful apron handling might require a program of preventive maintenance on apron equipment and adequate backup in the inevitable case of equipment failure.

Safety in the ramp area is also a problem requiring constant attention. The ramps of the passenger and cargo terminal areas are high-activity locations with much heavy moving equipment in a high-noise environment. Audible safety cues, such as the noise of an approaching or backing vehicle, are frequently not available to the operating staff members, who are likely to be wearing ear protection. Very careful training of the operating staff is required, and strict adherence to designated safety procedures is necessary to prevent serious accidents (IATA 2012; CAA 2006).

Departure Control

The financial effects of aircraft delay fall almost entirely on the airline. The impact of delays in terms of added cost and lost revenue can be very high. Consequently, the functions of departure control, which monitors the conduct of ground handling operations on the ramp (not to be confused with ATC departure), are almost always kept under the control of the airline or its agent. Where many of the individual ground handling functions are under the control of the airport authority, there also will be general apron supervision by the airport authority staff to ensure efficient use of authority equipment.

Division of Ground Handling Responsibilities

There is no hard-and-fast rule that can be applied to the division of responsibility for ground handling functions at airports. The responsibility varies not only from country to country but also among airports in the same country. Prior to airline deregulation, handling activities were carried out mainly by airlines (acting on their own behalf or for another airline) or the airport authority. The converse was almost universally true in the United States. Virtually all airport ground handling was carried out by the airlines. Since deregulation, there has been a general movement toward liberalization and the introduction of competition in airport operations. In the mid-1990s, the European Union introduced regulations that required airports to use two or more ground handing operators where the scale of operation made this economic (EC 1996). This policy has been mirrored all around the world. Specialist companies are now providing some or all ground handling services at most large and medium sized airports. In some facilities, the airlines still prefer to use their own staff where there is major contact between the company and the public. Ticketing, checkin, and lounge services are retained by the airline, but on the ramp, functions such as marshaling, steps, loading and unloading of baggage and cargo, and engine starts are carried out by the handling companies.

Airports using only one ground handling organization are also vulnerable to severe industrial action from a relatively small group of workers. Gains in efficiency may be more than lost in unreasonable wage claims, and it might be difficult to introduce any level of competition once a monolithic agency has been set up, which is why the European Commission (EC) has introduced regulations that discourage or prevent monopoly positions in ground handling (EC 1996). The very scale of large airports to a degree negates the idea of being able to operate ground equipment from one pool. Physically, the total provision probably will have to be broken into a number of relatively self-sufficient and semiautonomous organizations based on the various parts of a single large terminal or on the individual-unit terminals of a decentralized design.

In general, the ground handling function is not an area of considerable profit for an airport authority. Labor and equipment costs are high, and in general, either revenues barely cover attributable expenses or, as in many cases, are actually less than costs. These losses often are cross-subsidized using revenues from other traffic areas, such as landing fees or non traffic concession revenues.

Control of Ground Handling Efficiency

The extreme complexity of the ground handling operation requires skilled and dexterous management to ensure that staff and equipment resources are used at a reasonable level of efficiency. As in most management areas, this is achieved by establishing a system of control that feeds back into the operation when inefficiencies appear. The method of control used at any individual airport depends on whether the handling is carried out by the airline itself, by a handling agency such as another airline, or by the airport authority.

Four major reporting tools help to determine whether reasonable efficiency is being maintained and permit the manager to discern favorable and unfavorable operational changes. To ensure an overall level of operational acceptability, periodic inspections of operations and facilities must be made. This is especially important for airlines carrying out their own handling away from their main base or at airports where they are handled by other organizations. For the airport operation, it is equally important. Whether or not the handling is carried out by the airport, the general standards reflect on airport image. Inspections ensure that agreed standards are maintained and highlight areas where standards are less than desirable.

Baggage Handling

Baggage handling is an essential element of airport operations, but as with other utility functions, it is often remarked on only when it goes wrong. The effects of failure can range from a few passengers not receiving their bags when they arrive at their destination to the widespread disruption of airport operations, including flight cancellations, along with all that such events entail for airlines and passengers.

An analysis of customer complaints over the period 2009–2012 fig shows that baggage-related issues accounted for less than 5 percent of all complaints. A total of 3.8 percent of complaints are attributable to third parties–airlines and their handlers–and only 0.3 percent are attributable to terminal operations–the baggage handling systems themselves.

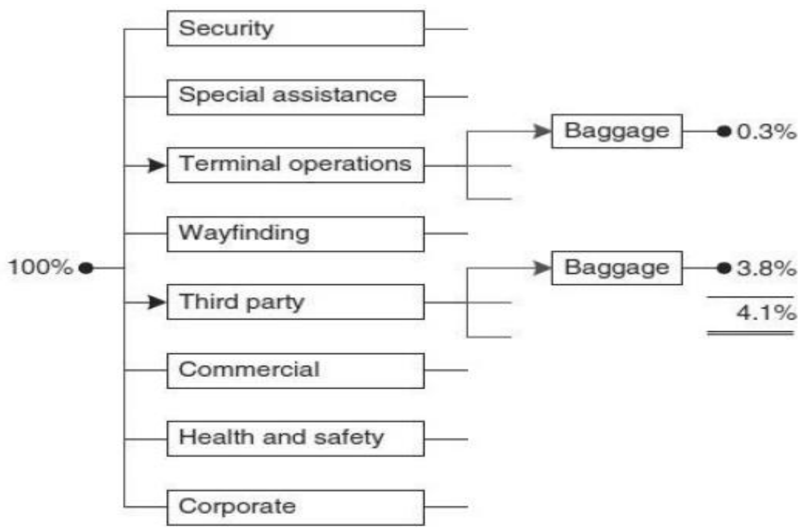


FIG. Baggage component of customer complaints.

Baggage-Handling Processes

A typical set of baggage processes is shown in Figure While all commercial airports will have checkin, reclaim, and flight build facilities (also called makeup), only hub airports will have any significant transfer-baggage facilities. Hub airports with multiple terminals also may have a significant inter terminal transfer process connecting passengers and their bags arriving at one terminal with their departure flights in a different terminal.

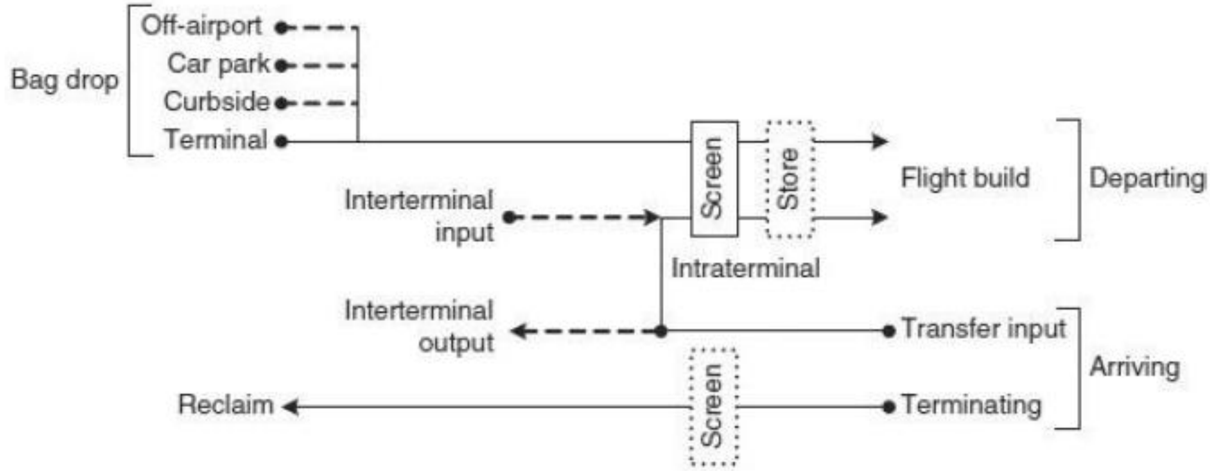


FIGURE . Typical baggage processes.

Bags entering the system via a bag drop generally will be screened in the terminal of departure. Once in the baggage system, optionally, they may be stored and then delivered to a flight build output. From there they are taken to the departing aircraft and loaded.

Terminating bags arriving at a terminal will be delivered to reclaim for collection by passengers. In some circumstances and jurisdictions, terminating bags are screened for illicit items.

Transfer bags arriving at a terminal will be input into the baggage system and routed to the terminal of departure. Once there, the process follows that for locally checked-in baggage. The major elements in this process are described in turn in the following sections.

Bag Drop

Off-airport checkin can be offered in a number of ways including in-town airline offices, checkin counters at downtown train stations, and services supporting checkin and bag drop at hotels. For example, in Hong Kong, most airlines have checkin counters at both Hong Kong and Kowloon Stations. Airport Express passengers can check in and leave baggage at these facilities so that they are free to visit the city for the rest of day before leaving for the airport without having to carry their baggage around with them.

Car-park and curbside checkins are convenient ways to check in for a flight and to drop bags without having to take them through a crowded airport building. They typically operate as follows:

- Pull up to a booth in a car park or the curb adjacent to the departure terminal, and present a photo ID along with a confirmation number, destination, flight number, or e-ticket number to an agent.

- Hand checked bags to the agent, collect the baggage receipt and boarding pass, and proceed straight to security.

Hold Baggage Screening

Once bags have entered the baggage system, generally they will be screened using in-line x-ray machines [also known as explosive detection systems (EDS)] to ensure that dangerous or prohibited items are not present. A typical European screening process is shown in Figure.

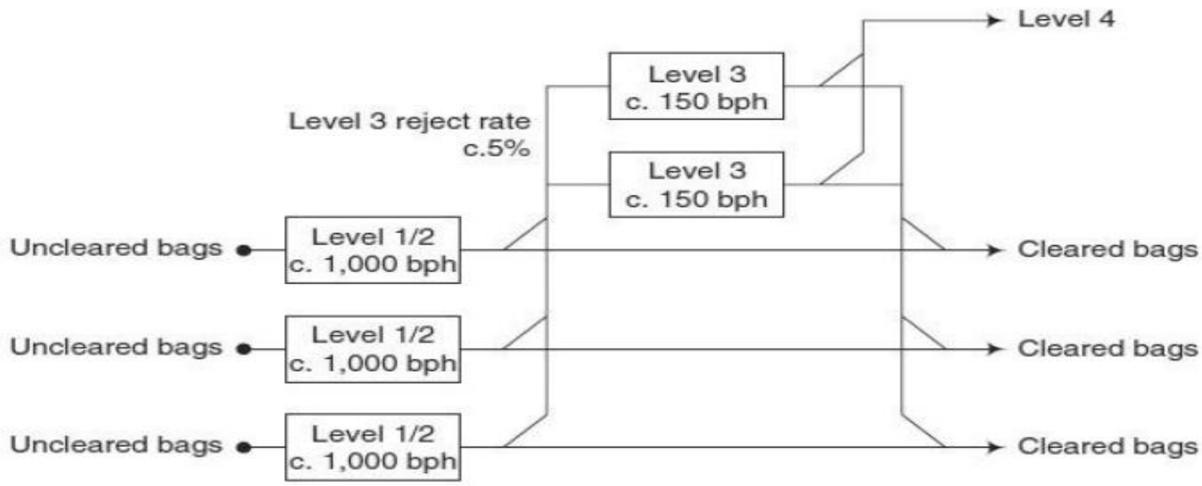


FIGURE .Multilevel screening protocol.

The multilevel protocol adopted in the United States is as follows: Level 1 screening is performed with EDS units. All bags that can physically fit in an EDS unit are directed to level 1 screening and scanned using an EDS.

All bags that automatically alarm at level 1 are subject to level 2 screening. During level 2 screening, Transportation Security Administration (TSA) personnel view alarm bag images captured during the level 1 EDS scan and clear any bags whose status can be resolved visually. All bags that cannot be resolved at level 2 and all bags that cannot be directed to level 1 because of size restrictions are sent to level 3 screening. Level 3 screening is performed manually and involves opening the bag and the use of explosive-trace-detection (ETD) technology. Bags that do not pass level 3 screening (typically, a small percent age of total bags) are either resolved or disposed of by a local law enforcement officer. The TSA has published guidelines and design standards for hold-baggage screening that provide an excellent introduction to the U.S. implementation of hold-baggage screening (TSA 2011).

Bag Storage

Originally, baggage-handling systems had no need to provide bag storage–bags for a flight were accepted at checkin only when the flight makeup positions were available for use, typically two to three hours before the scheduled departure time. Over time, the need for additional bag storage has increased. One factor is the growth in transfer traffic, which can mean that an inbound flight and its connecting bags arrive well before the planned flight makeup positions for the departing flight are open. Another reason is the desire to allow passengers to check in bags when they choose. And increasingly, bag stores can be used to manage and buffer the flow of bags to flight makeup positions, thereby enabling more efficient use of staff and infrastructure or even supporting robotic loading systems (e.g., at Schiphol Airport).

Flight Build and Aircraft Loading

Bags that have been processed and sorted ultimately are delivered to outputs where they are loaded either into ULDs or trailers. ULDs are containers into which bags and cargo can be loaded.

The number of makeup positions allocated per flight will depend on the expected volume of baggage, the flight build time, and the number of segregations into which bags have to be sorted. This can vary from one or two positions for small aircraft to 10 or more for larger aircraft with complex terminating and transfer products.

Transfer Input

Transfer bags need to be processed and, if on a minimum connection time, processed rapidly. To enable this, bags should be loaded into segregated ULDs on the inbound aircraft at the outstation. These short-connect ULDs then can be unloaded as a priority from the aircraft and taken to transfer input locations. Bags then are removed from the ULDs and input into the baggage-handling system. Once the bags have been accepted by the system (oversize and/or overweight bags will be rejected and need to be processed manually), the baggage system will transport and process them (including screening) so that they are delivered to flight build locations, much like locally checked-in baggage. In some cases, special provision is made for the most urgent bags. This may result in the bag being delivered to an alternative output from which it can be expedited, by vehicle, to a departing flight.

Equipment, Systems, and Technologies

Baggage-Handling-System Configurations

Conventional centralized-pier finger airports, such as Chicago O’Hare, Schiphol Amsterdam, and Manchester International, operate on one or more central bag rooms in the main terminal area. These require elaborate sorting systems, but can be efficient in the use of personnel who are released when not needed in off-peak periods. Decentralized facilities, such as Frankfurt (Germany) and Dallas–Fort Worth, have a number of decentralized bag rooms that are closely associated with a few gates. The sorting requirements of these makeup areas are minimal, but it is more difficult to use staff efficiently in the decentralized situation, where there are substantial variations in workload between peak and off-peak periods. A third concept of baggage makeup area is the remote bag room. In an airport such as Atlanta, where three-quarters of the traffic is transfer, there is considerable cross-apron activity. Remote bag rooms provide for the complex sorting necessary without transporting all baggage back to the main terminal. In Terminal 5 at Heathrow, the baggage system actually consists of two elements: (1) a bulk, centralized system for dealing with all but the most time-critical of bags (which brings the benefit of economies of scale for staffing and other resources) and (2) a distributed delivery system to most stands that is used to deliver just the time-critical bags (which brings the benefit of swift delivery right to the aircraft, giving handlers the best chance of loading last-minute bags).

Irrespective of the arrangement of the baggage system, most bag gage systems consist of some or all of the following components.

Checkin and Bag Drop

Traditional checkin and bag-drop desks can be arranged in a number of ways:

- Linear
- Island
- Flow-through

Schematics of these three configurations are shown in Figure .Both linear and island checkin have the disadvantage that the flow of passengers leaving the desks can conflict with queues of passengers waiting to reach the desks. Flow-through arrangements, however, avoid this difficulty but are feasible only where the terminal has the space to accommodate vertical movement of bags within the checkin floor plate.

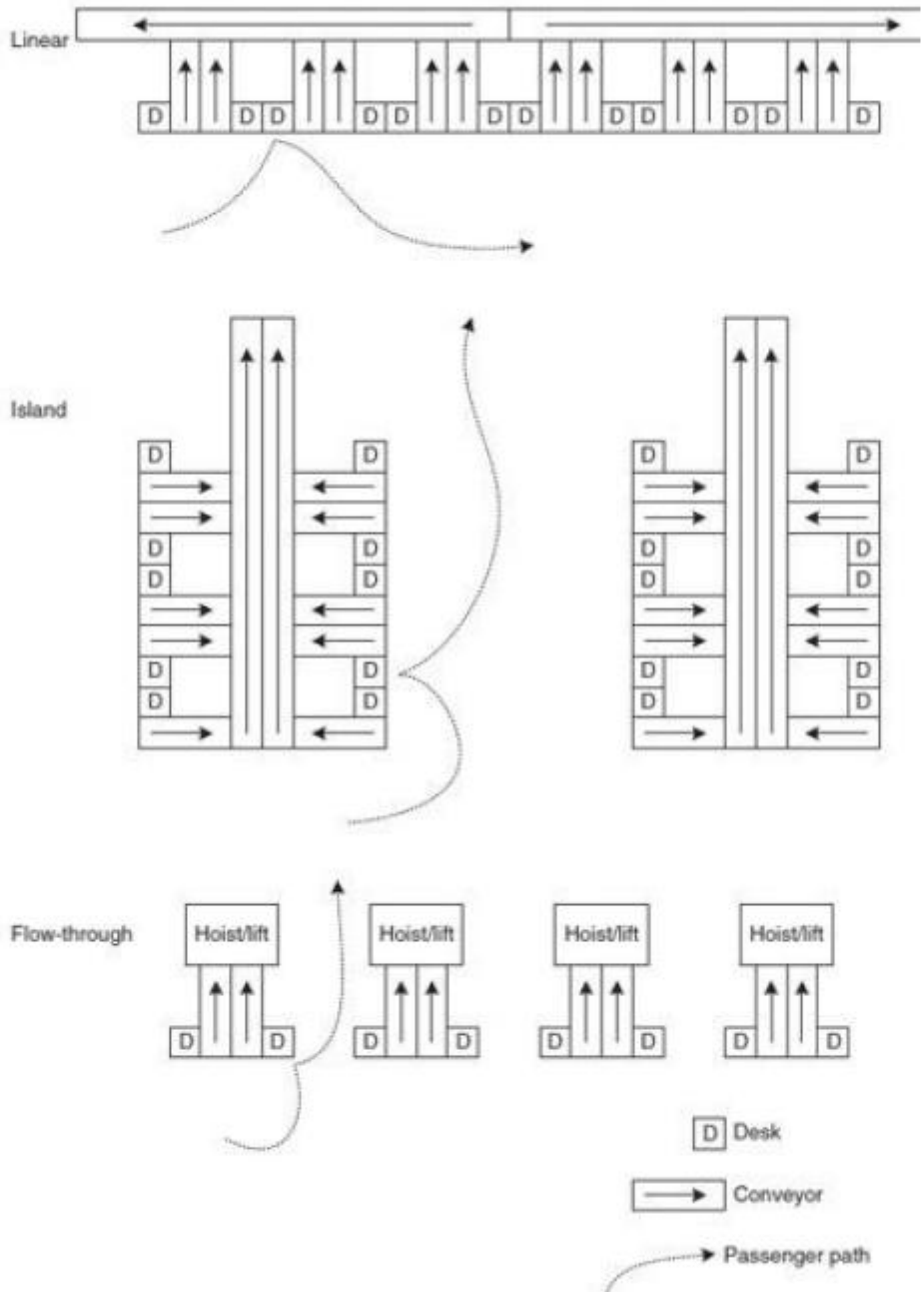


FIGURE. Checkin desk configurations.

Sorting

Once baggage has entered a system (other than the simplest), it has to be sorted. Destinations include screening equipment, manual encoding stations, and bag storage or flight makeup locations. There are several methods of sorting bags, the choice of which is governed by a combination of factors, including

- Space

- Cost
- Required capacity

For low-capacity applications, conveyor-based merges and diverts may be chosen. For somewhat higher capacities, vertical sorting and merge units may be employed because these can switch sufficiently quickly to allow adjacent bags to be sorted to two different locations with a throughput of over 1,000 bags per hour.

Hold-Baggage Screening

As screening technology develops, new and better machines become available. The control authorities build this into their regulations to ensure the best-possible chance of detection of known and potential threats. To date in Europe, three standards of x-ray screening equipment have been identified:

1. Standard 1–a single-view technology
2. Standard 2–a multi view technology
3. Standard 3–a computed tomographic technology

During 2012 in Europe, standard 1 machines will no longer be acceptable, and there have been major programs of work at airports to replace standard 1 equipment. While the precise dates are subject to change (somewhere around 2018–2020), standard 2 machines will themselves become unacceptable and will have to be replaced by standard 3 machines. The changeover program will not be trivial because standard 3 machines weigh 6 to 8 tons and are over 17 feet (5 m) in length.

Organization

Growth in the volume of baggage handled, coupled with the constant search for economies by airports and airlines, has led to gradual changes in the organization for this task. There has been a growing tendency for airlines and airports that have previously carried out the task of baggage handling to transfer it to handling agents, whether to another airline's handling company (e.g., Emirates' Dnata) or to an independent company (e.g., Menzies at London Heathrow). The tendency for airports in Europe to enjoy monopoly handling rights was challenged by the European Commission (EC). There is increasing pressure for the establishment of competing companies to carry out ground handling, including baggage handling, based on the argument that such competition will result in lower costs to airlines together with improved efficiency. Where an airline is a major operator at a particular airport, however, it is more usual for it to use its own personnel for baggage handling (e.g., British Airways at London Heathrow).

Staffing

As with all other aspects of air transport operation, the peaks and troughs of traffic so typical of the industry present problems to management when attempting to determine the level of staffing needed for any operation. There are obvious constraints in terms of costs, and as a result, there can be only limited response to the possibility of diversions or bunching of arriving flights. Where premium service is demanded and paid for, then special effort can be made, and a high level of staffing is assigned. Normally, however, there will be a compromise and a tacit acknowledgment that there probably will be a few occasions when staffing levels will be inadequate in the face of abnormal demand. The largest group of personnel engaged in handling baggage consists of those who deal with it on the ramp, transporting baggage to and from the aircraft and loading and unloading the hold. Ramp personnel must be allocated by some system to individual flights, and this necessitates an oversight of ramp activity. The basic method of allocating staff to flights is tackled in a variety of ways. At low activity stations, this is not a complicated procedure and merely requires the lead hand (head loader) personally to allocate staff based on personal experience. At higher-activity stations, where handling staff might number several hundred, it is usual to find specialist staff employed as allocators. Their task is not only to ensure the necessary number of staff for a particular flight but also to ensure a reasonably fair distribution of the workload. In order to satisfy these requirements, it is essential for staff allocators to have available upto- the-minute details of flight arrivals and departures, as well as prior notice of the load on board an arrival or the load planned for a departure. There is less of a problem in this respect if an airline is doing its own handling, but information easily can be delayed or forgotten when it has to be passed to another organization. All too often this is manifested by the unannounced flight. The establishment of a direct link between staff allocators and air traffic control (ATC), where possible, should ensure that accurate, up-to-the-minute times are available. Increasingly, computerized resource-management systems are being used to manage handler task allocations. These involve a centralized management system linked to mobile data terminals in handlers' vehicles. The handlers respond to tasks that are presented to them in the vehicle cab–acknowledging the task, confirming that they are undertaking the task, and indicating when the task is finished so that a new task can be allocated.

Management and Performance Metrics

Well-defined performance metrics are an important part of the management of baggage handling processes and systems. There are measures of the overall end-to-end performance of the baggage process, as well as subsidiary measures that focus on particular elements within the end-to-end process.

Overall

The industry-standard measure of success is the short-landed rate. This is the number of bags reported missing at the destination per 1,000 passengers flown–the lower this ratio, the better is the performance of the end-to-end baggage process. This ratio varies by airline, but is typically on the order of 1/1,000 for direct bags.

The short-landed rate for transfer bags is higher than for direct bags. This varies greatly by airline, route, and other factors, but typically is on the order of 5 to 50/1,000. This reflects the fact that a transfer bag is at greater risk of missing its connecting flight than one that is checked in directly. The reason for this is that the inbound leg of a transfer bag's journey is more variable. Factors include

- Late inbound aircraft, leading to little or no time to make the connection
- Poor segregation and loading of time-critical bags on inbound aircraft
- Poor handler performance in unloading and delivering bags to the baggage system
- Poor bag tag quality, leading to the need to manually code the bag
- Lack of data from the inbound airline, leading to the inability to sort the bag to the correct makeup position

Baggage System

Under normal circumstances, baggage-handling systems contribute only a very small fraction to the overall short-landed rate. The system-related measure is the system attributable mishandled-bag rate. This is the number of bags that are mishandled by the system (e.g., delivered late or to the wrong output) per 1,000 bags handled by the system. Values depend on the complexity and extent of the system but typically are on the order of 0.1/1,000—in other words, an order of magnitude smaller than the direct short-landed rate. The time it takes a bag to be processed through a baggage system can be important.

Arrivals Delivery Performance

The speed of delivery of bags from an inbound aircraft to either a reclaim device (for terminating bags) or the input of the baggage-handling system (for transfer bags) is the key measure of handler performance. Historically, this has been measured by first and last bag delivery times–for example, first bag on reclaim within 15 minutes and last bag on reclaim within 25 minutes of aircraft arrival on chocks. Such measures have the benefit of simplicity and can be used to encourage good handler performance, but three trends mean that more refined targets are becoming necessary at some airports:

- An increase in the number of very large aircraft
- A desire to reduce minimum connection times
- An increase in the size of airports and hence distances between facilities.