TITLE: CIRCULATION TRENDS IN AIR TERMINALS: EXISTING AND POSSIBLE FUTURE SYSTEMS APPROACH

B y

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Degree sought: Master of Architecture

Summary

This thesis is organized to look upon the entire air transportation system with special emphasis in the circulation of Airport Terminals. In attempting to achieve an understanding of the problem, all the subsystems have been examined in depth. Considering the ground and VTOL/STOL access of the airport with the city, special considerating has been taken. Finally the target of the study has been concentrated in the area of interterminal transportation for passenger and cargo movements.

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A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfilment of the requirements for the degree of Master in Architecture.

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Acknowledgements

I wish to thank the many persons and Organizations that aided in this thesis. The following persons deserve special recognition for giving me assistance.

Professor Radoslav Zuk, who gave much of his time offering guidance and instruction.

Professor Bradley who provided me with much information about the laws of Airports.

Professor Th. Valentis of the National Technical University of Athens, who offered many hours of his time to discuss the problems of High Speed Ground Transportation.

Professor I. Liapis of the National Technical University of Athens who helped me to demonstrate the phenomenon of interterminal transportation.

Kostas Mandros who continually since 1966, pointed out sources of information about Airports and Terminals and offered his invaluable experience.

Charles Morris who introduced me to the up to date systems of transportation involved in the city's central area.

The many persons of the Olympic Airliner who offered many hours of their time to aid me.

American Airlines, Boeing Co., Douglas Aircraft Division, Lockheed Co., Los Angeles Dept. of Aviation, Leigh Fisher Associates, International Air Transport Association, Federal Aviation Agency, Air Transport Association of America, International Civil Aciation Organization, Airport Operators Council International and many others provided much information for this thesis.

Finally I must thank the staff of the McLennan Library who aided me in gathering information.

PREFACE

I wish to indicate that no element of this thesis is a contribution to original knowledge.

At the beginning of the writing my aim was to present my personal investigation and viewpoints, but after a detailed study of the documents I discovered that all of my viewpoints had been published or applied.

Having no alternative further, I have collected information and portions from various documents and I have formed a thesis which is an up to date data on the topic.

This way my thesis proves only that I have read the relevant bibliography, while it does not offer anything else than the careful classification of the material.

GLOSSARY OF TERMS

Word of term used	Definition
1. Aircraft catering	The service, personnel, accommodation and facilities concerned with the preparation of food for aircraft and/or storage of aircraft catering equipment, washing dishes, and associated activities.
2. Aircraft servicing point	External connection on the aircraft to which servicing supply (or evacuation) lines are connected to the corresponding internal systems of the aircraft.
3. Air-side	That area of an airport which is in whole or in part under the jurisdiction of the Government Control Authorities. Where this jurisdiction of the Government Control Authorities does not apply, it is that part of an airport terminal building with immediate access to the apron. In both cases the air-side area is prohibited to the non-travelling public.
4. Apron (ramp)	A defined area on the air-side of the terminal building where aircraft are parked and all activities associated with the handling of flights can be carried out.
5. Apron occupancy time	Total elapsed time between the arrival of an aircraft on an operational stand and its departure from that stand.
6. Arriving passenger	Passenger arriving at the terminal by air.

Word or term used	Definition
7. Authority	The authority, whether of a national municipal or other character, responsible for the provision of airport buildings, aprons, and associated facilities such as Controls.
8. Baggage (luggage)	Articles, effects and other personal property of the passenger for transport in connection with his trip. Unless otherwise specified, it includes both checked and unchecked baggage.
9. Baggage, checked	Baggage of which the airline takes sole custody and for which a receipt or baggage (claim) tag has been issued.
10. Baggage claim area	Place allotted in the airport terminal for the claiming of baggage from the airlines by passengers on arrival.
11. Baggage, unchecked	Baggage other than checked baggage, such as hand baggage or cabin baggage.
12. Blast (wake)	High velocity movement of air experienced behind a turbine engine in operation or a rotating propeller.
13. Boarding of passengers (passenger embarkation)	Entry of passengers into the aircraft prior to its departure.
14. Bonded storage	Vehicles, area or accommodation under the joint control of the airlines and the Customs Authority for the storage, carriage or custody of uncleared airline property.
15. Breakway	Initial movement of the aircraft from the static position after parking.

Word or term used	Definition
16. Cargo	Anything carried, or to be carried, in an aircraft, other than mail or passengers' baggage.
17. Channel (passenger flow)	An established route for passengers withinthe airport terminal building.
18. Comb (supermarket)	A Customs Control system having a series of Customs benches parallel to one another and located along the normal passenger flow route, thus giving the passenger multiple choice.
19. Concessionnaire	An individual firm, company or organization permitted by the Airport Authority, to locate or carry on business at the airport terminal.
20. Conduits (cable channels)	Channels constructed in a building or in the ground for the accommodation of cables, wiring, piping, etc.
21. Controls (Governemnt Controls)	Check points, procedures, and/or formalities established by Government Authorities for the clearance of passengers, baggage, cargo and other load.
22. Conveyor system (baggage or cargo)	A moving belt used for the conveyance of baggage,cargo, mail, stores, etc.
23. Courtesy telephone	A free telephone service with direct connection to local hotels, cable companies, or car rental agencies.
24. Customs area	That part of an airport, under the direct jurisdiction of the Customs Authorities.
25. Departing passenger	Passenger departing from the terminal by air.
26. Dock (loading dock)	Accommodation with raised platform shaped as a dock for the purpose of loading/unloading air-

Word or term used	Definition
27. Domestic (flight, passengers)	Flight or passenger's journey which does not involve load control by the Government Authorities.
28. Finger (pier)	A protrusion extending from the terminal building into the apron area, giving protected access to aircraft parked on the apron.
29. Fixed servicing installation	Fixed installation in the apron (or at the site of the finger) at one or more operational stands of one or more types of service for the provisioning and/or servicing of aircraft, e.g. fuel, electrical power, water.
30. Flight information boards	Information boards indicating aircraft arrival and departure times and relevant gate numbers.
31. Flow (flow routes)	The movement of passengers, baggage, cargo or mail through the airport buildings and to and from the aircraft.
32. Gate	Point of access to the apron from the terminal building or extension thereto.
33. Ground communications	Communications system provided between fixed installations (as with telephones) or between a fixed installation and mobile radio apparatus carried by personnel or on vehicles.
34. Guide lines	Lines painted on the apron as a guide to pilots in the manoeuvring and parking of

Word or term used	Definition
	their aircraft on the allotted operational stands.
35. Hand baggage (hand luggage)	See "Baggage, unchecked".
36. Handling (processing)	This term is intended to convey the general airline activities at an airport concerned with the movement and procedural flow of and aircraft load.
37. Hydrant fuel system	Fuel outlet on an operational stand to which a detachable hose and other associated equipment can be fitted to supply aircraft.
38. International (flight, passengers)	Flight or passenger's journey which involves load control by Government Authorities.
39. Kerbside (curbside)	The roadside alighting area for passengers immediately in front of the passenger terminal building entrance.
40. Land-side	That area of an airport and buildings to which the non-travelling public has free access.
41. Left luggage (baggage locker)	Baggage awaiting later collection deposited by a passenger in suitable accommodation at an airport.
42. Levels (within a building)	Floors at different elevations effecting separation of flow.
43. Load	Passengers, baggage, cargo and mail.
44. Loading bridge	A protected passageway bridging the gap between terminal building or finger and the aircraft passenger door.

Word or term used	Definition
45. Mail	All types of mail carried on an aircraft, i.e. General Post Office mail, Diplomatic mail, Military mail and Company (airline) mail.
46. Operational control	The exercise of authority over initiation, continuation, diversion or termination of a flight.
47. Operational stand (aircraft apron parking spot: aircraft stand)	The area required on the main apron for manoeuvring and for the purpose of servicing, loading and unloading an aircraft.
48. Operational trim (weight and balance computation)	The process whereby the aircraft load is calculated in relation to its correct distribution on the aircraft in order to achieve the desired location of the centra of gravity of the aircraft.
49. Pre-cleared baggage	Arriving baggage which has already been cleared for entry into the State of arrival by Customs Authorities at a previous point in the journey.
50. Private aircraft	Aircraft owned by individuals, firms, companies, organizations, etc. not engaged in airline operations.
51. Processing	Handling of passengers, crews, baggage, cargo and mail by airlines through their own and Government Control formalities, as appropriate.
52. Service roads	Roads within the airport boundary which provide access to airport buildings or

Word or term used	Definition
	areas and from which the public is restricted.
53. Servicing equipment (apron equipment)	Equipment required for the handling and provisioning of aircraft on the apron.
54. Supermarket	See "Comb".
55. Supplier	The Authority, company, or organization supplying utility service (such as fuel) to the airlines.
56. Transfer passengers (interline)	Passengers arriving by one flight and continuing their journey by another (connecting) flight.
57. Transit load (on-line)	Load (including passengers) arriving and departing by the same through flight, i.e., the intended destination being at a later stage in the flight.
58. Turnround (turn-around)	A combination of the handling activities associated with the arrival and departure of an aircraft while occupying an operational stand.

INTRODUCTION

In commercial aviation the airport is the interface or exchange center where travelers change mode of transportation from ground to air. Passengers require or desire certain services, as do the carriers and airport operators.

Prior to World War II, this list of requirements and desires was modest, and services were minimal. The traveling public was a relatively small group, and carriers or operators needed to offer little more than basic, available transportation. In many ways, the very smallness of the air traveling group hid the potential problems that would multiply with increased traffic in later years to plague operations of our major airports today. Further, equipment was not complex or sophisticated, and a tolerant public was not particularly unhappy with services they did not have or did not know about.

After World War II, air travel burst upon the scene with new equipment,with a limited all-weather capability, and with much greater public awareness of air transportation need and potential. Similarly, general aviation, incorporating the recreational flier and nonscheduled commercial aviation, experienced a greatly increased growth rate.

Airports were built to serve our urban centers, and the more modern and elaborate terminals now provide the facilities to serve nearly every conceivable need of the traveler and shipper: expansive vehicle parking areas; freeway routes from civic centers; feeding, housing, and medical services; passenger processing operations; facilities for the handling of freight and cargo; elaborate maintenance and overhaul facilities for the aircraft; an endless list of special-purpose equipment and vehicles for ground services; sophisticated weather/air traffic control; safety and fire protection operations; and administrative functions for the staff of the airport operator, the government agencies involved, and the carrier's requirements.

Up until now, the growth of air travel has been unhampered by capacity restrictions in such system elements as runways, terminal facilities, and surface access between city centers and airports. As the demand grew, the system could grow to satisfy it. And as the service improved, the demand grew larger. But these favorable conditions are fading rapidly. Most of the hub airports are reaching a saturation point, and saturation equates with costly delays - costly in terms of the ill will of inconvenienced passengers, and costly in operating dollar losses to airlines. The Air Transportation Association estimated the direct cost of operating delays in 1965 at $41 million in crew time and fuel expended alone. Of no less importance, these delays cost the traveling businessmen $50 million worth of work hours.

Figure 1 indicates that passenger traffic will double between 1966 and 1971 and double again by 1976. Similar indications are that total freight movement will increase by a factor of 10 in the same period. Growing population, increased vacation time, reduced travel costs, and expanding business needs all point to sharply rising traffic demands.

Any given set of facilities has a finite capacity beyond which it cannot handle the load. We are already experiencing frequent and serious congestion at our major hub airports during peak traffic hours, and we cannot avoid worse congestion and longer delays if we keep looking to that fixed capacity to handle still heavier loads simply by projecting today's environment forward. We can improve and add to our present facilities, which we are doing. But we cannot expect to generate substantial new facilities in time to avoid further stoppages such as that experienced in the summer of 1967 when ground traffic was tied up at Kennedy International Airport for two hours. It is difficult to predict what will finally limit the capacity of individual airports. It could be airport access and egress. It could be the ability of the air traffic control system to handle arrivals and departures. It could be the terminals themselves - the number of people that can flow through them in a given period. It could be the

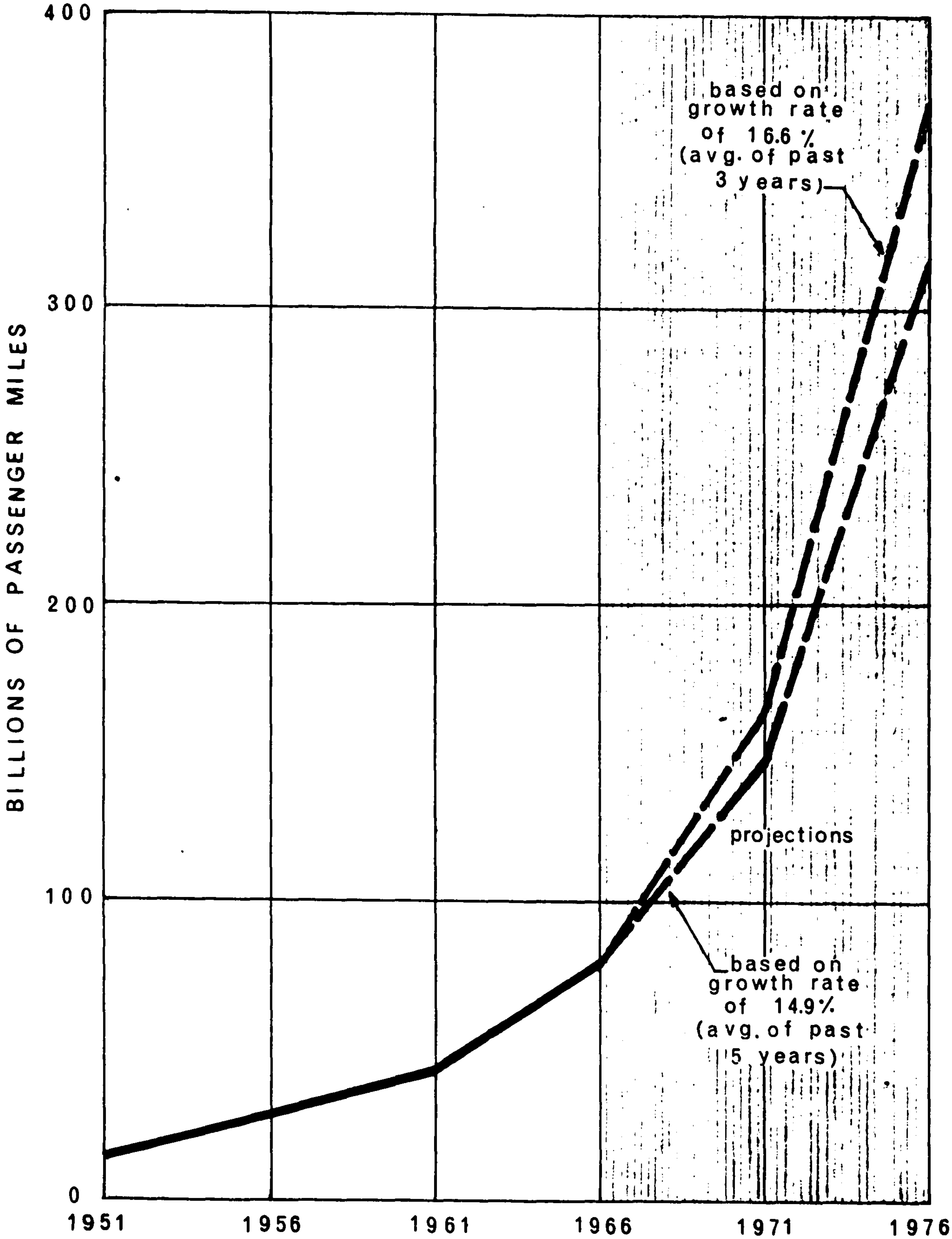


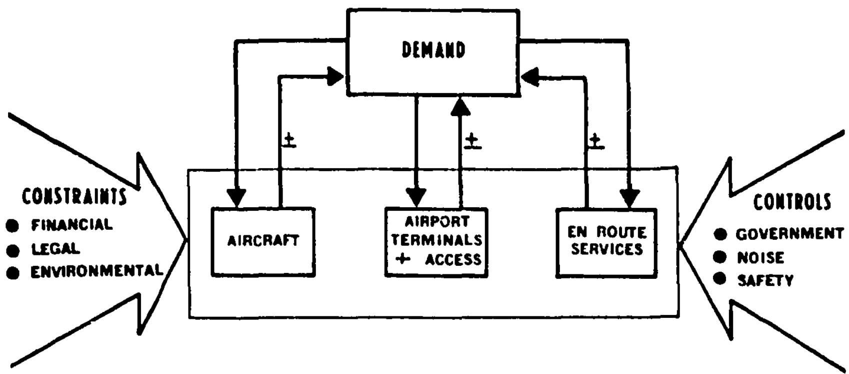
Figure 1. Projections of passenger traffic on U.S. scheduled airlines 1951-1976

ground-handling facilities for airplanes. Each airport is unique, each has unique problems. But delays at any of the major hub airports back up to cause system-wide delays as equipment fails to arrive on time and schedules deteriorate.

CHAPTER ONE

SIZING THE PROBLEM

In attempting to achieve an understanding of the air transportation problem it is helpful to reduce the system to its key subsystems and to examine each of these in depth. Basically, the air transportation system (Figure 2)



contains three subsystems - the air vehicle, en route services (airways, navigation, approach control, meteorology, and radiation monitoring), and the airport/ terminal with its access and egress systems.

User demand rises or falls as the system provides or fails to provide service that is economical, fast, dependable, comfortable, and safe. The subsystems are interdependent, and deficiencies in one subsystem affect all the rest. One can see how easily this complex system can get out of balance. As a result of improved technology, the flow of aircraft down the production lines and into service occurs in an orderly progression and at a rate that is almost a pure function of market-place decisions. However, the two supporting subsystems, the en route services and the airport with its collection and distribution complex, lag behind.

The air transportation system operates in a dynamic environment composed of people and their economy. This environment influences and shapes the demands that will be made on the system simultaneously offering both opportunities and constraints. On the one hand, the burgeoning of population, industry, leisure, education, and disposable income creates new and expanding markets for the air transport industry. On the other hand, factors such as noise, pollution, and legal, financial, and jurisdictional problems act to restrain its growth. The socioeconomic environment is both an expanding and a limiting factor; as yet the influence of the social effects of transportation are not understood sufficiently well for planners to know how to react to vice. Safety requirements in a climate of austerity will force even greater air and ground delays than those now heing experienced, as inadequate traffic control facilities and overburdened controllers try to shoulder heavier traffic loads. New airports and improvements to airports must be planned against lowered federal assistance. New access systems to move people and goods to airports are needed and are also expensive. Because of the nearness of the crisis and the lead times for constructing new facilities, austerity measures could not have come at a worse time for the air transportation system. Policy changes tend to lag behind changes in the climate that occasioned the policy change in the first place, a factor that suggests that the system will have to live with austerity for a critical period of time to come.

This brief review has identified some of the factors that will create heavier demand for air transportation and some of the problem areas standing in the way of satisfying that demand. In addition to this system-wide perspective, it is felt that understanding of the problem may be enhanced by focusing on the size of one aspect as it appears to an airport planner.

FACTORS IN PLANNING OF NEW AIRPORTS

The following sections refer to these planning factors in more detail. It is not intended to be a specific guide to airport planning but rather as a digest of various well documented methodologies which reviews the many interacting that must be considered to ensure that the new airport becomes an optimum element of the air transportation system.

Air Traffic Demand

The first basic criterion to be developed in planning new airport facilities is the determination of the extent of present and future air traffic demand. The fact that five to seven years are required to build a major airport must be taken into account. The planner must estimate how many people will be traveling by air and how much cargo will be shipped by air in order to "size" airports capable of handling the volume.

Air traffic demand consists of three components: commercial passenger demand, cargo service demand, and general aviation demand. Each of these components is generated by distinct and independent factors, with individual characteristics that must be separately evaluated and projected to estimate total future air traffic demand. Estimated passenger and cargo levels must then be translated into the number of plane movements needed to accommodate the demand.

By analyzing present fleets of the airlines operating at each of the airports in a region, and then phasing into the present fleets the subsonic and supersonic aircraft on order, estimates of average-seats-per-aircraft at each airport can be computed. By developing estimated future load factors (percentage of available seats occupied), the number of plane movements required to accommodate average peak-hour passenger demand can be computed. To this total must be added the number of plane movements required to accommodate average peak-hour cargo and the general aviation demand to be served.

The controlling factor in determining an airport's ability to accommodate traffic is the number of aircraft movements that can be handled in an average pek hour when Instrument Flight Rules (IFR) are in effect. Ehen forecast pek-hour IFR demand is matched to expected peak-hour IFR capacity, the suitability of new facilities planned to meet future air traffic demand can be judged.

Airspace Requirements

Air traffic is considered to be IFR traffic, which requires more airspace per aircraft than Visual Flight Rules (VFR) traffic and is the more demanding of the two.

Airspace requirements may be based on the highest standards required by the most demanding user aircraft. Such aircraft operating under IFR consume enormous segments of airspace, and airports must be located so that one in no way impedes another. Consequently, airports must be separated by certain minimum distances that depend upon the type of operations conducted under IFR conditions.

A poorly located airport will not reach full potential if traffic from other airports interferes with its operation. Existing airport capability can also be reduced if new air traffic interferes with established routes and patterns. Considering established procedures for IFR traffic and underlying fundamentals, certain basic criteria can be established to rate a proposed location:

. Runway alignment relative to other runways in the area

. Major air traffic directions

. Holding airspace

. Local control airspace

. Navigational aids and other facilities

The effect of a new airport upon navigable airspace depends upon present airspace use and proposed use of the new airport. In a highly developed area the airport should obtain and advance airspace review by the FAA to identify possible problems that may be associated with a proposed site.

Safety, an urgent consideration, is partially dependent upon the quantity and type of user aircraft. Current airspace criteria on separation of airports, runway structures, effects of navigational aids, and other matters are made available by the FAA (Federal Aviation Agency).

Airport Size and Design Considerations

The basic design requirements for a new major airport should be based not only upon future traffic volume but must also reflect operating characteristics of future aircraft as well as airspace and desired airport capacity. Design should also incorporate FAA safety standards and planning guide principles. As with location, the types of aircraft using the airport - commercial, private, military, or general - must be considered in the layout and design. Mail and cargo volume are other critical factors.

In determining airport size, a primary consideration is the amount and type of anticipated usage the airport is to accommodate. The specific aircraft type or class expected to be the heaviest user, and that requiring the longest runway length, should be analyzed first. A simple schematic layout plan, identifying aircraft movement and major land use areas, is desirable initially. Provisions for internal and freight traffic are more simply visualized on such a plan. Other factors influencing runway length are elevation of airport site, temperature, and longitudinal gradient.[1,2]

Airport Layout

Two basic configurations for airport layout have been considered for comparison purposes. First is the contemporary radial layout with all terminal activities centered in a "hub". Figure 3 is typical of this type of layout. Taxiways emanate from the hub area to the rim or runway area. In this design, airport terminal activities (i.e., passenger processing) are generally centralized. Airline support activities such as maintenance are usually decentralized.

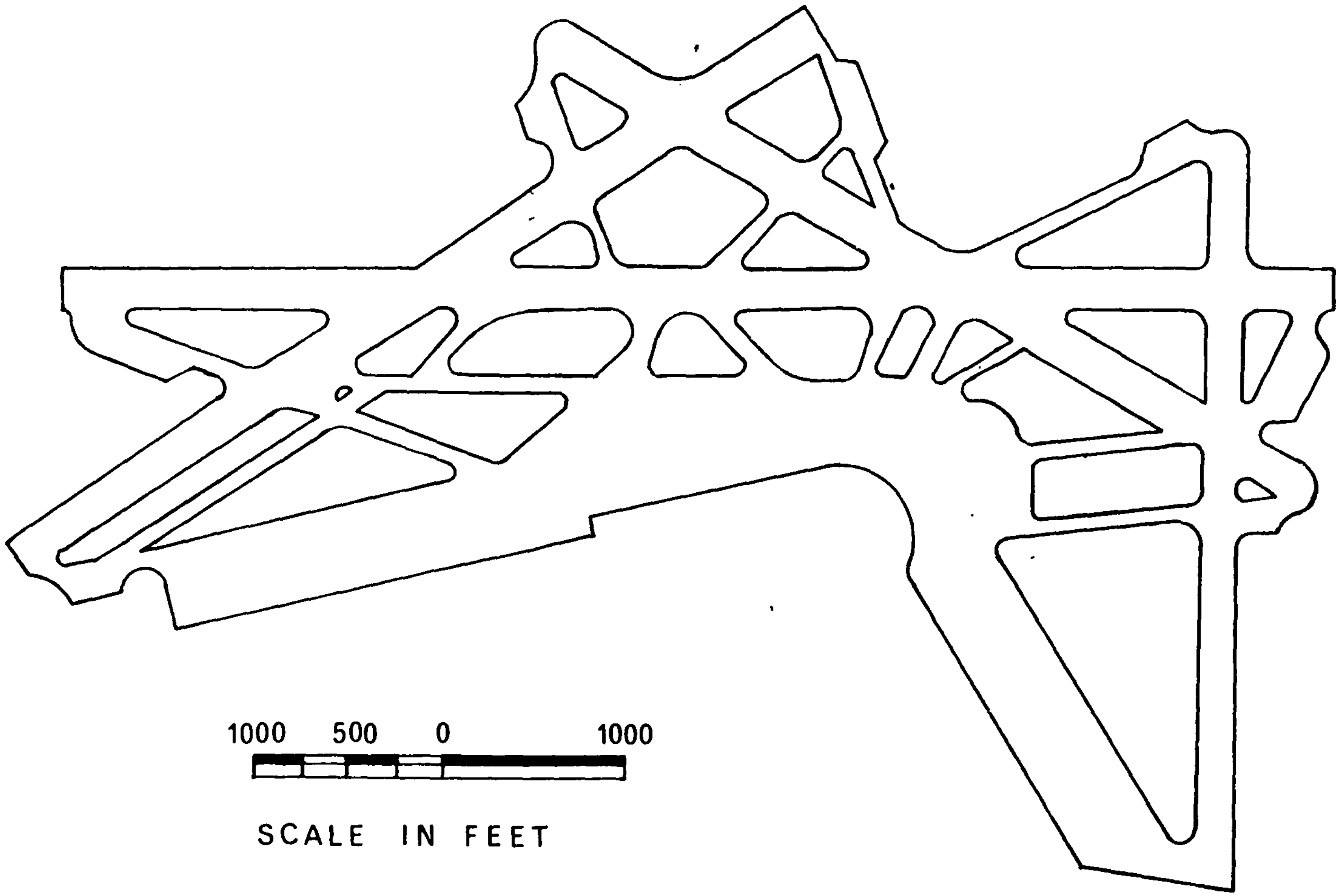


FIGURE 3. Typical radial airport layout

The second basic configuration is the linear or parallel offset design. Here, the basic emphasis is on a process that moves the payload from surface to air in the simplest fashion along the shortest route with minimum recirculation or backtracking.

In the hub design, taxiway lengths exceeding runway lengths by ratios of as much as seven to one interlace the surface of the airport, joining runways with maintenance areas, loading and unloading ramps, and servicing facilities. One runway normally is designated the IFR runway, and this runway actually determines peak or near-peak demand capability of the airport in terms of flights per hour. At many airports congestion at this IFR runway has already become unacceptable because of the cost of delays. New airport planning should critically examine methods to reduce this nonproductive ground time.

The parallel offset layout illustrated in Figure 4 offers significant economies in ground traffic flow and ground time, and is highly recommended where suitable land space is available. The concept complies with FAA instrument flying rules for separation requirements, allowing aircraft to progress in a generally uninterrupted flow from the exit end of a landing runway to the terminal and then on to a takeoff runway and thus minimizing taxi distances (no doubling back) and the necessity for crossing taxiway or active runway traffic.

Variations upon this general layout provide for efficient incorporation of crosswind runways when required by local conditions and allow for addition of other parallel runways for expansion. Also, if appropriately shaped plots of ground are not available to allow implementation of the full offset configuration, the amount of offset can be varied to incorporate more overlap without seriously affecting efficiency of aircraft ground movement. A recently introduced true linear concept 3 with the takeoff runway a linear extension of the landing runway is appropriate to certain site configurations and worthy of further evaluation.

Instead of a multistoried square, round,or triangular terminal building with numerous long branches, the terminal structure associated with a linear

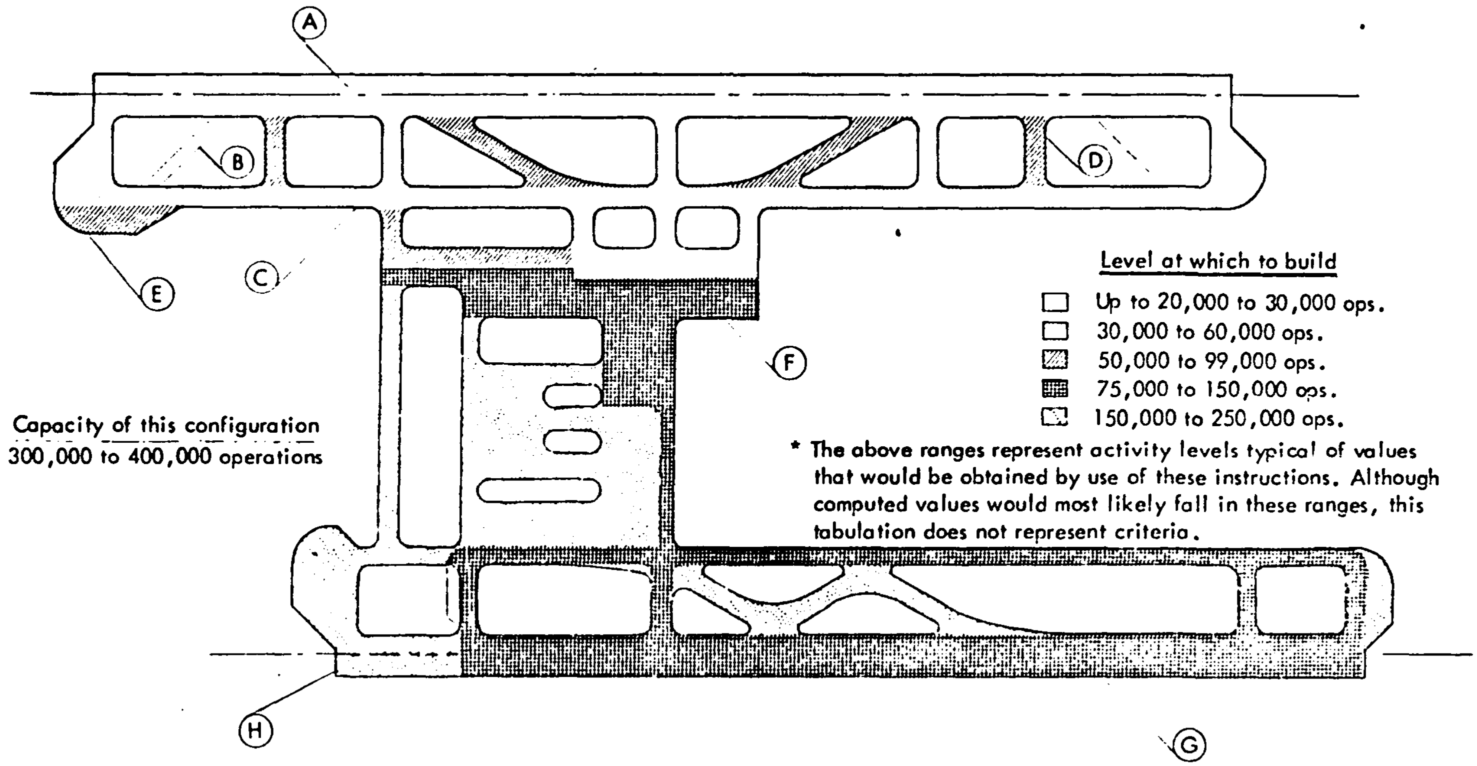


Figure 4. Parallel offset layout plan

layout may be 80 feet wide, a mile or two long, and located two stories below taxiway level. A one- or two-story intermittent or continuous structure could be atop the lower structure for aircraft loading and unloading. If the terminal building is long and narrow, extensive parking areas could be available closer to passenger check-in and loading lounge areas would be adjacent to the apron.

The long, narrow terminal building along a service road or other ground transportation system can provide easy, short access routes to departure and arrival areas. A considerable monetary saving may lie in eliminating the need for a complex mechanical handling system for extensive movement of passengers and baggage. In this layout one side of the aircraft fuselage might be moved adjacent to the face of the terminal itself using a transfer table and thus further minimize the time and distance factors involving passenger movements.

Aircraft maintenance structures, mail and freight distrubution centers, ground transportation terminals, and employee parking areas could be positioned along additional aprons located adjacent to runway extensions.

Airport Accessibility

Airport access time, distance, and cost are vital considerations in site selection, closely related and interacting with demand. Airport accessibility is essential to full realization of a region's air commerce potential and to the development of sufficient traffic to make an airport economically feasible.

The location must be as close as possible to developed areas that provide the travel demand the airport is to serve. In this connection, population and employment must be projected well into the future to determine those areas of the region likely to grow most rapidly in population and employment, and to generate increased air travel demand.

Projections of the need for various types of ground access at a new major airport will be accurate only if theyare based on estimates of the number of each category of persons to use an airport at each site. The origin and destination of each user within the region must also be taken into account. A further distinction must be made between air trips originating or ending in the central air-traffic generating center and trips that originate or end at other points in the region.

Each category of user is an important segment of total airport traffic, and employees and visitors must be considered too. However, required and possible airport access services are quite different for each. The travel modes of each group (e.g., highway transportation, public transportation, rail, or helicopter service) should be analyzed in depth.

Geological Considerations

Physical characteristics of the soil of proposed sites play an important part in layout, design, construction, and costs. A thorough knowledge of soil types and physical properties to be encountered is essential to proper selection of a major airport site. Soils information can be obtained from geologists and highway departments, consulting engineers, private contractors, industrial building owners, and other sources. It may be neither practical nor necessary to take borings at all sites under consideration, but enough information should be obtained to estimate types of soils likely to be encountered, and how the characteristics of each would affect construction.

Compounding this problem is the lack of standard methods for calculating pavement stress. Two basic methods are presently used, flexible pavement analysis (by the FAA method, the Corps of Engineers CBR (California Bearing Ratio) method, or the U.S. Air Force SESL method), and rigid pavement analysis (by Westergaard analysis, the Influence Charts method, the FAA method, the Portland Cement Association method, or the Load Classification Number methods).

Climatographical Considerations

Because of the closerelationship of weather and flying, a survey of the climatographical features of the area should be undertaken to give the airport operator a climatological planning guide. A general climatographical survey of land area within an 80-mile radius of the proposed site should be made for a major airport. Topographical features should be assessed and existing weather patterns evaluated, along with observational data analyzing climatographical features of the area. The survey should define important meteorological experience in approaches, landings, and departures at airports in the local area (i.e., stratus clouds, precipitation, severe storms, wind and turbulence) and relate them climatologically to the area within the 80-mile radius.

Fundamental weather and climatological characteristics of the region should be determined on the basis of weather systems, as reflected in historical weather maps and studies of weather conditions at major airports in the area.

Obstructions to safe use of the airport site are an integral part of the airspace and climatological study. The number and type of obstructions should be tabulated for each site, and the cost of eliminating obstructions must be analyzed in each site evaluation. Enactment of local zoning to protect airport approaches and other related surfaces is highly desirable[4].

Ecological Considerations

Bird strikes and bird ingestion into turbine engines are serious flight safety problems that must be considered by the planner in locating a new airport, and by the designer in developing detailed plans. Natural habitat and surroundings such as natural preserves and feeding grounds that would attract fowl are important in evaluating potential sites. Once the site is chosen, the designer must be careful not to create a more favorable ecological climate for wildlife by creating ponds that in turn attract waterfowl or insects that would attract other birds. Ground cover and treatment should be such that the number of rodents or of seeds and berries does not increase, since these attract both predatory and nonpredatory birds.

Noise Considerations

A major social consideration in selection of an airport site is the community's response to aircraft noise. An airport should be acceptable to its neighbors in this respect. Consequently, existing and proposed development of property surrounding a potential site is extremely important in the determination of a proper location for an airport. The site should not be in close proximity to established schools, churches, and residential areas.

Special attention should be paid to runway orientation so that adjacent buildings are not in immediate approach-departure paths. Ideally, airports should be located in relatively undeveloped areas and land-use zoning legislation then should be enacted to prevent or minimize future problems.

One of the troublesome aspects of coping with the airport noise problems is the inability of regional authorities to control land use beyond the confines of the airport. In most cases the regional airport body has no control over adjacent land use, and even where the neighboring land is undeveloped the zoning power resides in local jurisdictions. For the most part, in the vicinity of developed major airports, zoning and existing land use are predetermined, and all too often the area is zoned for residential occupancy.

To sum up, planners should take all possible measures to encourage land use in the vicinity of airports in ways compatible with expected noise levels.

General Engineering and Construction Costs Criteria

General engineering criteria common to all major airport sites under consideration would include those involved in design and construction of runway and taxiway pavement, hangar and terminal apron pavement, interior and terminal roads, buildings, utilities such as heating and air conditioning, high and low pressure water, power, communication and fuel, sanitary and drainage collection systems, blast and security fencing, and landscaping.

Utilizing preliminary layout plans for selected locations, other factors, include standards for landing aids, approach and clear zones, overrun areas, runway configuration and orientation, expected traffic loads, and aircraft ground-handling efficiency.

Wide variations in total construction costs will result from varying conditions at each site. The cost of basic site preparation is dependent upon site topography, geological conditions, and requirements for clearing, grading, and accommodation of proper drainage. Relocation of existing buildings, utilities highways, railroads, or streams will also be required in some sites. Geological conditions can affect foundation costs of structures to be built. Cost of access highways to a site depend upon proximity of existing or proposed major roadway networks. Other major variables include a potable water supply and sanitary disposal facilities.

The Economic Effect of a New Major Airport

In addition to total development costs, the possible economic effects resulting from development of a major new area airport must be considered. In the past a new airport has often proved a positive force in creating new growth and stimulating further expansion of the economy of the commynities in the immediate vicinity.

Four factors best measure the economic effects of a new major airport on a community:

- Wages and salaries earned by employees in the primary aviation activities connected with a new major airport.
- Purchases of goods and services by establishments in the primary aviation group.
- Expenditures by out-of-town business travelers, tourists, convention delegates, and other visitors at the travel-serving businesses within the region.

- Sales transacted by area manufacturing and distribution establishments with out-of-town business visitors arriving at the airport.

Selection of Heliport and V/STOL-Port Sites

Commercial heliport dėsign is much more complex than it seems initially. Careful site selection and proper attention to approach-zone clearance are essential if the heliport is to be operated safely and efficiently in an urban environment. Although many criteria established for heliport site selection are similar to those for airport site selection, these criteria must be applied in terms of the unique operational characteristics of present and future helicopters and proposed V/STOL aircraft.

A helicopter built today, based on overly optimistic prediction of future helicopter performance, might prove entirely useless if helicopters fail to meet projected performance standards. On the other hand, a heliport built on the basis of an underestimate of future performance may prove slightly larger than necessary but would still be a safe, usable installation.

Major factors to be considered in the selection of commercial heliport sites may be summarized as follows:

- Proximity to traffic-generating centers.
- Accessibility to cars and vailability of public transportation.
- Sufficient site area and proper elevation. Elevation ranging from ground level to that of a relatively low building seems preferable. Space needed for the landing area, combined with the necessary parking facilities, will require a sizable area - possibly unobtainable in downtown sections.
- Location such that the using aircraft will be able to operate in conjunction with other helicopter and V/STOL traffic in the area without detrimental effect on fixed-wing traffic.
- Clearance of existing obstructions. Possibilities of permanent approach protection by zoning or through natural means should be explored.

- An approach area that permits emergency landings in case of engine failure without serious damage to the aircraft, occupants, or property owners. This requirement may be reduced by improvements in one-engine-out performance of future helicopter and V/STOL designs.
- Cost of site development.
- Effects on neighboring property use due to helicopter operations, noise, air pollution, and air blast effects.
- Practicability of providing refueling facilities and bulk storage. Storage of large amounts of fuel in residential or business areas must be evaluated from the standpoint of safety and fire codes.

The Specialized Airport System

The designation of single purpose airports is one of the options available to the planner confronted with the problems of most effective utilization of multiple landing fields in a large metropolitan area; i.e., one type of operation or mission (cargo, general aviation, military, long-haul passenger, short-haul passenger, etc.) is to be carried out at that field. Arguments for and against such an approach to handling the growing number of flights and the increasing demand for air transportation of passengers and cargo could fill several volumes.

The parameters of the problem will differ for each metropolitan area because of differences in weather, geography, size, and type of ground transportation network, and demand. However, many factors pertaining to the future growth of air transportation suggest that a "divide and conquer" approach will be necessary, if we are to avoid chaos at our major airports. FAA predicts that within ten years private corporations and individuals will be flying 8,000 jet aircraft while domestic airlines will have only 3,500. Increasing size and speed of commercial planes along with higher utilization emphasize the need for minimum delays to these aircraft while on and near airfields.

Changing technology and procedures relative to safety, fuels, maintenance, cargo handling, passenger processing, and air traffic control indicate the need for segregating varioustypes of air operations wherever practical. Even though new and larger airports will be built to meet the needs of 1975 and beyond, the realities of geography, cost, airspace and other factors will still dictate that improvement (and improved utilization) of existing airfields be the primary approaeh to meeting future airport needs. An article entitled "Tomorrow's Solution to Today's Air Traffic Jam" (Esquire, August 1967), outlines a future specialized airport system for the New York City area, tied to a modern ground rapid-transit system and a system of depots and interchanges supplemented by V/STOL aircraft. Specialized airports are visualized for a variety of flights: international, long-haul domestic, short-haul domestic, general aviation, cargo and major maintenance, and military aviation. Emphasis is placed on a ground transportation system which would be used to tie the airport system together.

A general summary of the advantages and disadvantages of the single-purpose or specialized airport approach in a major metropolitan area is presented here.

Advantages of Specialized Airport System

- Improved air traffic control and safety. Approach and takeoff routes can be more clearly delineated and operating zones of certain types of aircraft more readily prescribed.
- Better location of airfields in relation to problems of noise, height limitation, climatic conditions, and ground transportation network.
- Better design. Runways, taxiways, parking fueling, and terminal facilities can be specifically designed for specialized needs.
- Better handling of passengers. Passenger services and service facilities may concentrate on the effective handling and processing of a particular kind of traveler.
- Improved ground transportation and air feeder-system planning. Needs for rapid transit, freeways,and V/STOL, can be more accurately determined and

Directional Specialization

For the dispersal of activity to major airports within a megalopolis area, an option available to the regional planner is that of designating individual airfields in terms of the origin or destination of flights using the airfield. For example, if a traveler from the Los Angeles area wished to embark on an east-bound flight, he might board the aircraft at Ontario Air Terminal, approximately 40 miles east of the city center. A passenger bound for the northwest quadrant of the country might depart from Van Nuys or from Palmdale airports, in the northern part of the Los Angeles metropolitan area. An overseas-bound passenger to Hawaii or points west might depart from Los Angeles International or from Oxnard air terminal. (Both of these terminals are in the westerly portions of the Southern California megalopolis; Oxnard is approximately 50 miles northwest of downtown Los Angeles.) Finally, southbound passengers might be boarded at one of several airports in the southeastern quadrant of the Los Angeles metropolitan area.

In such a scheme an effective feeder system would be required to move passengers from collection points to point of departure. This collection system could involve the use of feeder aircraft operating from existing limited-capacity airports such as Burbank, Long Beach, Santa Monica, and the Riverside/San Bernandino area. V/STOL aircraft could also be used to collect passengers from even more widely distributed metroports. Although this concept of airport specialization would probably increase travel distances to the airport for most travelers, the direction of travel would always be the same, and total travel time would therefore tend to be equalized.

The Los Angeles area probably lends itself more readily to this approach than most areas of the country; however, actual planning for this type of specialization is not implied in this discussion. The geographical location and travel patterns of Los Angeles encourage a moderately rigid directional flow, and a higher than normal percentage of 500-mile or greater flights. In addition, a relatively large percentage of scheduled flights either terminate or originate there.

Advantages of Directional Specialization

- Improved air traffic control and safety. Less mixing of aircraft from different airways into and out of the approach zones of the airport can be expected. Approach control can be more effectively coordinated with en route control.
- Less crowding of passenger service facilities. The directional concept, combined with the GAB route-allocation structure, could significantly reduce the number of different carriers processing passengers at any one airport and thereby reduce duplication of facilities.
- Improved collection and distribution of passengers. Feeder routes to the airport would always be in the same general direction of travel, with less convergence and mixing of local travel patterns.
- Possible reduction in total travel time. Passengers would always be traveling in the same general direction, and consequently would not "lose" time spent in doubling back in a different transportation mode on the route of travel to the airport.

Disadvantages of Directional Specialization

- Decreased flexibility to meet unusual requirements (as in the case of functional specialization discussed previously).
- Inflexibility caused by arrival/departure at different locations. A passenger, for example, who departs from an airport located on the west side of the city would conceivably park his car at the west terminal. If he then returned to the city through the east side airport he might find himself 50 miles from his parked car.
- Inconvenience to passengers. Some passengers would have to travel considerably greater distances across a metropolitan complex to reach departing aircraft, depending on point of origin and intended direction of travel.

- Difficulty of interline or interdirectional transfer if a mode change were required.
- Interline scheduling inflexibility. Scheduling between major trunk routes and feeder routes would be more difficult.
- Through-flight stops. To preserve the purity of the directional arrival and departure concept, it would be necessary for through flights to make two stops - one at the inbound direction arrival terminal and one at the outbound direction departure terminal.

The two concepts of single-purpose or single-direction, represent extremes of possible multiple airport designations. A similar, more easily implemented (but probably less efficient) concept would involve the dispersal of various scheduled departures by time to different airports.

CHAPTER TWO

AIRPORT TERMINAL ACCESS

1. The Terminal area

One of the most exasperating problems faced by today's air traveler is increasing vehicular congestion in the airport terminal area. To the airport operator, vehicle congestion represents both a management problem and a strangulation of essential operations. At the same time, vehicle parking fees are an important source of airport revenue. In the face of rising traffic forecasts, airport operators and authorities will be forced to re-examine theories of private vehicle access to airport areas. Increasing use of taxis and automobiles, delivering only two to five passengers each to an airport, will create chaotic problems when flows of 20,000 passengers per hour are reached. Steps are now being taken at many airports to minimize the problems, but congestion is generally increasing at a much faster rate than relief offered by corrective actions.

There are two general approaches to solution of this problem:

a. Reduce the number of vehicles that enter and leave airport areas.

b. Improve movement and parking of vehicles in the airport area.

Vehicles entering and leaving the airport area include those transporting airline passengers and crews, airport employees, visitors and sightseers, or freight and cargo. Options for reducing the number of vehicles required should be considered. Two of the options are these:

Limit types of aircraft using the airport. By limiting the number and type of commercial flights, the number of passengers and volume of freight are also reduced. This solution, of course, is not feasible unless the area is served by additional airports operating at less than capacity. However, general aviation craft might be excluded from major airports.

Reduce number of employees working in the airport area. The number of employees arriving at and departing from John F. Kennedy Airport each day is over 35,000.

Los Angeles International has over 33,000 employees, and Paris-Nord expects to have about 50,000. With increasing passenger and cargo movements, reduction in the number of airport employees will be difficult; however, overall reduction may be possible by streamlining and mechanizing some activities and by relocating some functions away from the airport. Activities that could be considered for remote locations are processing and consolidation of passengers and baggage, some concessions, equipment maintenance and overhaul, cargo consolidation, overnight accommodations, airport administration and service support functions, communication and data centers, and training facilities.

Closely related to any effort to reduce the number of ground vehicles entering and leaving airport areas is the desirability of decreasing flow during peak-load periods. Two primary options for accomplishing this purpose are

. Reschedule airport employee working hours.

. Reschedule aircraft arrival and departure.

Rescheduling working hours can be more readily accomplished than rescheduling aircraft timetables. However, aircraft speeds, routes, and numbers are now so varied as to permit some flexibility in scheduling to avoid delays because of ground and air traffic congestion. In particular, peak demands for individual airport access can be lowered by scheduling simultaneous "golden hour" departures from two or more satellite airports serving the same hub area. Similarly, simultaneous arrivals could be scheduled into different airports at the destination hub to relieve individual peak-hour congestion.

When aircraft are delayed, it is difficult or impossible for an individual picking up a passenger to determine that the aircraft has been delayed and the approximate delay time. For the FAA to obtain a broadcast frequency and constantly report arrivals, departures, and delays at major airports would be a possible method of alleviating peak loads of ground traffic. Persons going to an airport to pick up a passenger could more effectively plan their arrival time by turning into the radio broadcast station for specific data on delay and arrival and departure times.

Improve Ground Access to Airport

Too many airport locations make vahicle access to the airport unduly difficult, dangerous, and congested. As a result, the harried traveler is stalled, frustrated, and under tension from the time he approaches the airport until he has left it far behind. Some of the options that should be considered for improving this situation are

- Provide more than one route of vehicular access. This alternative may be difficult at some existing airports but should be carefully examined, especially where the existing airport area road net would support multiple access routes. Access from opposite sides of the airport, for example, is being planned for the new Dallas-Fort Worth complex, and ultimate four-directional roadway access is being planned for Los Angeles International.
- Separate the various types of vehicular traffic in the airport area. Closely related to multiple access routes is the desirability of separating various types of traffic to the greatest possible extent as they enter the airport/terminal area. Separate areas and access thereto could be provided for passengers using public transportation, those using taxis and limousines, passengers parking and leaving their cars, passengers being picked up or dropped by private car, visitors or sightseers, and cargo trucks. Separate levels of access and departure, including underground levels, would normally be required, depending on existing airport configurations.
- Provide for smooth flow of traffic on and off access roads. Many present airports have poor connections with adjacent highways, resulting in congestion and accidents. Separation of flow through use of cloverleafs and other designs is desirable. A well-designed system of lights and

and signs backed by effective policing is essential to minimize congestion. Such planning and controls must be effective not only at the airport boundary but also within the surrounding area of traffic dispersal.

- Increase the use of public transportation to and from the airport. Such an increase would result from a combination of better facilities, better scheduling, better pricing and better promotion. It may also involve discouragement of private vehicles through increased parking charges and airport tolls. Rapid-transit type, high-speed rail has high potential in this area if vehicles are designed and dedicated to the needs of the air traveler rather than the daily urban commuter.

As air commerce continues to grow and urban population density increases, land demand for airports will be further affected by demands for rights-of-way to and from the airport. In many communities, especially large metropolitan hubs, rail right-of-way may be used as a network for interconnecting airports as well as various satellite locations throughout the metropolitan region.

- Eliminate visitors and sightseers from congested areas. This may require increased traffic control during certain periods, increased charges for parking, or perhaps some provision of observation areas adjacent to the airport but outside the flow of airport traffic.
- Increased use of V/STOL aircraft for arrival and departure of passengers. At present little use is made of V/STOL service with the result that this mode has not provided significant relief to ground transportation. However, the potential involved is great, and as appropriate aircraft reach operational status, they should aid considerably in the movement of passengers and air cargo to and from the airport. Increased emphasis should be placed on V/STOL research development and demonstration to hurry the date when this important element of the transportation system becomes available for use.

Improve Vehicle Movement in Airport/Terminal Area[5]

Actions available to improve vehicle movement in the airport/terminal area are similar to those for consideration in improving access to and departure from the airport. The basic principle should normally be division of traffic by destination at the earliest possible point and insofar as practicable, the design of vehicle movement to facilitate handling of passengers and baggage.

Grade intersections should be avoided, and visitors or sightseers should be routed away from passenger-handling areas. After a desirable pattern of vehicle movement has been provided for, it should be enforced with traffic control (lights, signs, police, grade separation). Interference of pedestrian traffic with the flow of vehicles must be avoided by use of overhead or tunnel crossings.

Make Appropriate Provision for Vehicle Parking

Problems of parking vehicles in the airport/terminal area can be expected to increase as air travel increases, regardless of public transportation provided. Facilities for parking should give primary consideration to passenger- and baggage-handling. Some options to be considered in handling parking problems are

- Provide separate parking areas, according to purpose for which vehicle is brought to the airport. Access to terminal and gates should not be the same for passengers, employees, and visitors. Employees and visitors can be required to walk or to ride shuttle buses to and from parking areas.
- Provide multilevel parking facilities. This choise will decrease land area requirements and shorten walking distances for individuals arriving in private vehicles. Priority for multilevel parking should go to meeting the needs of air passengers. While height will be a limiting factor, seven-story facilities are already planned or under construction at existing airports.
- Improve traffic control procedures related to parking. This will be difficult, especially in relation to passengers vis-à-vis visitors or sightseers,

but ways can be developed to improve existing controls. Parking space reservations for travelers who store their autos at the airport while away might be sold with the advance purchase ticket, thereby giving improved service through guaranteed parking and improved management information for parking facilities and traffic control.

- Limit private vehicle parking through premium parking charges. This will have the combined effect of decreasing parking area requirements decreasing traffic congestion (both personnel and vehicle), and increasing the utilization of public transportation. Such steps will require the close attention of airport operators to assess the net effect on airport parking revenues.

2. Airport Access and Urban Distribution

All major hubs currently have an airport access problem. Some of the basic reasons for these problems are as follows:

- Inadequate airport access, as a result of insufficient approaches, bottlenecks, and lack of parking.
- An excess of nonpassengers in the airport system.
- The urban environment.

Inadequate Airport Access

The traveling public and the air transportation industry still depend on the automobile as the major means of transport to and from the airport. The bulk of this growth is the result of passenger demand. A significant upsurge of cargo traffic can also be anticipated when the strech and jumbo subsonic jets go into operation.

Many of the major hub airports have aviation-related industries located at the airport. The shift-change traffic from these industries unfortunately coincides with the peak aircraft arrivals and departures, and saturation of the roadway system leading to and from the airport usually results. Recreational facilities such as major league ball parks and race tracks located near airports aggravate the problem. The only alternative for the time-restricted business traveler is to leave for the airport in sufficient time to allow for all unpredictable variables. The consequent loss of productive manhours alone represents a substantial financial loss. There is an urgent need for better integration of the airport access roadway system with the metropolitan roads and freeway systems feeding the airport.

Airport Population

When one considers that air travelers constitute only about one-half the airport population, the scope of the problem becomes overwhelming. Several studies have been conducted to gather data on the airport user[6]. One study of terminal populations at Chicago's O'Hare and Midway, Dallas/Fort Worth, Nashville, and the New York airports established the following user breakdown:

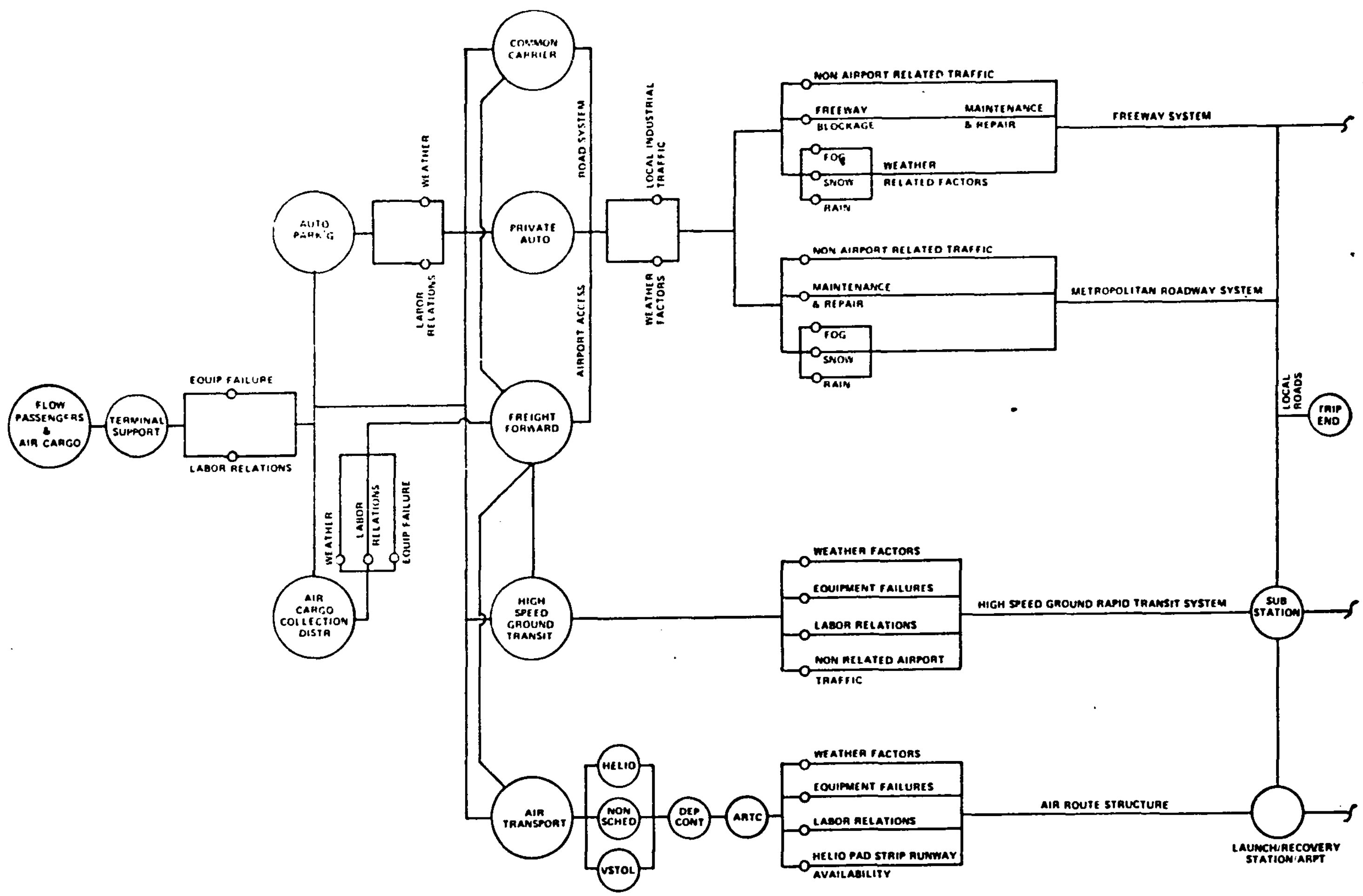
Air passengers	33-56 percent
Employees	11-16 percent
Visitors, sightseers, shoppers	31-42 percent
Service suppliers	3-7 percent

The Urban Environment

The air traveler's trips to and from the airport represent only a small percentage of the total trips made in an urban region. Accordingly, urban planners tend to dismiss air travelers as statistically insignificant. However, the economic impact of the air traveler on the urban environment must be taken into consideration. Comprehensive transportation planning for urban regions must include airport access. The air passenger, although completely controlled during the air portion of his trip, is entirely on his own in an uncontrolled environment while moving to and from airports. Many factors affect passenger flow as well as that of air freight (Figure 5). The most critical from the standpoint of the collection and distribution system are

- Weather
- Labor-relations disturbances
- Equipment failures
- Traffic not related to the airport
- Number of modes available

The interrelationship of these factors will vary greatly, depending on the mode, the time of day, the day of the week, and holiday-related peaks. Weather, for instance, has a variable impact on collection and distribution. Although weather will slightly impede the time constants for a high-speed ground transit system, such constraints are minor in comparison to the effect it has on the


FLOW PASSENGERS & AIR CARGO
TERMINAL SUPPORT
EQUIP FAILURE
LABOR RELATIONS
AUTO PARK'G
WEATHER
LABOR RELATIONS
AIR CARGO COLLECTION DISTR
WEATHER
LABOR RELATIONS
EQUIP FAILURE
COMMON CARRIER
PRIVATE AUTO
FREIGHT FORWARD
HIGH SPEED GROUND TRANSIT
AIR TRANSPORT
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WEATHER FACTORS
EQUIPMENT FAILURES
LABOR RELATIONS
HELIO PAD STRIP RUNWAY AVAILABILITY
AIR ROUTE STRUCTURE
LAUNCH/RECOVERY STATION/ARPT

Figure 5

automobile roadway and the air systems. The flow chart (Figure 5) may be considered a conceptual model of air transportation passenger and freight collection and distribution. Complete development of this model into a computer simulation of passenger and cargo movement would generate an effective tool for analysis of the sensitivity of passenger and cargo flow to the various modal systems, weather, and the other parameters indicated. The results would be helpful to urban planners, airport operators, and airlines in evaluating alternative solutions that have been or will be posed.

DEVELOPMENT OF ALTERNATE SOLUTIONS

Once the requirements analysis is completed, the next step is to begin the development of alternate solutions. In this phase, transportation system concepts are developed. It is during this process that various methods of propulsion and suspension and types of vehicles and networks are considered and matched against the previously determined requirements. To this end, consideration is given here to the present and future role of the automobile, four conceptual ground transportation systems, and a conceptual air dispersion system utilizing helicopters, V/STOL, and CTOL aircraft.

THE PRIVATE AUTOMOBILE

Without doubt, the private automobile continues to be a dominant factor in providing access to airports.

Congestion at airports will continue to increase as the automobile population grows. Forecasts such as the one predicting 400,000 daily vehicular operations by 1975 for New York's Kennedy Airport point up the demand for immediate stopgap measures to relieve the congestion problem. The extent of the access problem is readily apparent when peak-hour demand is taken into consideration. Assuming that peak-hour operations represent 8 percent of the daily total, there would be at Kennedy Airport in 1975 32,000 vehicular operations during the peak hour.

On the basis of an extremely liberal flow capacity of 2000 vehicles per freeway lane per hour, 16 freeway lanes would be required to handle the peak-hour demand. All major metropolitan hub airports will eventually face this serious capacity-constraint problem.

New York is presently considering a spur line from the Long Island Railroad to serve Kennedy Airport. Planners for Chicago's O'Hare Airport are considering remote parking garages. Development of an efficient, possibly automatic system of intra-airport transportation, together with the simultaneous control of the access of private automobiles and possibly taxis to the terminal areas, will be necessary if the full advantages of these concepts is to be realized.

As a stopgap service for intra-airport movement, including that to and from remote parking areas, the immediate application of minibuses looks promising. On a longer range basis, these buses might be operated under a system of flexible routing, somewhat in the fashion of a taxi system. A communication network would be required so that passengers could call a bus to a specific location to pick them up, with a control center from which a dispatcher could direct buses to specific locations using a radio communications link. Such a system might be quite effective at medium airport hubs, but at the large hubs it should be considered an emergency measure only. The major hubs require more than an upgrading of present modes.

CONCEPTUAL GROUND COLLECTION AND DISTRIBUTION SYSTEMS

If future urban transport systems are to function well, certain gaps in transport technology must be eliminated. Several classes of new transport systems can be envisaged to accomplish this end. In general, these systems are visualized as meshing with new or modernized versions of rapid transit, of which the Bay Area Rapid Transit District is the most prominent example. This does not imply that we should abandon the search for improvements in the systems built on the basis of existing technology; there is great need for improvement in these basic transport systems as well[7].

It appears fairly clear that in the remaining decades of the twentieth century we will see the development of an urban transportation network based on low-, medium- and high-speed systems, with a range of capacities and offering a choice between private and public service. Better coordination and interfacing of these systems into an integrated whole will be highly desirable, and the technology of the subsystems should be on a comparable level.

Considerably more study is required to identify precisely the transport requirements for urban areas. Present projections represent only educated guesses, although there is considerable historical basis for making such guesses[8]. For illustrative purposes we will assume the availability of operational requirements, considering that there is already an analytic basis for assuming that ground systems of the types to be described are actually needed.

Analysis of hard data for specific sites against a background of existent urban constraints will no doubt produce additional refinements in the critical operating parameters for future systems. Speeds and capacities lower or higher than those postulated here may ultimately result.

It is unrealistic to assume that overall improvements in the urban transport system and airport access can be made in one fell swoop. It is important to consider feasible individual improvements, recognizing that the overall system will be less than optimum.

The four proposed systems for ground collection and distribution of passengers as presented here were spelled out in a Stanford Research Institute report[9] but reflect the thinking of a number of other groups.

System I: Collection and Distribution

This system would employ a low-speed, high-volume transport device[10], operating at 10-20 mph and usually with total trip lengths of less than a mile. Stops might be about 500 feet apart, with overall speed thus averaging about 7 mph. Capacities might be on the order of 12,000 to 15,000 passengers per hour. The device envisioned would be a horizontal counterpart to the elevator. One version of this system would be used as a fine-grain distributor for the business district, providing a connection between building elevators and transit terminals (bus or rail). The vehicles should move continuously, carrying small batches of passengers - perhaps six seated passengers and six standees. The device would provide a convenient way for all passengers either already in the central business district or delivered there by other means to get to a downtown airport terminal.

A device similar to that for the central business district would be used for intraterminal movement of passengers in large airports, for example, to connect terminal buildings to loading piers. With low speed, high volume, and continuous flow, such a device would fill a serious gap in airport transport planning. In the business district and airport version of System I, most passengers might be content to stand, since trip durations would typically be only a minute or two. A second version of the system, with similar speed and capacity, could be used as a collection device for transit terminals in suburban areas, thus broadening the area served by transit systems. This version would be operating over slightly longer distances, and seats would be desirable.

System II: Intraterminal Movement

A system of intraterminal and parking-lot-to-terminal connections will be required for large complexes such as Kennedy and Los Angeles. This system would have a medium-volume capacity on the order of 12,000 passengers per hour one way. Speeds would be in the 40 to 50-mph range, and the distance between stops typically a few thousand feet. Vehicles might carry 20-30 seated passengers and could be coupled in short trains as required.

Average speeds might be on the order of 25 mph, depending on specific stop patterns. System II would serve not only as transportation within the airport complex, including parking-lot-to-terminal, but also as a connection between the airport and off-site parking lots within a radius of 4-5 miles or less. It might also be used as basic transportation to and from close-in airports. Its principal characteristic must be a low cost commensurate with the low volumes typically envisioned for such service.

System III: Connecting Systems

This would be a high-speed system, operating at 120 to 200-mph. Stops would be on the order of 8 to 24 miles apart. The system could be exploited for several types of links in the airport access system. It could be used to connect the business district to the airport, e.g., Washington, D.C., to Dulles and Friendship. In cities of low density it could be used to connect several remote parking lots or terminals ringing the downtown area. (Los Angeles is an example.) Such a system could also connect two or three airports in an urban area.

At least two versions of system II are contemplated. The first would employ a single-mode vehicle with a conventional passenger compartment and special provisions for baggage handling. This version would be similar to modern rapid transit, although some application of unconventional technology would probably be required. On runs of 25 miles such a system could average 3 miles per minute. A second more advanced version would employ a dual-mode vehicle capable of running on a guideway at high speed, stopping for capsule transfer of passengers at the terminal, and then switching to lower speed for moving onto the airport runway and discharging passengers directly into the planes. Passengers would be ticketed in the downtown terminal or onboard, and the airport terminal stop would be necessary only in order to pick up passengers who had driven to the terminal. A third, even more advanced version, would entirely eliminate the need for an airport passenger terminal. This version would use very large vehicles, carrying perhaps 200-300 passengers in 50-passenger "modules" or containers. The modules would contain standard aircraft seats and facilities and would be transferred intact to the plane.

System III in a lower-speed version might form the basis for a greatly improved transit option. The technology described, as one plausible way of meeting these requirements, is equally applicable to systems with a maximum speed of 80-90 mph.

System IV: High-Speed Ground Transportation System

In a class by itself is a system of high-speed ground transport for intercity travel in major U.S. corridors. Such systems, which may operate in the 200 to 500-mph range, are important to our discussion for two principal reasons:

1. These systems can be employed as coarse-grain feeders for major regional airports serving entire urban corridors, where such airports may be located up to 100 miles from the major urban centers.

2. Such systems may ultimately handle most of the short-haul (less than 300-mile) trips in the Chicago, Great Lakes, Northeast, and California corridors.

The Office of High-Speed Ground Transportation is currently studying these systems and has an extensive research and development program to advance the requisite technology[11,12].

HSGT systems could be operational between larger cities in the major corridors in the 1980's. If successful, systems of this type could be carrying the majority of intercity passengers in these corridors by 1990. The possible emergence of such a new mode of ground transport needs to be carefully monitored by long-range planners for airlines, aircraft manufacturers, and airports. Major inroads into the short-haul freight markets may also be expected. To some extent the advent of HSGT systems would tend to ease the problems of airports, inasmuch as it would decrease the demand for short-haul air transportation.

Planners considering sites for major new regional airports in the urban corridors should also be aware of the prospects for HSGT systems. Distance of airports from urban centers is, after all, significant mainly as a time factor. If such systems can average 250 mph, there is no reason why a major new airport should not be located 100 to 150 miles from the cities it is to serve. Conversely, it is important that airport access be taken into consideration in the development of HSGT systems. Such systems could, for example, be designed to serve as the collection and distribution network for the supersonic transport airports in the region.

Networks

The use of these new systems under ideal circumstances can be visualized by an examination of networks for an urban area. In Figure 6.1 a typical transit system network is sketched, showing the strong focus on the central business district. Overlying this system would be the freeways and major streets and highways of the city. The four systems are shown for illustrative purposes; only two or three of them would generally be required, and in any case they could not be introduced all at once. The air traveler in the business district would simply board a horizontal counterpart to the elevator, which would discharge him at the downtown terminal. Alternatively, he might walk or take a taxi to the terminal. There he would be relieved of his baggage and ticketed through. On system III he would ride nonstop to the airport at two or three miles per minute. On arriving at the airport he would transfer to a lower-speed system (either I or II), which would take him to the loading pier. All transfers would consist of a few second's walk across a platform. There would be a minimum of baggage handling.

For the traveler originating in the suburbs, ticketing and baggage routing for the entire trip would take place at the transit terminal.

CURRENT U.S. GOVERNMENT-FUNDED STUDIES IN GROUND TRANSPORTATION

Extensive transportation studies are being conducted by HUD and DOT. Many of the findings may be applicable to the airport collection and distribution problem. The following studies are particularly relevant.

The high-speed ground transit system, with special emphasis on the corridor between Boston and Washington, D.C. This study is being conducted by a number of contractors under the sponsorship of DOT.

A rapid-transit system connecting the Cleveland business district to the airport terminal. This demonstration project, sponsored by HUD, was developed by the

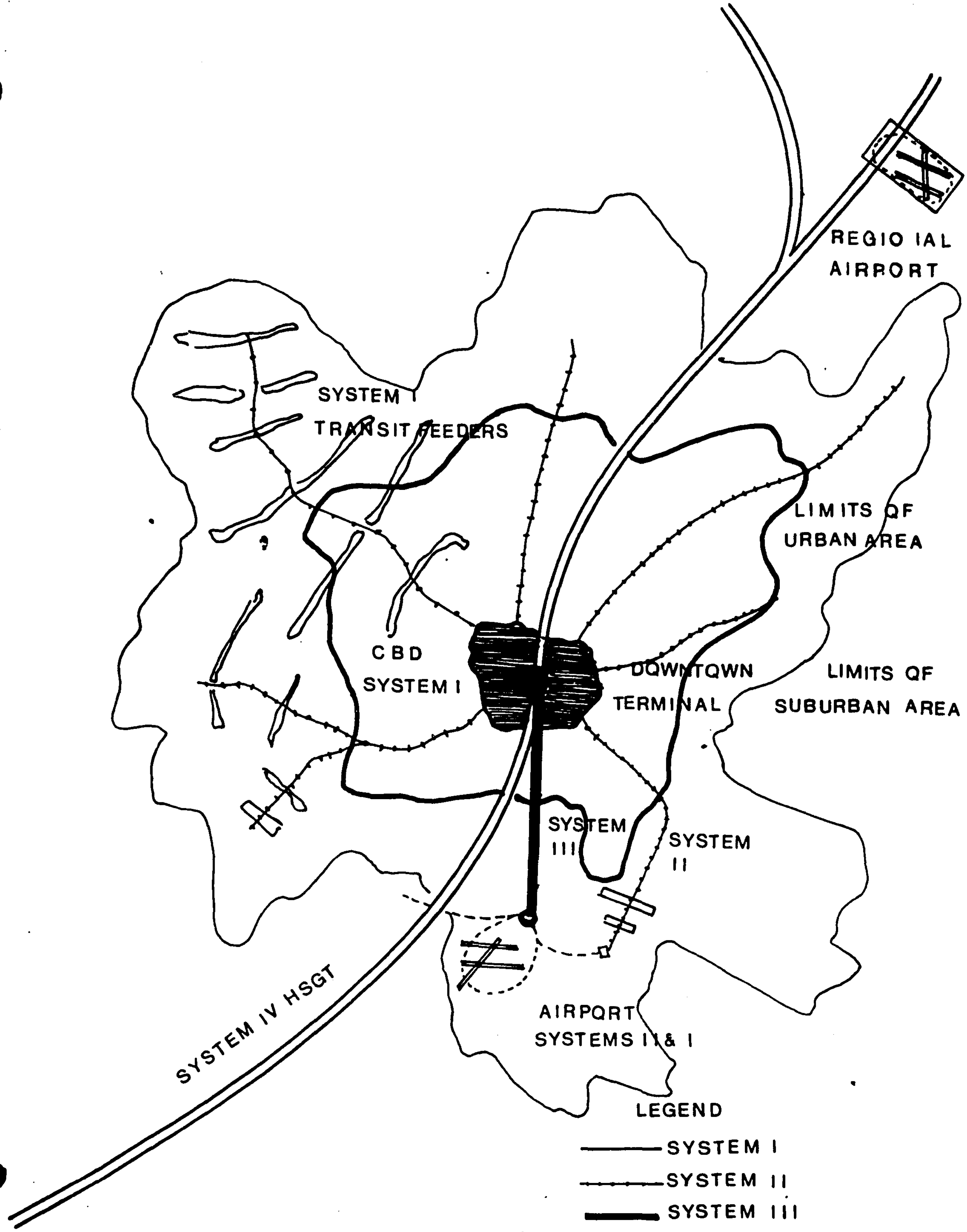


Figure 6. Transit network making use of the four systems

Cleveland Transit System.

Jet skimmer air cushion vehicle demonstration project[13], between Metropolitan Oakland International Airport, downtown San Francisco, and San Francisco International Airport. This project, sponsored by HUD and conducted by the Port of Oakland, ran for a year from August 1965 and was then abandoned. Operating costs proved high and the relatively small vessel was unable to give reliable service in rough-water conditions.

A futuristic study of ideal technological solutions to urban transportation problems. The goal of this study is to identify solutions to be available between 1973 and 1983. Sponsored by HUD, the study is being conducted by the Stanford Research Insitute.

An evolutionary study of substantial improvements in existing urban transportation systems and the emergence of new systems. This study aims to find solutions to be available from 1971 to 1976. The study has been sponsored by HUD and conducted by the Melpar division of WABCO in cooperation with the National Planning Association and Wilbur Smith and Associates.

A utilization study of methods to obtain improved results from existing transportation technologies. This program was also to have included an appraisal of improvements that could be introduced by 1970.

General Research Corporation was given responsibility to examine improvements that might be achieved at any stage in the three time periods (before 1970, between 1971 and 1976, and between 1973 and 1983) and to appraise the degree of improvement which might result from three different levels of expenditure in four different cities.

SOME PROMISING TECHNOLOGIES

In addition to these and other studies and demonstration projects, the need for technological innovation in four subsystems of ground transportation has also been recognized. These are receiving attention from industry as well as government.

- Suspension
- Propulsion
- Command and control
- Tunneling

Suspension

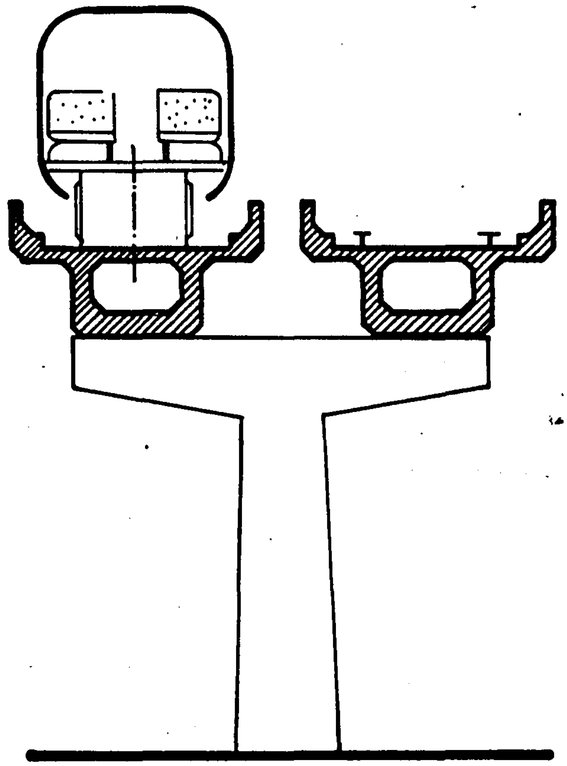
The most promising innovation here is to use a cushion of air instead of wheels (Figure 7). With this cushion, a form of propulsion could be used that does not depend upon adhesion between wheels and the guideway (e.g., linear induction motors), and the vehicles could be operated under complete automatic control. Most proposals such as the four systems previously discussed incorporate two or more of these concepts in a single system. Vehicles that operate automatically on a restricted guideway but that could be driven manually on a conventional road represent another proposed set of systems using some of these schemes. Air cushion vehicles show a great deal of promise. Low vehicle weight and height are possible, and the load may be distributed over larger surfaces, with resultant simplified support structure requirements, as shown in Figure 7. The ride is excellent, and the vehicles are simple and reliable. Maintenance of both vehicle and guideway is reduced since there is no physical contact between the two.

Propulsion

The propulsion subsystem is being considered from several viewpoints.

(a) Linear induction motors

The linear induction motor may be thought of as a conventional rotary induction machine, the stator of which has been cut open and unrolled to form a linear array of electromagnet coils. The inherent advantages of this type of machine are apparent: It is not necessary to mount the entire prime mover on the vehicle; there are no moving parts and no air contamination; and



Conventional rail vehicle (cross section)

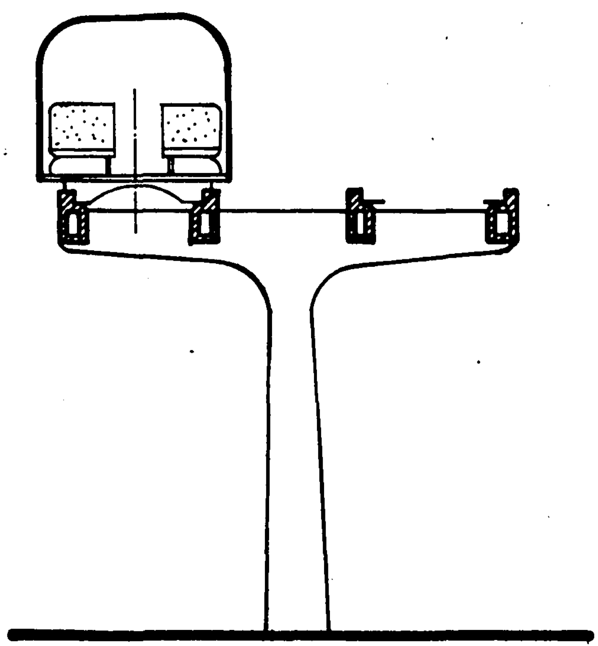


Figure 7. air-supported vehicle on guide track

the system is simple, reliable, and well suited to both wheeled and air-cusion vehicles.

Theoretical and experimental studies of linear machines are being conducted in the United States, Japan, France, and England. Much of the original research and development on machines of this type has been done by Professor E.R. Laithwaite[14] at Imperial College in England.

From the purely technical standpoint,the most attractive configuration for such a machine would utilize primary windings embedded continuously along the whole length of the guideway, together with a secondary (merely a sheet of aluminum), suspended from the underside of the vehicle. Preliminary calculations made by a group at Massachusetts Institute of Technology[15] for a linear induction motor to provide propulsive power for a vehicle 100 ft long and 10 ft in diameter, weighing 44,100 lb, and capable of a cruising velocity of 300 mph an acceleration of 0.2 g, indicate that the aluminum secondary plate would weigh 1320 lb. However, the primaries embedded in one mile of double track would require approximately 120,000 lb of steel laminations and 40,000 lb of copper. From the standpoint of the vehicle, placement of the primary in the guideway is attractive, but the cost of installing the primary in a number of miles of guideway can be justified only if the traffic density over the line is high. Nonetheless, installation of a linear-induction motor with this configuration to provide supplementary power in the vicinity of stations where vehicles would normally be accelerating is an attractive possibility.

The inverse configuration, in which the primary is carried on the car and only an aluminum plate or beam need be installed in the guideway, would substantially reduce the cost of the system but introduces the problem of supplying power to the moving primary. Way-side power could be employed at speeds up to 80 mph, but no adequate means has been proposed to obtain sufficient power for speeds on the order of 300 mph. Of course, chemical fuel could be burned on board to drive a turbine and in turn a generator, but this would create air-pollution problems. The use of individual prime movers would also increase the difficulties associated with maintaining proper speeds and headway on a busy line.

(b) Pneumatic propulsion

An alternate propulsion scheme is similar to the pneumatic tube system formerly used in department stores for transporting bills and change between the sales counters and a cashier's station. In the scheme proposed by L.K. Edward[16] and designated the Gravity-Vacuum Transit System, trains move on rails through tubes buried in tunnels. Pumps mounted at the surface reduce the pressure in the tubes to approximately 1 psia. When a train is ready to leave the station, a valve is opened behind it, and the atmospheric pressure applied to the rear of the train, combined with the gravity assist which results from the fact that the tunnels slope away from the stations, accelerates the train. As it approaches the next station, a valve at that station is closed, and the air ahead of the train is compressed. This action, along with the upward grade built into the guideway, decelerates the train to its stop at the station. Calculations indicate that the trip from New York to Washington, with seven intermediate stops, would take only 58 minutes, and that the system can be adapted for use where the stage lengths are as short as three miles.

Air Dispersion System

An alternative for alleviation of the overcrowded or choked conditions in passenger collection and distribution around major airports is a dispersion system that breaks the large passenger groups of a single aircraft into a number of smaller groups, transporting them as closed groups to dispersed secondary traffic centers, where the public transportation systems or private automobiles would provide transportation to final destination. Traffic volume would be much smaller at the secondary traffic centers than at the major airports, and the danger of overloading or choking the ground traffic arteries would thus be greatly reduced.

The dispersion systems between the major airport and secondary traffic centers, as envisioned here, would be operated so as to serve exclusively the passengers of the large jets. Other passengers would be accepted on a space available basis only. Careful attention should be exercised to ensure that passenger routing, travel time, and convenience are not compromised. Such a dispersion system would be an integral part of the long-range trip of traveler groups, over the route: secondary traffic center to major airport to long-range aircraft to major airport to secondary traffic center.

The dispersion routes could serve suburban areas around large cities, megalopolitan areas in general, and areas remote from large cities. In the last case the primary airport would function as a regional airport instead of a large-city airport. The socioeconomic impact of this possibility must not be underestimated.

The growth of such dispersion systems depends upon the balance between supply and demand and the strong interaction between them. Flexibility and adaptability to rapidly changing conditions, routes and numbers of passengers will be major attributes of a successful air passenger dispersion system.

Group passenger movement

To alleviate the congestion around major airports, the majority of passengers and freight will be processed not on an individual basis but in groups; combined transportation will be employed for pe-sons and freight with a common destination. This concept has already been applied to freight processing through containerization; the equivalent system for passengers will involve scheduled group travel to and from the primary airport, facilitated by the establishment of conveniently located subterminals. The transition from individual to group transportation will occur at these subterminals.

Dispersion by V/STOL aircraft and helicopters

Forecasts of tomorrow's air transportation system must be based on forecasts of tomorrow's technology. Advances in V/STOL aircraft and heavy-lift helicopters offer flexibility of operational routes and location of terminals, speed, safety of operation, and economy, thus assuring this mode of transportation a role in traffic dispersion to and from primary airports of the future[17]. In effect, this sytem shifts the interface between air and ground transportation away from the primary airports to the subterminals, or even farther. The overall system of long-range air travel, as shown in Figure 8 will have the following essential elements:

- High-altitute air umbrella, for long-distance travel from primary airport to primary airport.
- Low-altitude air umbrella, for group transportation from primary airport to sunterminals, and from one subterminal to another subterminal.
- Ground transportation, for individuals, groups, and freight, from the subterminal by private automobile, rented automobile, subway, bus, boat or ferry.

In some cases, an extra low-altitude air umbrella will become advantageous for suburban airbus service using V/STOL aircraft.

Short-range travel (up to 500 miles) may not touch the primary airports at all. By using aircraft such as the advanced VTOL, short-range traffic could proceed from the subterminal of an air terminal cluster to other subterminals along suitable air trunk routes. Since such traffic represents a major part of total air transportation, traffic dispersion around the airport cluster would be significantly improved.

Importance of Subterminals

The primary airports that are points of departure and termination for the long-distance jets will remain passenger hubs. They will be located preferably at considerable distances from residential areas, so that noise will be less objectionable. Industries, particularly those that give service to the airport, the

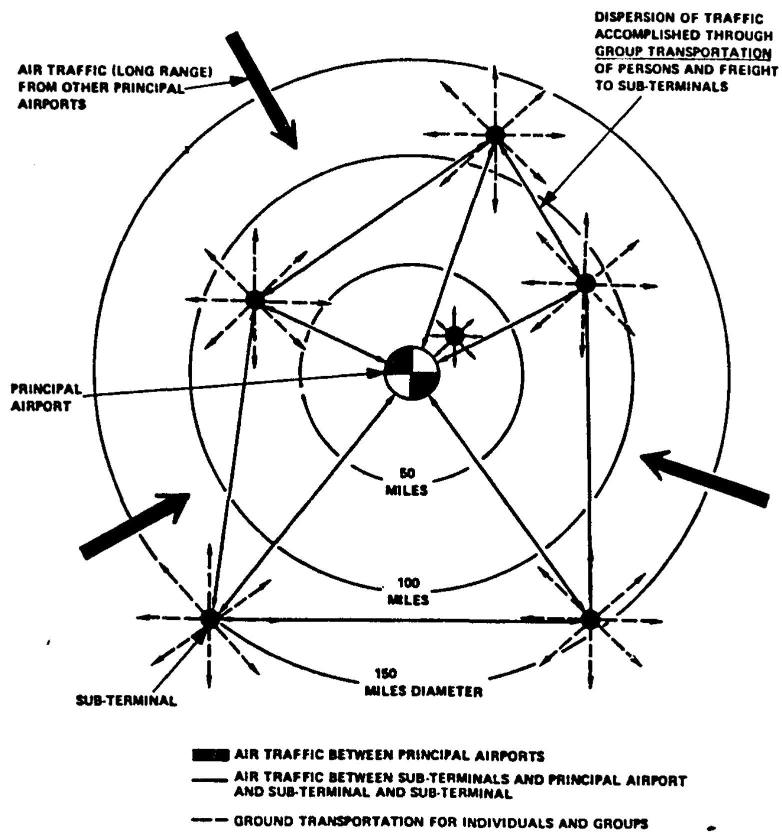


Figure 8

aircraft, and the equipment, would tend to cluster around the primary airports.

The primary airport will be mainly an exchange area for transfer from long-distance jets to short-distance aircraft. Neither passengers nor goods should normally pass in large quantities through buildings or gates at the primary airport. Transfer will be from large jets to other aircraft, either directly at the ramp or by means of transfer buses. It is estimated, for instance, that each large jet will require approximately five V/STOL aircraft, each having a load capacity of 80 passengers. Ticketing facilities and gates would be limited, and comfortable waiting rooms would be available for passengers transferring from one long-range flight to another long-range flight within a short time. Transfer passengers with a long wait would be transferred to a nearby subterminal with special stopover facilities. Subterminals would be located along the outer boundaries of business and residential areas, and would be tied in with other modes of transportation, including public ground transportation, private automobiles, and rented cars. Extensive parking facilities would be required, probably in the form of a large multistory garage with a V/STOL airport located on the roof. Aircraft noise must be kept to as low a level as technology can economically provide.

The subterminals would be the main processing centers for long-range air travel, including ticketing and baggage checking for the entire trip. Subterminals should emphasize passenger comfort and should provide waiting lounges, restaurants, small travel shops, and similar facilities. The aircraft departing from the subterminal would bring the traveler directly to the loading ramp for the large jets at the primary airport, without further processing through gates. Subterminals could also handle freight processing.

Regardless of the collection and distribution system used by a major airport, there are certain basic requirements. The system must provide

- Rapid, convenient, and economical transportation of closed groups of air travelers from large jets to a number of secondary traffic centers.
- Rapid processing of passengers and luggage at secondary traffic centers and transfer points.
- Growth potential to handle up to 10,000 passengers perhour at peak times.
- Transportation of groups of passengers to dispersed secondary terminals in such a manner that insertion into public or private ground transportation systems is achieved without local overloading or choking of the ground traffic.
- Flexibility to adapt to changing demands, routes, and stops.

The Future Outlook

The helicopter has proved its worth over the last 20 years as a reliable, flexible vehicle, but its operating costs have been high. With the expected advances in technology in the near future, VTOL-V/STOL aircraft promise a like flexibility, safe operation in a high-density traffic environment, and accptable cost factors. They also have the potential for alleviating the congestion of airport access roads. Moreover, VTOL-V/STOL aircraft, in addition to making city center to airport service available, will offer attractive competition to high-speed ground transportation in city center to city center traffic.

In the past decade about half a billion dollars has been appropriated by Congres for research and development of VTOL-V/STOL aircraft, mainly for military applications. Additional review of costs, reliability, and safety will be required before these aircraft can be certified for commercial operations.

Nonetheless, this flight regime offers such promise that the federal government should fully support a live demonstration project in the interests of the national transportation system. The United States is in the fore in this area and is in a position to move ahead in refining and improving techniques that will make VTOL-V/STOL-helicopters more attractive economically. Improvements must be made to achieve simplicity of maintenance, longer periods petween overhaul, large seating capacities, less noise and vibration, and suitable all-weather navigation systems.

ANALYTICAL METHODS

The vastness of the national air transportation system, together with the uniqueness of the collection and distribution problems at each hub, indicates the need for analytical methods to study the collection and distribution problems systematically, It is recommended that a comprehensive computer model of the total air transportation system be designed and developed. This model could comprise a set of general submodels, so that data describing a specific hub airport region could be collected and the model used to diagnose the collection and distribution problem and to measure the sensitivity to change of the various parameters of the system. This model would include the following factors but would not be limited to them:

- Projections of future air traffic demands - passenger, freight, and vehicular
- Origin and destination matrices for airport users and other
- Social, economic, and political variables
- Capacity to evaluate all possible modes of airport access individually and in combination

CHAPTER THREE

SATELLITE COLLECTION CONCEPTS

TYPICAL AIR TERMINAL FUNCTIONS

N = Necessary Function D = Desirable Function C = Convenience Function	At A/C	On airport	On airport	Optional on-off airport
A. Air Passenger Service				
1. Ticketing				N
2. Baggage checking/claiming				N
3. Restaurant services		N	D	
4. Recreational services		C		
5. Medical services		N		
6. Customs processing		N		
7. Mail receiving		C	C	
8. Restroom services		N	N	
9. Security protection		N	N	
10. Hotel accommodations		C	N	
11. Motel accommodations		C	N	
12. Insurance sales				N
13. Gift shops/barber/shine, etc.		C	C	
14. Newsstand		N	C	
15. Provide flight and schedule information	N	N	N	
16. Bar		C	C	
17. Telephone	D	N	N	
18. Flight check-in				N
19. Passenger boarding/deplaning	N			

N = Necessary Function
D = Desirable Function
C = Convenience Function

	At A/C	On airport	Off airport	Optional on-off airport
B. Air Passenger Ground Movement				
1. Automobile loading/unloading		D	N	
2. Automobile parking (short-term)		D	N	
3. Automobile parking (long-term)		D	N	
4. Taxi loading/unloading		N	N	
5. Bus and limousine loading/unloading		N	N	
6. Helicopter-V/STOL, loading/unloading		N	N	
7. High-speed rail loading/unloading, if provided to airport		N	N	
8. Intraterminal transit	D	N		
9. Auto rental terminals access				N
car storage and preparation			N	
C. Auxiliary Passenger Service				
1. Provide baggage handling	N	N	N	
2. Provide baggage loading/unloading	N			
3. Flight meal catering				N
4. Flight meal loading	N			
D. Air Cargo Processing and Handling				
1. Receive small lots and individual packages				
from shipper				N
from forwarder				N
from pick-up and delivery service				N

N = Necessary Function
D = Desirable Function
C = Convenience Function

	At A/C	On airport	Off airport	Optional on-off airport
2. Receive outsize, special shipments	D			N
3. Receive pallets/containers from shipper				N
4. from forwarder				N
from pick-up and delivery service				
Receive intermodal shipments truck				N
sea			N	
rail				N
5. Prepare documentation (air bill)				N
6. Consolidation/containerization/ palletizing of cargo into lots				N
7. Label and identify shipments				N
8. Provide in-process storage ware-housing		N	N	
9. Provide bonded storage (inter-national terminal)				N
10. Provide customs, health, or agricultu-ral inspection facilities		N		
11. Provide transportation to and from aircraft	N	N		
12. Provide storage and handling for special categories				
refrigerated		N	N	
livestock		N	N	

N = Necessary Function D = Desirable Function C = Convenience Function	At A/C	On airport	Off airport	Optional on-off airport
restricted, classified, or hazardous		N	N	
13. Provide aircraft loading/ unloading	N			
14. Provide intercarrier transfer		D		N
15. Breakdown containers, pallets				N
16. Tender small lots and individual shipments to consignee				N
17. Tender containers and pallets to large lot receiver				N
other modes		D		
forwarders				N
18. Provide administration facilities				
tracing				N
rating of shipments				N
routing of shipments				N
personnel administration				N
19. Provide communication	N	N	N	
20. Provide access to automated records, schedules status, etc.	D	D	D	
21. Provide maintenance support to facilities and cargo-handling equipment		N		

E. Airport Operations

1. Airport administration facilities		N		

N = Necessary Function D = Desirable Function C = Convenience Function	At A/C	On airport	Off airport	Optional on-off airport
2. Customs, FAA, other government agency administration facilities		N		
3. Nonpassenger service concessions				
employee cafeterias		N		
vending services		N		
4. Automobiles parking				
passengers				N
visitors				N
employees		N		
5. Intraterminal transit		N		
6. Fire protection				
crash/fire	N			
buildings and structures		N		
7. Security and police		N		
8. Provision for service vehicle traffic		N		
9. Provide utilities and communications		N		
10. Provide air traffic control facilities		N		
11. Provide ground traffic control facilities		N		
12. Provide airport maintenance facilities and equipment, i.e.,				

N = Necessary Function D = Desirable Function C = Convenience Function	At A/C	On airport	Off airport	Optional on-off airport
snow removal, runway maintenance		N		
13. Provide facilities for related industries		D		
14. Provide refuse collection and disposal		N		
15. Provide common P.O.L. facilities	D	D		
16. Provide aircraft storage parking	N			
F. Aircraft Servicing				
1. Fueling	N			
2. Cleaning/service lavatories	N			
3. Food servicing, potable water	N			
4. Aircraft washing				
5. Provide aircraft utilities (power, air)	N			
6. Checkout, minor repair, remove and replace	N			
7. Major overhaul of components				N
8. Major overhaul of airframe	N			
9. Store spare parts and supplies		D	N	
G. Air Carrier Operations				
1. Flight operations/crew dispatch		N		
2. Ground crew ready rooms	N			

N = Necessary Function D = Desirable Function C = Convenience Function	At A/C	On airport	Off airport	Optional on-off airport
3. Air crew ready rooms		N		
4. Communications center		N		
5. Ground crew and air crew intraterminal movement		N		
H. General Aviation				
1. Flight filing		N		
2. Transient parking/tie-down	N			
3. Weather forecaster access		N		
4. Parking to operations transportation for passengers, crew, and luggage	D			
5. Additional strips		N		
6. Additional (satellite) airports			N	

The functions listed above have been designated as necessary, desirable, or convenient. These designations have been assigned to specific zones of activity. The column headed "at A/C" indicates those functions performed immediately adjacent to or in physical contact with the aircraft, no matter where it may be parked (usually at the loading gate). The "on airport" functions are those performed in the immediate vicinity of the airfield, runways, and taxiways. The "off airport" functions are those that may be performed in facilities normally dedicated to the air transportation system but not necessarily on the airfield property, e.g., at a downtown air terminal.

Allocation of the various functions to categories is necessarily a matter of judgement and subject to variances between different air terminal concepts. However, the structure of functions as listed represents generally acceptable distribution within a typical urban hub area and is included here to establish a basis for subsequent discussion of airport and terminal problems related to the introduction of larger aircraft into a rapidly expanding future market. This sort of approach to identification and classification of functions is essential in future airport planning efforts in order to ensure objective evaluation of requirements and alternative solutions.

The preceding problems and alternate solutions to both on-airport and regional airport problems, has indicated that certain functions traditionally found at the airport might better be distributed throughout the large areas served by our major hubs. This implies the need for satellite points. These might also provide a shuttle service to get passengers across large metropolitan areas efficiently, to take advantage of the specialized (in function or direction) airport.

There seems to be no question but that hubs serving large metropolitan regions, many of which are already at the point of crisis with respect to intra-urban surface transportation, will have to meet the problems of air transportation through some sort of collective airport system to serve the scheduled air traveler properly. It is impossible to foresee a solution that would allow a single airport such as New York's Kennedy International, Chicago's O'Hare International, or Los Angeles International to handle adequately the air traffic necessary to meet the forecast passenger demand. The dispersal of airports, coupled with the increasing problems of any surface traveler, demands that careful attention be paid to integration of the air transportation system into the urban environment, and particularly the urban transportation system.

Users of air transportation are becoming more concerned with total door-to door travel time. Door-to-door travel time can be broken into five discrete time slices:

1. Time from office or home to airport
2. Processing time from curb to enplaning

3. In-flight time
4. Deplaning and processing time to curb
5. Time from terminal to destination

Continued improvements in flight time will have only a marginal effect on the air transport system's performance. Time slices 1,2,4, and 5, however, will be greatly affected by the large increase in the number of travelers during the 1970 to 1980 period, regardless of improvements in aircraft. To remain viable, the air transport industry must maintain an image of comfort, service, newness, and speed not just in the third time slice but in all five segments. Processing of baggage and passengers must be improved to reduce the delays, waits, and queues that will occur with the predicted growth in air travel and the increase is that passengers, cargo, and baggage should move to the point of maximum congestion, the aircraft boarding area, as discrete groups rather than individually. This concept affords more control in passenger processing and also permits early separation of the passenger from "bon voyage" wishers.

One way to achieve the grouping of passengers and to gain better control over movement and behavior is to capture the passenger in the air transportation system as early as possible in time slice 1 and to release him as far downstream as possible in time slice 5. An approach to this goal would be establishment of satellite collection terminals throughout the major metropolitan hub area, in a manner similar to that discussed previously for air cargo collection and distribution. Into these collection satellites would be distributed all processing functions that need not be performed at the airport site.

Location of these satellites may be within the downtown business district with distribution throughout suburban areas where air travelers are concentrated. The satellite collection centers should have complete facilities to maintain the image and amenities that the air traveler has grown to expect. These will include concessions of all types, food and drink, car rental, and other personal services. Basic functions of satellite collection centers are to process both passengers and baggage away from the airport proper and to organize controlled movement of groups of passengers as directly as possible to aircraft boarding positions.

Satellite Collection Terminals

Design and configuration of the satellite collection terminals would depend greatly upon their location in the urban environment and their interface with other modes of urban transportation. For example, a terminal located in suburban or predominantly residential areas in an automobile-oriented community should provide adequate, convenient, and secure parking for those passengers who would customarily drive their cars to the airport and leave them there.

A satellite terminal serving a denser residential area, such as a heavy concentration of apartment houses, would probably have less need for long-term parking but would want to give stronger emphasis to the interface with urban transportation systems and taxicab loading and unloading. A city center satellite collection terminal might well be integrated into a high-rise commecrial building, such as the Pan American Building in New York; parking would normally not be required at such a facility.

Two major technological advances will be required at the satellite collection centers: automated handling of baggage and fast, reliable passenger ticketing. With these advances, centers at various locations in a community could preprocess both baggage and passenger for the complete trip and insert them into a coordinated collection and distribution transportation subsystem.

Various modes of surface and air transportation for collecting and distributing passengers and cargo are under consideration. Each mode has advantages and disadvantages in specific situations. It is extremely important, however, that the planner recognize that when airport and terminal functions are distributed as described here, the mode of transportation must become an integral part of the satellite. Passengers must be made to feel that they are in the system from the minute they enter satellite terminals until the trip is completed - with the hope that they will find an equivalent level of service in some distant city. The system design applies not only to function but to imagery and esthetics. Certain thematic identities should be sustained throughout, from main airport terminals and boarding areas through collection and distribution-transportation media to satellite terminals. At the same time, satellite terminals should esthetically blend into the local community.

Transportation Between Satellite and Main Terminals

Economics, prevailing climatic conditions, and reliability of equipment are factors that will influence decisions on use of ground transportation, air transportation, or combinations of both to link satellite collection terminals to major airports. If a ground system is chosen, the total time considerations of the air traveler will emphasize the need for high speed.

If a high-speed rail (rapid-transit) system is chosen, vehicles working in this sytem must be dedicated to the needs of the air traveler, which are considerably different than those of the urban commuter. The ultimate in this regard would be a combination rail-transportation vehicle and boarding lounge, similar to the Dulles concept, that would speed travelers from off-airport satellite collection terminals directly to the aircraft boarding location at the airport. There the lounge would join a compatible enclosed loading-ramp system. Automatically controlled and dispatched vehicles with high operational reliability could be scheduled so that they arrive punctually for sequential boarding of passengers for one flight from several collection centers. Such precision is entirely feasible, as demonstrated by modern automatically controlled rapid-transit systems.

Figure 9 shows one of many possible concepts for collection of air passengers into a surface transportation system that has been fully integrated with the air travel mode. In this case, a number of the facilities normally found within the passenger terminal (check-in counter, baggage checking, passenger-holding area, etc.) have been included at the loading platform or in the special-purpose high-speed rail car.

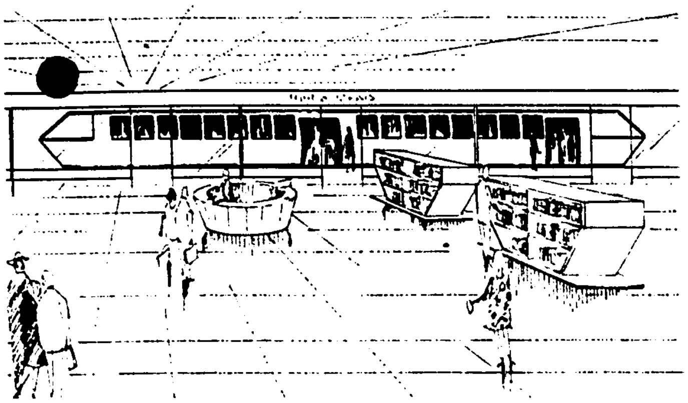


Figure 9

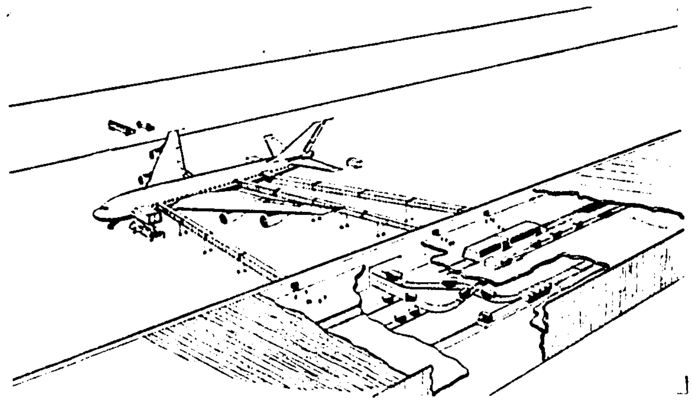


Figure IO

Each car would be individually destined for a particular flight and could perform many of the check-in and passenger information functions en route. The car would be designed to carry standardized baggage containers, allowing baggage to be checked directly into the container for its particular satellite destination, i.e., a particular satellite terminal at the destination hub. Passenger and baggage, container capacity of the cars would be determined from the observed and predicted travel characteristics of the population served by the bub. Partial or split containers might be provided for low-traffic destinations.

Figure 10 shows a possible approach for the interface of the rail car and the airplane. Here, as in the case of satellite collection terminals, a minimum of facilities is required. A highly functional structure is provided to support the loading fingers, terminate the rail system, and provide for handling of baggage and freight and comfortable, rapid transition of passengers from the rail car to the aircraft. This concept patterned around the Boeing 747, also shows the simultaneous arrival of a special carload of freight containers from an off-airport freight terminal. This freight, along with the baggage containers, would be processed through the lower level and out through under-ramp tunnels via conveyor systems to loading elevators at the aircraft. Containers would be automatically checked for weight and balance and would be given other final inspection as required. Some capability would be provided for repacking and consolidation of baggage within the containers, but this would be kept to a minimum and done quickly in order not to compromise the rapid transfer of preprocessed passengers into the air.

Problems of integration into an urban environment

Concepts like these are described not as recommended solutions to specific problems but rather to encourage critical appraisal of the problem of air transportation integration into a complex urban environment. Actually, there are many reasons that preclude the immediate introduction of concepts such as these into the urban and air transportation system. If such an integrated system is to be achieved at all, it will undoubtedly be through a process of evolution rather than revolution. For example, baggage containers are not sufficiently standardized among carriers or among aircraft to allow the design of an efficient universal system. Also, passenger-handling, check-in, or recording procedures are not standard among carriers. Lastly, the system is geared to the long-haul, large-capacity type transport. A high volume of this type of traffic would be needed to accrue the full advantages of the concept.

Nevertheless, such problems are not beyond solution, and he concept does illustrate some of the advantages of integrated air and surface transportation. It also illustrates the necessity for the integration of such functions as ticketing, reservations, aircraft status, and schedule deviations into an industry-wide information system - a system that would also allow efficient control of the ground transportation system as an operational extension of each individual carrier's flight operations, Since it is unlikely that each carrier could profitably operate his own satellite collection system, it is probable that such a system would have to be operated jointly by the various carriers served.

A critically important planning factor in high-speed ground transportation systems is the cost of acquiring and constructing exclusive right-of-way with grade separation from routine urban vehicular and pedestrian traffic. Because the cost is great, it is extremely doubtful than an exclusive-use high-speed ground transportation system of the type described above will be economically feasible within the foreseeable future. Therefore, air transportation-system planners should join urban transit-system planners in attempting to evolve common plans for routing and right-of-way that will allow joint use of this expensive right-of-way. This does not suggest that rolling stock would be common to both air and urban systems, but rolling stock is not the major cost item in the total system.

Such an effort does presuppose, however, that urban air transportation collection terminals be within short spur-line access to rapid-transit right-of-way; that control and scheduling of urban and airport traffic on rights-of-way be coordinated and integrated; and that minimum feasible distances between collection terminals and airports be considered in overall routing and interchange provisions of the rapid-transit right-of-way.

Where urban rapid-transit systems are not planned, or integration of the two systems is otherwise not feasible, collection and distribution travel loads will undoubtedly be relegated to some other form of transportation. Many of the concepts discussed above can be effectively applied to other types of transportation, such as the skybus currently under study for Los Angeles, in which the passenger lounge is airlifted from collection satellites to airport by a "flying crane" type of helicopter. In this case, the same principles of identification with the system, convenience of boarding, and interfacing with terminals should be applied.

Two concepts for terminals to serve V/STOL collection media are shown in Figures 11 and 12. Except for the psychological effect, it should make relatively little difference to the traveler whether he is in a high-speed ground transportation vehicle or a high-speed air transportation vehicle such as the skybus. Although point-to-point speeds would undoubtedly be higher for the skybus, maneuvering and

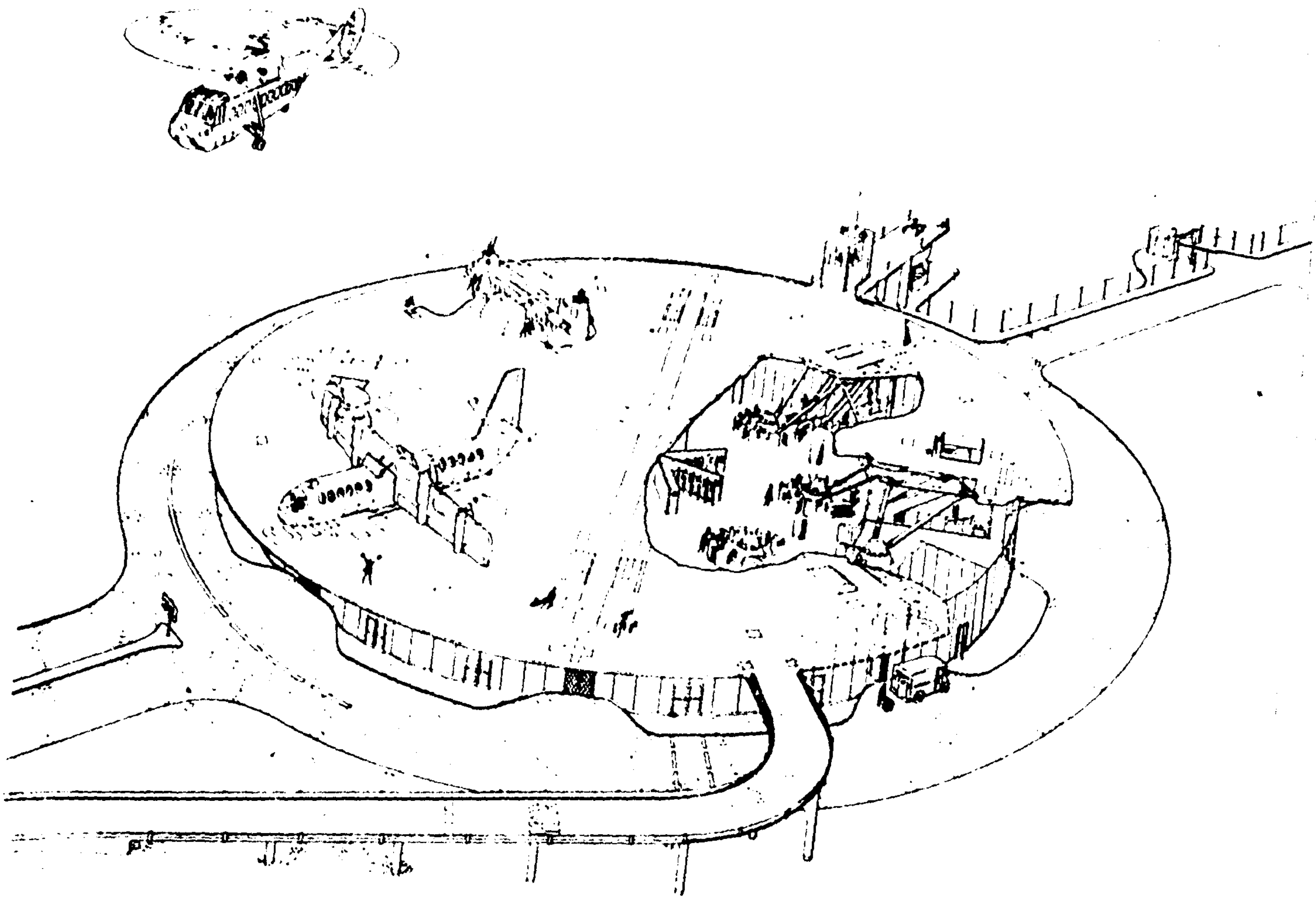


Figure II

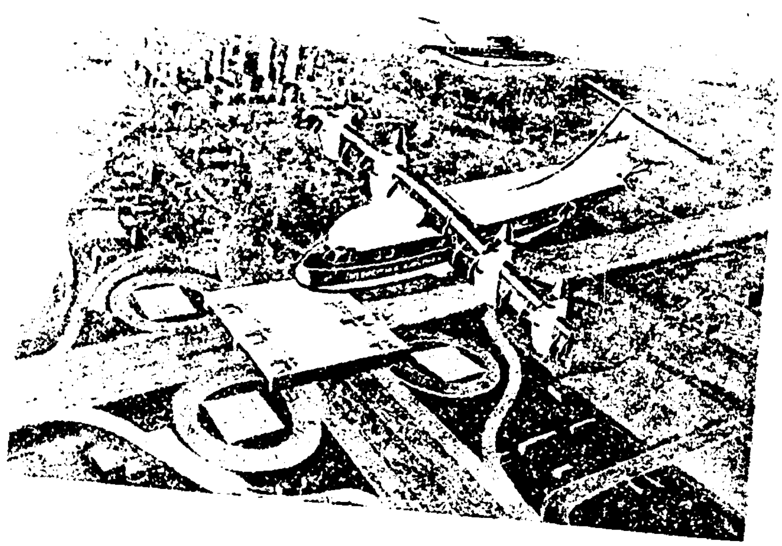


Figure I2

interface time at the destination may be somewhat more complex and scheduling may be less precise, thereby equalizing the overall time. Of course, overall time would be greatly dependent upon the trip length. As a result, it is quite possible that a combination of air-plus-surface connecting systems may be employed in larger hub areas.

Pooled Operation of Satellite Facilities

Costs of facilities and maintenance within satellite terminals will depend greatly upon carrier policies. The very fact that passenger reception functions have been distributed away from the central terminal to reduce congestion implies that processing density over a 24-hour period would be less at the satellite locations than at the central locations.

In some cases, a less-than-optimum work load for each satellite agent for each individual carrier may result. Likewise, density of processing may be reduced below the level where each individual airline is justified in having its own unshared processing desk. For these low-density collection terminals, carriers should evaluate the possibility of pooling passenger agent manpower, along with employment of the maximum automation feasible. This approach would not only reduce direct costs to the individual carriers but in many cases would reduce costs of structures and fixtures too. Further, it is entirely feasible to consider a completely unattended satellite station with automated ticketing and closed-circuit television monitoring by one agent serving a number of satellite terminals.

Integration of Satellite Collection Systems of Passengers and Cargo

It is important that any analysis of modes of transportation between satellite collection terminals and airports consider air cargo problems as well as air passenger problems. Careful consideration should be given to the design of multipurpose satellite collection terminals with contiguous but physically separated areas for handling cargo and processing passengers. For cargo handling, planning between urban transit systems and airport collection systems would require coordination of standards for container sizes and tunnel cross sections (of underground rapid-transit systems).

Advantages and disadvantages of the regional satellite terminal approach are summarized as follows.

Advantages of distributed terminal functions

- Decentralization. Functions not essential at the airport area are removed from the airport.
- Increased convenience and peace of mind to the traveler. Travelers may enter the system at points closer to their true point of origin and then relax, knowing they are shielded from obstacles beyond their control such as traffic jams.
- Improved reservation status. The earlier capturing of individual passengers will allow improved advance notice of shows and non-shows.
- Improved handling of passengers under adverse conditions. Precise scheduling of the collection mode will allow holding passengers away from the airport during delays due to mechanical difficulties or weather, as well as efficient transfer of passengers to alternate departure points on flights.
- Reduced travel time. Overall travel time from point of origin to ultimate point of destination will be reduced.

Disadvantages of distributed terminal functions

- High cost. The investment required, primarily for transportation media between satellite collection terminals and airports, may be greater than can be extracted from the traveler in additional fares. Also, total facility cost for a given passenger-processing capability will probably be higher with distributed facilities than would be the case for centralized facilities.

- Higher operating costs. Individual carriers will experience higher operating costs unless pooling and automation are employed.
- Urban integration. Much coordination between urban planners, air carriers, local and federal regulatory agencies, and other modes of transportation would be required. Experience has shown that such fully integrated planning and development are difficult to achieve.

Single-purpose airports, single-direction airports, and satellite collection points have been discussed. These three concepts of regional airport systems are only a few of many possible variations. For example, it is quite possible that in major hib areas such as New York or Los Angeles a specialized airport might eventually be combined with the satellite terminal. It should be emphasized that the systems presented have been singled out for discussion merely to emphasize and amplify some major planning problems facing the air transportation industry, and not as recommended solutions to specific problems.

STOL/VTOL AIRPORTS AND TERMINALS

Design and layout of the STOL/VTOL port buildings and apron should aim at achieving minimum apron-occupancy time, minimum time for processing passengers, baggage, and cargo, and maximum turnaround efficiency consistent with airline operational requirements. Terminal parking, passenger processing, and aircraft apron areas should be designed to provide passengers with increasingly effective service and facilities.

STOL/VTOL Terminal Requirements

The airport designer must generally satisfy the diverse objectives and desires of many interested groups, and STOL/VTOL terminal design is no exception. Such interested parties include the municipality, the airport operator, passengers, officials of airlines and equipment representatives, airport neighbors, and regulating government agencies. Each can be expected to be concerned with such key items as location, size, appearance, technical requirements, initial costs, noise and air pollution, and operating costs.

Special STOL/VTOL terminals may be established for city center service (if noise and pollution conditions are acceptable), or they might be developed at existing general aviation or air carrier airports convenient to city centers. Terminal requirements for STOL/VTOL operations are listed here. These indicate the more important considerations in establishing STOL/VTOL facilities, but are not listed in order of priority. What applies to one location may not apply to another.

- Proximity to traffic-generating centers, convenience to central business district
- Vehicular accessibility (in downtown areas, taxicab traffic primarily)
- Availability of site
- Adequacy of size (STOL will require more space than VTOL)
- Proper elevation (ground level or elevated)
- Operational safety
- Obstruction clearance
- Permanence of obstruction clearances (preservation possible by zoning or through natural means, with approaches over water, parks, or highways)
- Relative insensitivity of area to noise (industrial or nonresidential locations preferable; sites near schools and hospitals to be avoided)
- Compatibility with normal air traffic patterns and helicopter traffic
- Cost of acquiring and developing site
- Compatibility with neighboring property uses
- Accessibility to utilities (water, gas, electric power, A/C fuel, sewage disposal)
- Connection convenience with other transport modes

. Aircraft physical and operational characteristics

Design of STOL/VTOL Terminals

STOL and VTOL terminals might be located in the central business district or "downtown", in outlying or suburban areas, or in ceonventional airports. The central business district location is visualized as a multilevel structure, with lower levels for parking and passenger processing and upper levels for loading and unloading travelers and for aircraft operations. The STOL/VTOL facility at a conventional airport might possibly be situated at ground level. It may include a terminal, to separate the short-haul traveler from the conventional air-traveler, and specially constructed short runways or pads for efficient STOL/VTOL operations. At major hubs these should be located so as not to interfere with conventional carrier operations.

The outlying or suburban facility location may permit the use of more land (instead of multilevel vertical structures) and will require more overnight automobile parking than central business district locations.

STOL/VTOL airport design must be in accord with anticipated operating requirements of future STOL/VTOL aircraft and with other facilities in the system. Required terminal facilities depend upon traffic potential and airline operational methods and requirements to ensure efficient and safe air service operation.

Detailed criteria used in developing the required facilities involve

1. Aircraft types and physical characteristics.
2. Aircraft capacities with respect to passengers and cargo.
3. Passenger traffic.
4. Movement rate (including peaking).
5. Gate control and passenger-cargo handling techniques.

Design of passenger and aircraft areas must take into account noise, fumes, and heat. A primary consideration is minimization of aircraft ground-stop times,

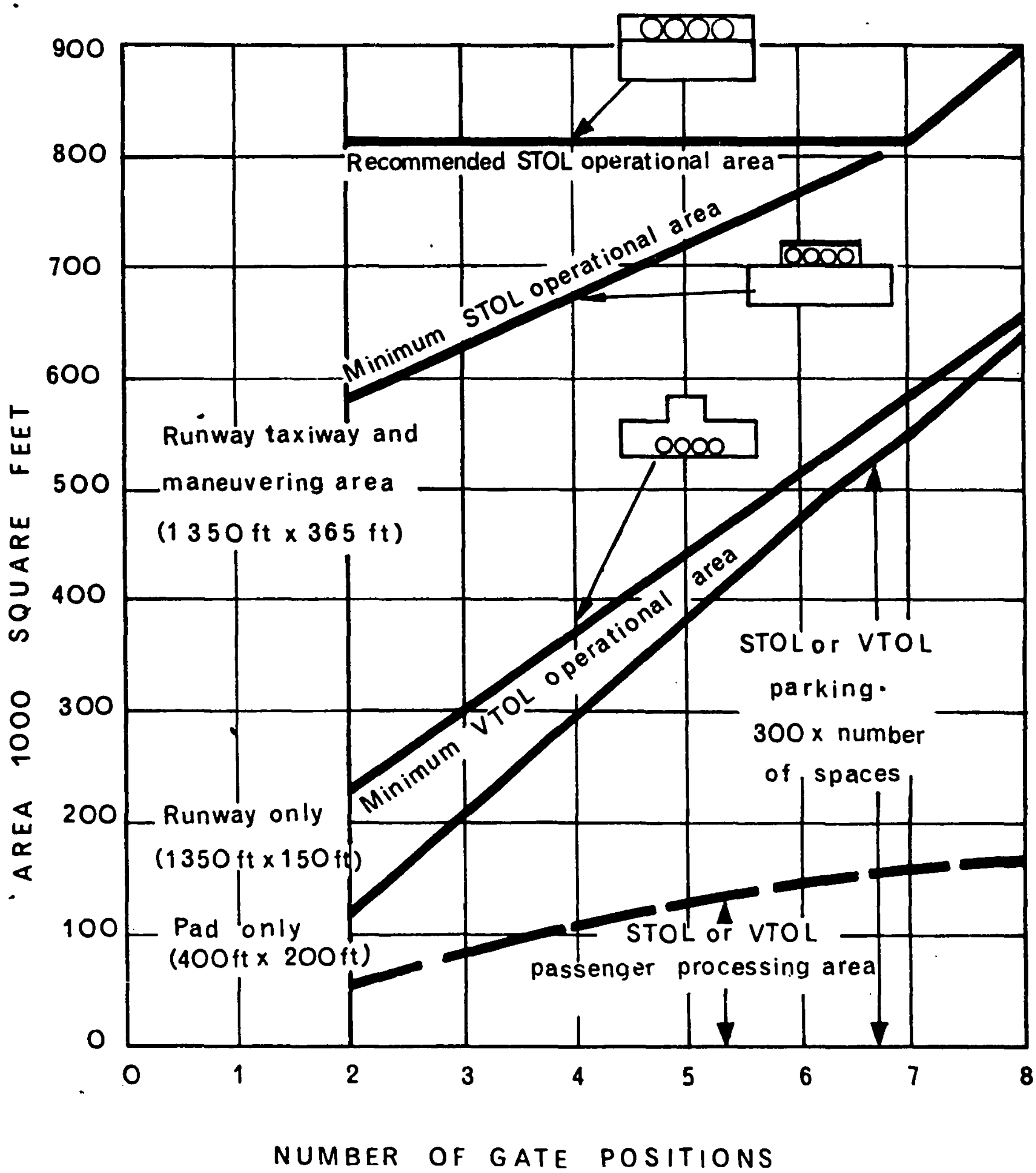


Figure I3. How area requirements for STOL and VTOL ports vary with number of gates.

which can be achieved by efficient traffic flow and simplification of interposed formalities. Also, safe passenger movement to and from aircraft without engine shutdown is a consideration in reduced ground time. Primary consideration in reduced ground time. Primary considerations in passenger processing are space relationships and area requirements, which contribute to construction and operation costs.

The size and number of gate positions will of course affect apron design, and consideration must be given to fixed installations for ground service to reduce apron congestion and servicing times. Building costs should be held to the minimum appropriate to the architectural motif of the surrounding area and future planned developments. Each terminal in the system will differ in size and configuration because of passenger volume and location, but in general the linear-type layouts are more easily expanded if original terminal capacity is exceeded.

Figure 13 summarizes the estimated area requirements for elevated or ground level STOL or VTOL ports. Major areas required are those for aircraft operations, passenger processing, and vehicle parking. In an elevated configuration, passenger-processing parking areas can be efficiently decked or situated below aircraft operational areas. For conventional designs at ground level, passenger processing and parking areas must be added to the port's minimum operational area. The total area required for a four-gate ground-level STOL or VTOL port is about twice that required for an equivalent elevated configuration. This difference in area requirements diminishes as gate positions are added, owing to the fact that, while requirements for run-ways and taxiways are fixed, variation with number of gate positions is fairly constant for STOL ports but increases rapidly as gate positions are added to VTOL ports.

As the number of gates for the STOL port increases beyond seven, the planform must be lengthened to maintain clearances when all positions are in use. A family of curves for different gate position sizes could be generated. Operational areas can in some designs be utilized for off-line parking and maintenance of STOL

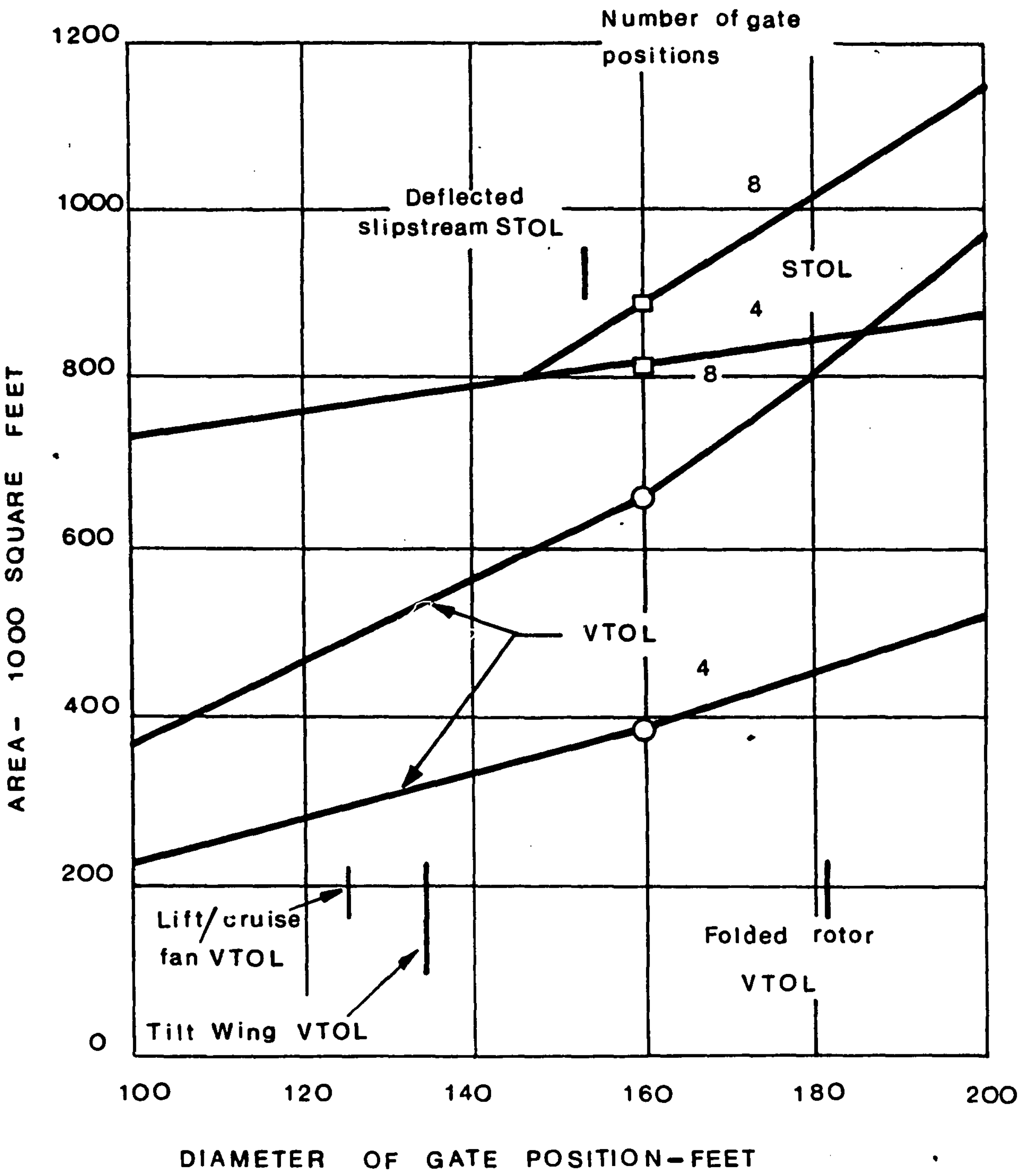


Figure 14. How STOL and VTOL airfield area requirements vary with diameter of gate position.

aircraft, with lower levels providing additional parking area.

A two-gate terminal is considered the minimum practical size. Terminal area requirements for vehicle parking, servicing and fueling of aircraft, and processing of passengers are similar for STOL and VTOL handling equal traffic volumes. The major differences are in the takeoff and landing areas.

Airfield area

A principal design element of STOL/VTOL terminals is the aircraft operational area (comprising the landing facilities and apron areas). The size of the airfield is based upon (1) physical and operational characteristics of the aircraft, and (2) the size and number of gate positions.

Evaluations of various STOL port and VTOL port planforms have shown rectangular planforms to be the most efficient, based upon STOL/VTOL aircraft operational requirements and future expansion possibilities inherent in these designs. Airfield area requirements are summarized in Figure 14.

Terminal area

The STOL/VTOL terminal is essentially the service center for transferring passengers and their property, as well as mail, express, fuel, and cargo, between surface carriers and air carriers. Passenger area space requirements (Figure 15) are based upon FAA airport terminal building design data. Space allocation should be coordinated with carriers to promote efficiency, reliability, and speed of airport and airline operations.

The space relationships developed by the FAA are based on the functional disposition of facilities for airlines, the public, and concessions, allocated on the basis of passenger volume. Floor space required for STOL/VTOL operation is taken as 80 percent of the FAA design curve for conventional terminal facilities, for airlines operations, waiting area, and restaurants.

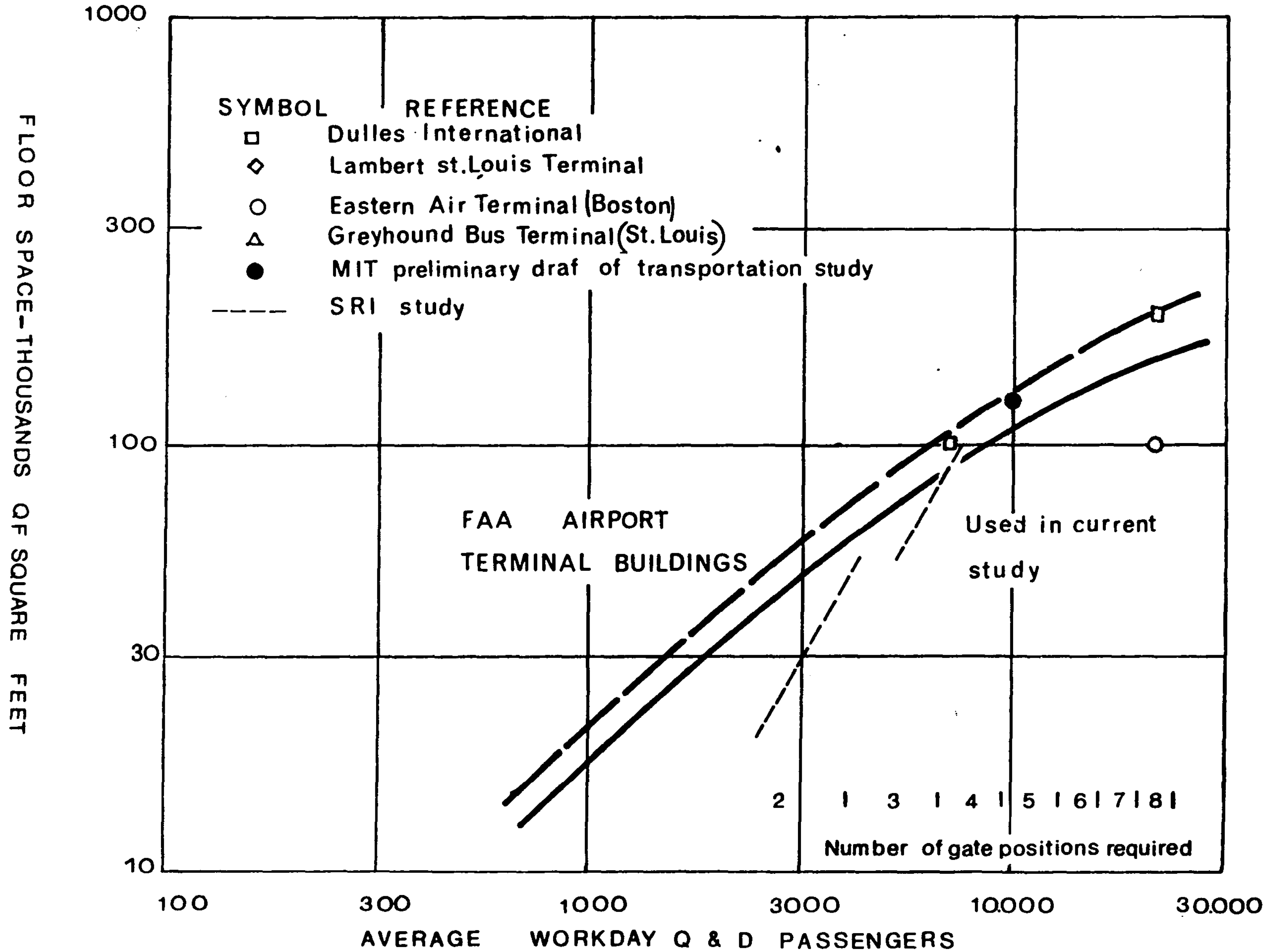


Figure 15. Passenger-processing space requirements in the STOL/VTOL airport.

V/STOL METROLINE SERVICE

Urban and short-haul interurban transportation can be expected to face increasingly heavy demands. Freeways and other automotive developments are being pursued to meet part of these demands; another avenue being extensively explored is high-speed ground transportation (HSGT); a third approach is through V/STOL aviation. It is clear that a combination of road, rail, and air transportation will be needed to satisfy the travel demands of the future, but it is not clear what the role of such a V/STOL Metroline service might be.

There are several inherent advantages to a Metroline service:

- It does not require a tremendous investment in right-of-way.
- Its airports (metroports) can be located at many points throughout the region where travel demand originates. The flexibility of site location provides a great opportunity to reduce short-haul door-to-door travel time, which has increased recently in spite of scheduled improvements in the air vehicles.
- Facilities can be added to the basic metroports as traffic builds up, and other metroports can be added without any restrictions imposed by immovable right-of-way.
- The size of the vehicles and their frequency of service can be increased to accommodate demand.

This section examines some factors governing the introduction and spread of V/STOL urban and interurban service, identifies the actions needed to foster its practical development, and presents financial data suggesting the extent of the cost involved. The basic premise is the same one that underlies current interest in high-speed ground transportation (HSGT) and mass transit: For reasons of national welfare and security, improvement of transportation is in the public interest.

The Metroline service would have a profound effect on planning the facilities

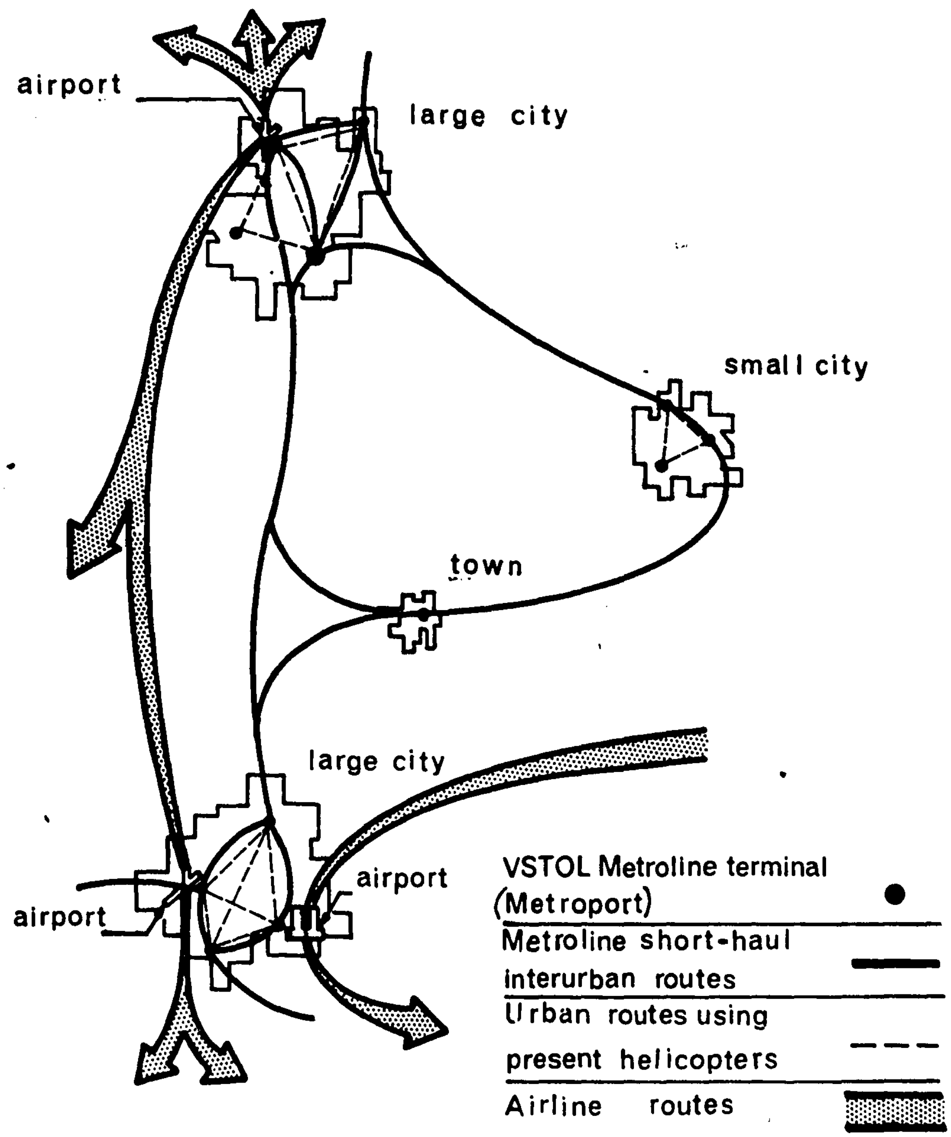


Figure I6. Metroline system route structure.

required for the transport system. It would allow access to air transportation at a number of new city-center and suburban terminals. It would require changes in major airport buildings for rooftop loading, revised use of terminal-area airspace, and new ATC procedures. Multiple-access interurban transportation would probably attract new travelers and shift short-haul passengers away from present fixed-wing airport facilities. When and where Metroline service will be introduced are significant uncertainties in air transport planning.

This application of V/STOL technology seems remote at present for reasons other than technical, as outlined later in this section. It would cause a far greater revolution than did the introduction of jet transports. It is essential that those who plan this nation's future transportation facilities have more detailed knowledge of full-scale systems, so that V/STOL may develop as an integral part of the overall transportation network.

A description of a general Metroline system is necessary to delineate the role it could fill. Figure 16 shows typical routes, both urban and interurban. The vehicles (metroliners) would be best suited for interurban service. Local service would be provided by helicopters of the present type.

The distances traveled would range from 10 to 250 miles. At these distances the metroliners and metroports have a decided door-to-door trip time advantage, as shown in Figure 17. This advantage would have to be supported by frequent sergice, particularly on the shorter routes. Flight times would be less than half an hour, permitting simpler cabin furnishings, no meal service, fewer toiles, and other savings.

The system would be used by a variety of travelers. By interfacing with major airports, it could quickly and conveniently collect and distribute medium- and long-haul passengers from both the urban area and the outlying cities and towns. This might obviate the construction of major airports in the smaller cities in favor of metroports. Another use would be interairport transfer in areas having more than one airport. There is also the possibility of intermodal transfer

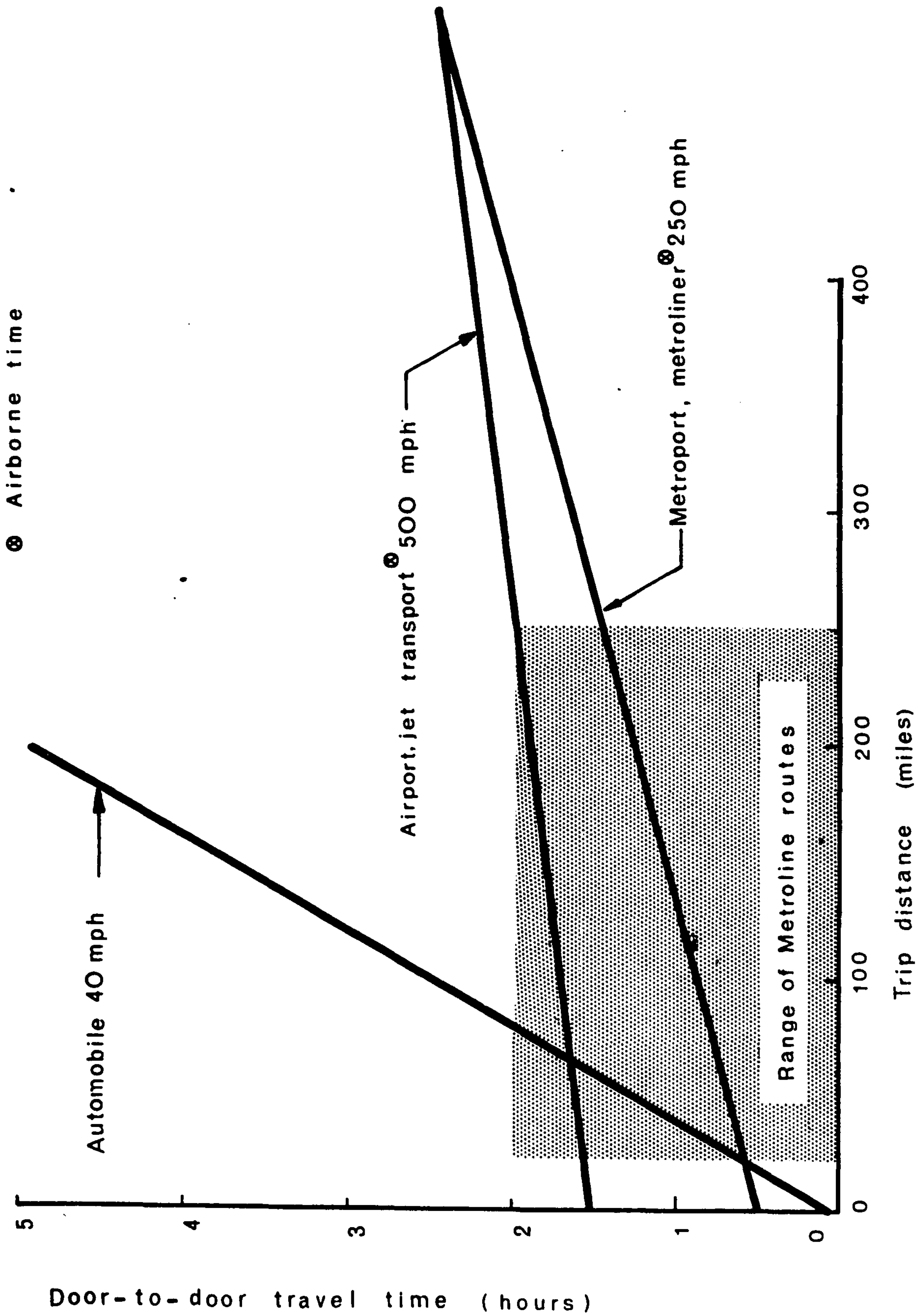


Figure I7. Metroliner travel time comparison.

between bus or rail stations and the airports.

The existing helicopter services in New York, San Francisco, and Los Angeles already partly fulfill some of these functions. Los Angeles Airways provides a collection-distribution service to the airport from multiple sites within the Los Angeles urban area. New York Airways provides interairport transfer as well as airport access for the New York airport system. These would be relatively small parts of a full-scale Metroline system.

The major use of the system would be interurban travel between large cities less than 250 miles apart, as in the megalopolitan or corridor areas developing in the United States. Short-haul air travelers would find frequent service from multiple access points in each city to be quicker and more convenient than using the fixed-wing airports.

The system would relieve short-haul airports by diverting much of the predicted air traffic. Because of the time saving, it might also divert traffic from other modes such as train or auto. Introducing new routes and services could generate much new traffic as well, since business travelers would be able to make new types of interurban trips.

The interurban portion of the Metroline system does not exist today. Future V/STOL aircraft will be particularly syited for this type of service.

The system promises many advantages in time saving, convenience, and flexibility. The technical feasibility of suitable V/STOL vehicles has been indicated, and future technology promises much-improved direct operating costs. Operational feasibility seems assured, although there are problems of site location, community noise level, design and construction of major terminals in city centers and urban areas, ATC, and all-weather operation. These problems are soluble, but they require some operating experience.

Determination of economic feasibility requires marketing experience at various levels of service and fares, and some operating experience to determine station-operating expenses, maintenance costs, block times, and daily vehicle use. Operating experience is also required so that the operator can guide the designer by specifying vehicle size and configurations, interior arrangements, fuel reserve requirements, and stabilization requirements.

The uncertainty in V/STOL development lies in the areas of regulatory policy, market development, and financial interest, The technology for the vehicles is here, but an impasse has been reached among the various actors who normally play roles in the development of new enterprises in our society. To understand this impasse, it is useful to describe briefly each of the actors and their present situations.

1. The manufacturers stand ready to initiate design and construction of the first generation V/STOL transports, but they cannot find a suitable operator who has any plans to initiate V/STOL service. The commercial market to justify a costly manufacturing program is not visible.
2. The operators fall into three groups: major (trunk) lines, local or second-level lines, and helicopter or third-level lines. The major airlines are busy with growth problems, and their fixed-wing experience tells senior management that there is no profit to be made on short-haul traffic. Because of the poor performance of present helicopters and the uncertain performance of military experimental vehicles, they are reluctant to gamble on new V/STOL transports. No fixed-wing trunkline has a suitable route structure for Metroline service, and the operators are uncertain as to whether they would be allowed to add new short-haul routes. If they do consider a new route structure, they find they are talking about extensive development of markets where air travel does not now exist. A few years of promotional service would be required to develop the full traffic, indicating an initial financial exposure of millions of dollars in operating expense where market potential is unknown. The operators find it difficult to divert the capital and manpower required by their growing operations into expensive, long-term development of an uncertain

new area of business. Their boards of directors and financial backers can always find a better return at less risk in buying fixed-wing airplanes and developing their present long-haul system.

3. The local airline operators who perhaps do have suitable route structures and who might feel that they could get new routes for Metroline service are on federal subsidy. It would require a clear statement of support from the Civil Aeronautics Board (CAB) to let them start planning such a service, and with no market information they would face severe problems in raising financial backing.
4. The helicopter carriers, who might logically expand their heliport services into a Metroline system, are losing money. They have neither the financial nor the management resources to contract for the large initial order that the manufacturer would require. Like the local airlines, they could not take action without the support of the regulators and legislators.
5. The investors who might be attracted by the long-term returns of a Metroline service must have some idea of the investment requirements and the period of development until a profit can be made. They need a strong demonstration of market response and assurances of economic viability before they will lend their support to any operator.
6. The public, whose response is essential to Metroline development, has not had a chance to sample this type of service, aside from the airport feeder and transfer operations of present helicopter lines. The public will not get this chance unless an operator can persuade himself, the regulators, his investors, and local authorities of the long-term viability of the service.
7. Local authorities, who will be responsible for siting and constructing metroports, will await the request and assurances of an operator before they give approval and funds. They will need to coordinate their actions with nearby cities to get the service started.

8. The regulators have only recently faced up to the possibility of a new mode of air transport. The lack of any regulatory framework for developing a new system is a gap that needs to be filled. A statement of policy that somehow defines the rules of the game for the various actors is needed before the operators and investors can act. This policy has not been set, since the technical and economic feasibility of V/STOL aircraft has only recently been recognized. It is not clear whether national transportation policy will include the development of such systems, but an important first step was taken by the CAB on October 4, 1967, when it decided to institute "an investigation to determine the need and the feasibility of metropolitan area to metropolitan area VTOL, V/STOL, and STOL service on a subsidy-ineligible basis, between certain major cities of the Northeast Corridor" (Docket 19078).
9. The legislators' experience with subsidies to helicopter services has left them with a strong impression of unprofitability. While subsidy is one avenue to V/STOL development, it can blunt the profit incentive and cost consciousness of management. Furthermore, the pressure to minimize subsidy expenses often leads to minimal service and avoidance of experimentation in marketing or operation. Such experimentation may be the only way to obtain the basic market data needed to guide decisions concerning the new system's development.

Thus the actors are at an impasse. The manufacturers will not build until a market is visible. The operators will not provide the service because they have other interests and because they lack suitable route structure, financial backing, and market information. Investors are wary because of the amount of capital required, the risks involved when there is no clear evidence of public response, and the uncertainty about future government action. Since the operators show no interest, the regulators and legislators have been slow to investigate V/STOL development and methods of encouraging it.

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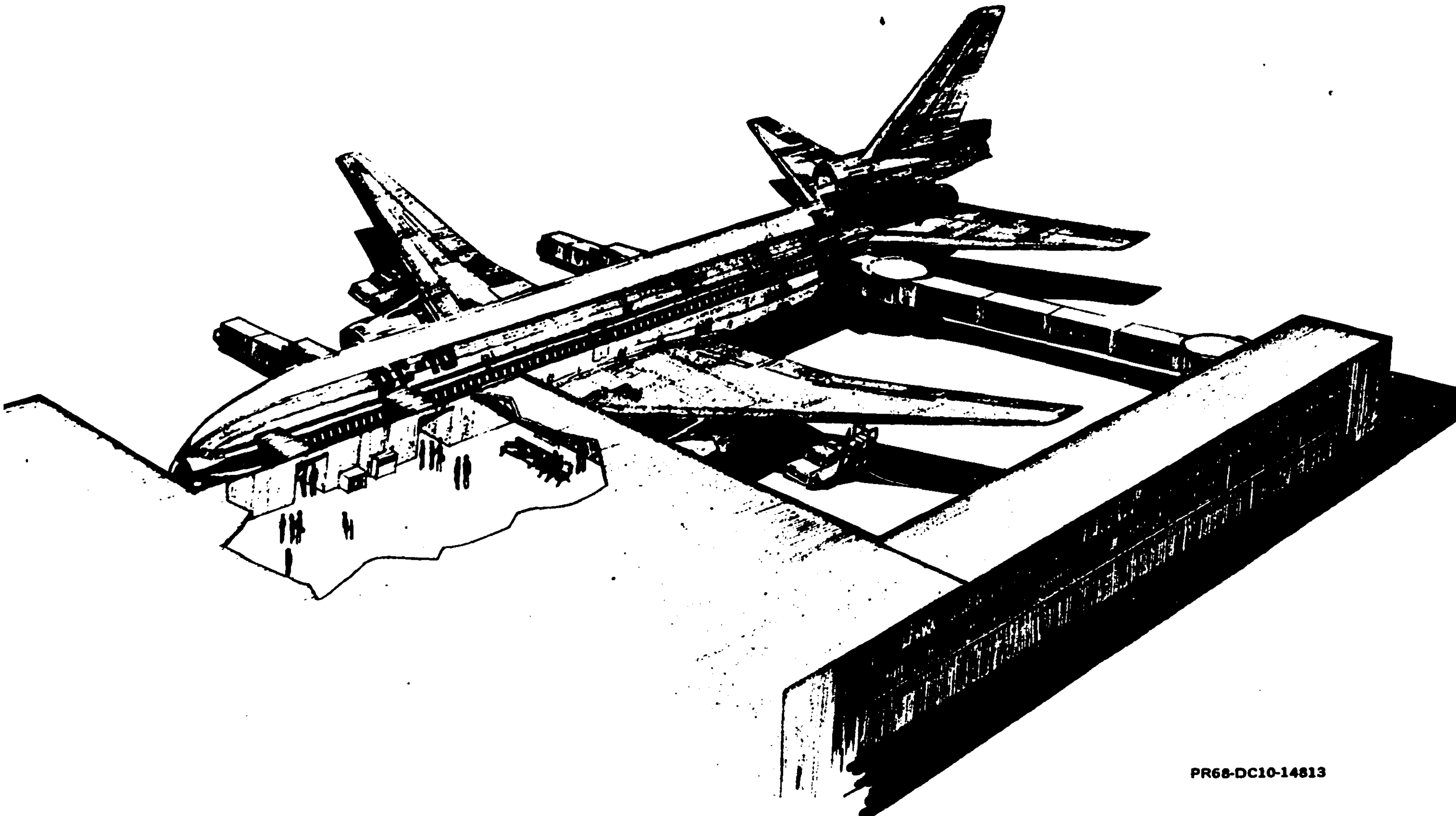

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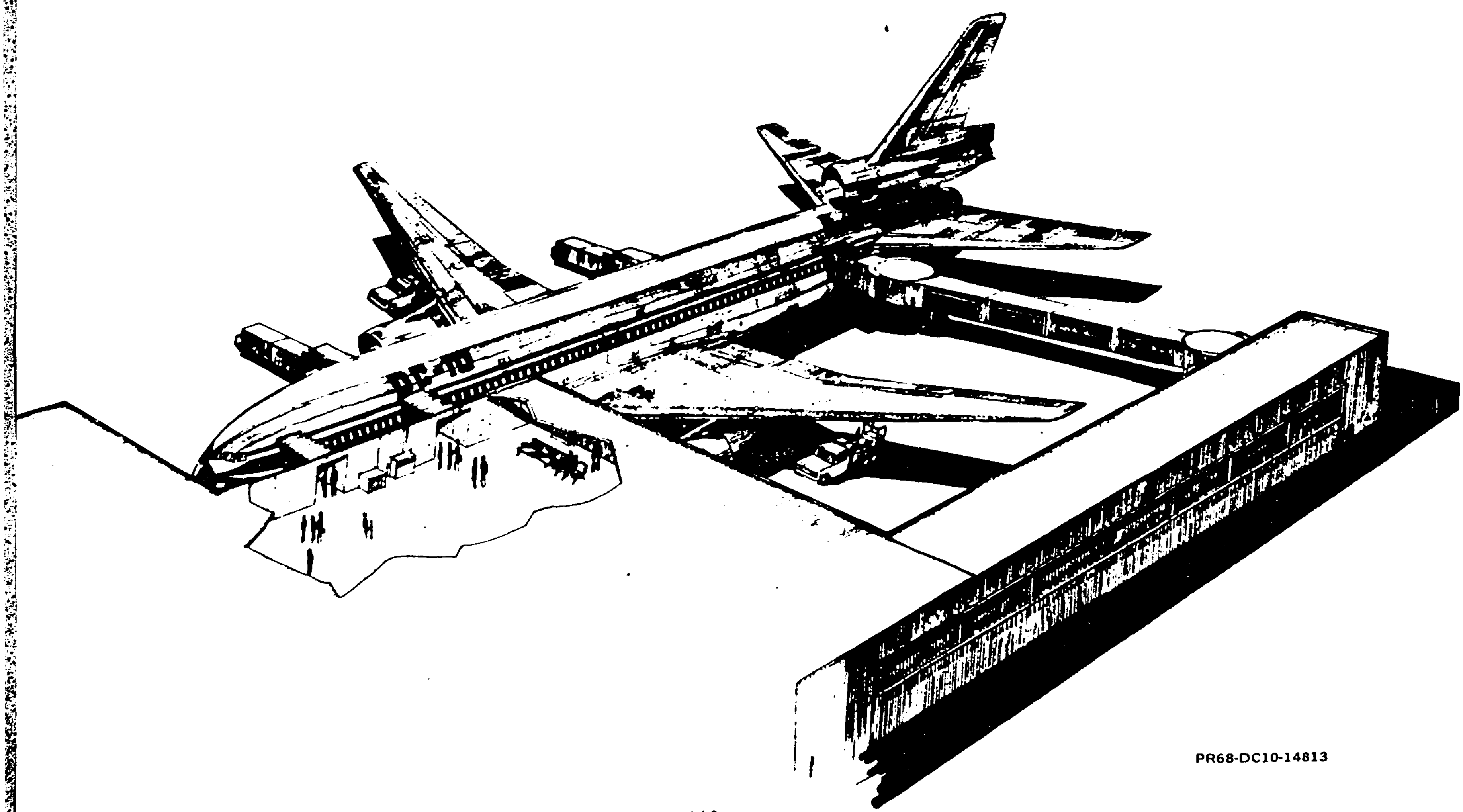

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SPECIAL TECHNICAL PROBLEMS OF FUTURE AIRPORT, TERMINAL, AND FACILITY PLANNING

Regardless of the nature of the airport or regional concept adopted, insertion of technically sophisticated and expensive aircraft into the system will create certain technical problems for the facility planner and designer. In many instances, this interface between the facility and the aircraft will exert a much greater influence upon profitable aircraft operation in a commercial environment than is now the case. In other cases, new facility technology must be developed in order to serve demand adequately at a cost compatible with projected growth.

RAPID AND CONCURRENT PASSENGER AND CARGO LOADING AND UNLOADING

As aircraft become larger and more expensive, means of decreasing ground time will be of increasing importance. Rapid and concurrent passenger and cargo loading or unloading will be among the most important factors to be considered in decreasing ground time (and in moving hundreds of passengers on and off planes with minimum frustration and inconvenience.

Efficient handling of passengers and cargo involves three primary elements:

- Aircraft design and configuration.
- Airport facilities for delivering passengers and cargo to and from aircraft.
- Preparation of passengers and cargo for loading and unloading.

The relation between these elements must be carefully considered so that loading and unloading can be readily controlled and adjusted to meet changing requirements.

The principal determinant will be the design and configuration of the aircraft. Speedy handling of passengers will require multiple entrances, ease of movement inside the plane, and easy seat selection and seating. Three-door front loading has been proposed for the B-747, as shown in Figure 18. Rapid cargo handling will require ready access to plane cargo areas, compartmented areas within

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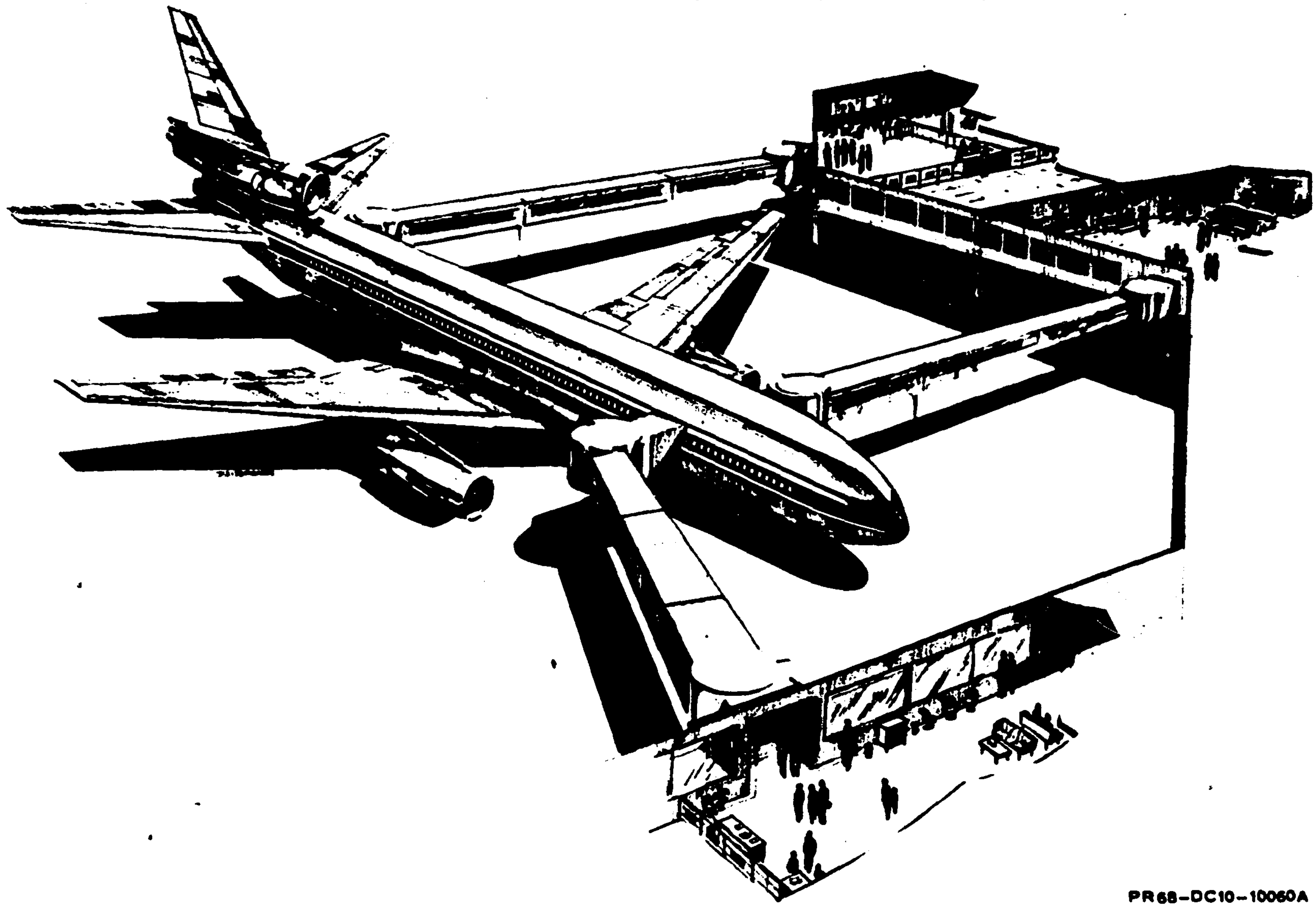

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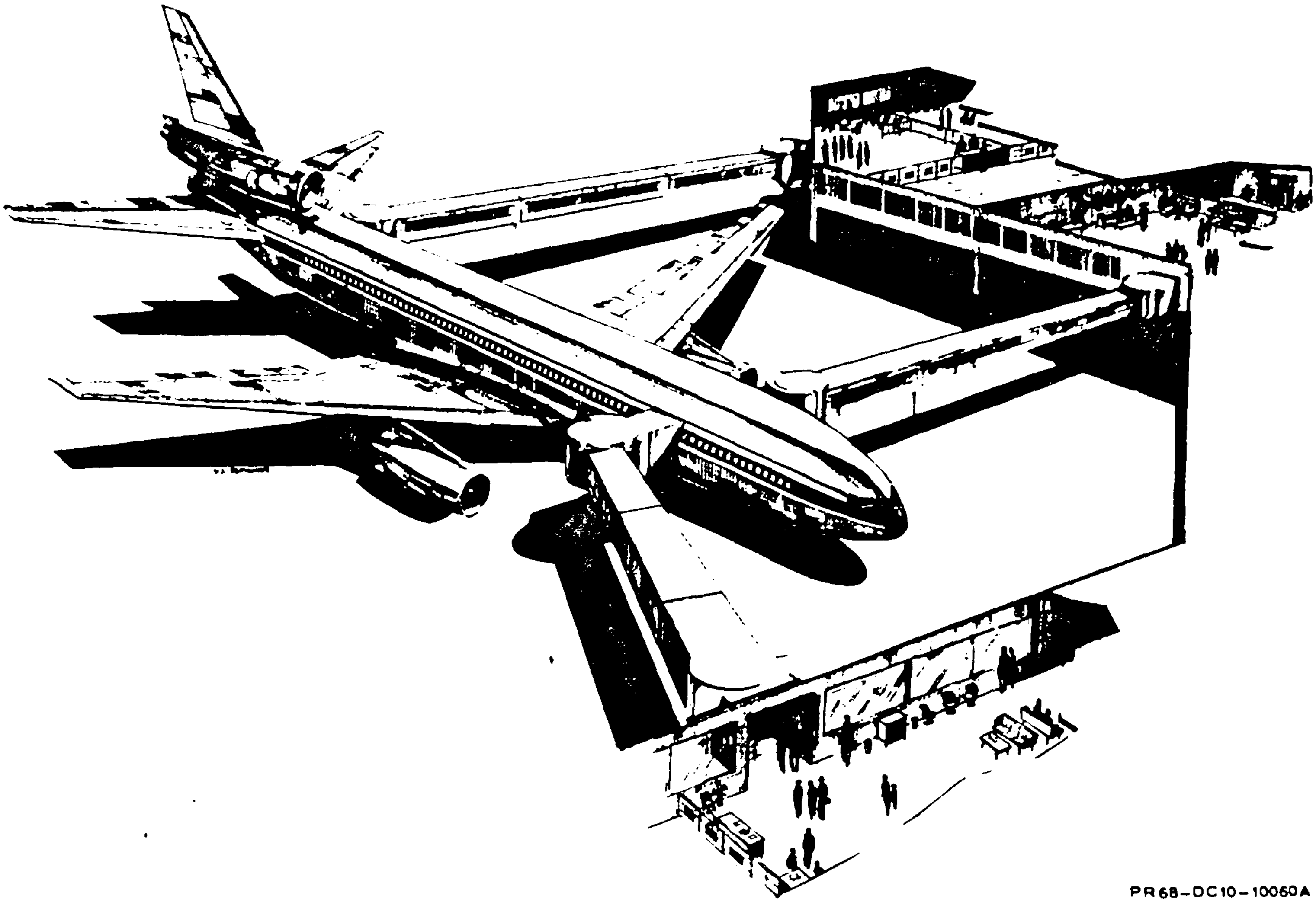

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the cargo area to allow for sorted loads, and equipment installed aboard the plane to facilitate rapid handling of cargo. Concurrent loading or unloading of passengers and cargo will be largely a matter of simultaneous access to the plane and adequate entrances, probably on both sides of the fuselage.

The second most important determinant of rapid loading or unloading will be adequacy of airport facilities involved in delivery of passengers and cargo to and from the aircraft. One can envision the offloading of 200 or more passengers at an alternate stop that has no covered loading finger, on a rainy night, with all of these passengers passing single file through one or two narrow doors into the terminal building.

Distance between passenger and cargo assembly areas and aircraft is also a major factor. Whether passengers reach the aircraft via mobile lounge, along a telescoped gangplank, or up a snorkel from underground, or are merely aided by moving sidewalks, skybuses, and the like, distance is a major factor in determining time required to load or unload the aircraft. Distance is also an important factor for cargo, but more significant is the avoidance of undue interference with other airport and aircraft service activities in moving cargo to and from planes.

While aircraft servicing (fuel, food, water) must be accomplished concurrently, congestion around an aircraft should be minimized for rapid, safe aircraft turnaround. Loading cargo onto an aircraft while passengers are enplaning will greatly increase the congestion.

Only very sophisticated facilities, such as the underground type originally conceived for the proposed Burlington County, New Jersey, Jet Global Airport, can be expected to provide rapid turnaround without congestion. This type of facility may be justified in a few high-volume traffic generation areas (New York, Chicago, Los Angeles) or when cargo and passengers must be loaded concurrently).

CARRIER OPERATIONAL DATA SYSTEMS

Basic to all preparation of passengers and cargo for loading must be an effective system of control, computerized as necessary, to ensure that airline and airport employees involved have up-to-the-minute formation on passenger and cargo movement and timing. The need for data systems in handling, storage, and transfer of air cargo at the present time is confirmed by experience with both commercial and military data systems currently used to provide inventory control and processing management information. The enormous forecast increase in air cargo volume and tonnage will certainly not simplify inventory management and processing control problems in the 1975 time frame.

An effective data management system is also required for planning of air cargo flow, inventory control, and tracing of lost cargo. Present technology can be applied in developing the data systems required, using available equipment or future product improvement. Paramount in any data system application is the ability to communicate with other data systems in use; a finite evaluation of the specific tasks it must perform should be made in advance. Accordingly, the facility designer must not only accommodate the data system hardware but must be fully aware of its function, since it influences operations and process flow within the facility.

STANDARDIZATION OF EQUIPMENT AND FIXTURES

In a rapidly growing field such as the air transportation industry, in which changing technology has many profound effects on primary system elements, standardization of equipment and fixtures is difficult to obtain. Nevertheless, maximum standardization is essential in a volume operation of this nature, where time is vitally important and the interfaces between airplane and airport terminals are crucial to successful operation of the system.

Many different areas should be continuously considered for standardization of equipment and fixtures. Following are some of the more important:

- Cargo handling on the airport and in aircraft cargo compartment.
- Passenger loading, especially within each airport.
- Baggage servicing (fueling, air conditioning, waste disposal, aircraft cleaning, food servicing).

Equipment involved in transfer of cargo from one airline to another must be a primary target for standardization. Pallets, containers, restraint systems, data interface-billing, and tracing and cargo identification fall within this area. The SAE Subcommittee AGE-2A, Passenger and Cargo Handling, has established pallet standards for the most part, and interchangeability of pallets between aircraft and airlines has been achieved. Small containers (types A,B,C, and D) are now sized to fit standard pallets.

Large van-type containers (8 ft x 8 ft in cross section, and 10, 20, 30, or 40 ft in the long dimension) have been recommended by industry. Containers of this type are designed and sized for maximum intermodal compatibility among railroads, highway trucks, cargo vessels, and commercial aircraft. Jumbo jet commercial aircraft are being designed for efficient loading with 8 ft x 8 ft containers. Conversion of other cargo aircraft to this standard will be necessary to achieve true intermodal capability. As now conceived, large van containers will induce a weight penalty and a deadweight shipping charge which directly or indirectly is paid by the shipper.

GROUND HANDLING OF AIRCRAFT

The increased weight of future aircraft poses problems in moving to and from gate positions. If tow tugs are to be used for this purpose, they would have to be considerably larger and much heavier than at present, and would thus further encumber and congest ramps. Some alternate methods might employ the following:

- Turntables on which aircraft wheels would be positioned and the aircraft then rotated to or from the gate.
- Drag lines with subpavement driven cables (similar to the San Francisco cable car system). Arriving or departing aircraft would be connected by a simple drop-in-device and towed to or from the gate.

- Driven aircraft main wheels for aircraft maneuvering. A mobile power plant of relatively small dimensions would be driven into position between the main gear wheels of the aircraft. Telescoping arms could then be attached to opposing gears and, by means of a transmission, drive the aircraft wheels to maneuver it as required.

CHAPTER FOUR

PASSENGER AIR TERMINALS

CIRCULATION ANALYSIS

Factors Affecting Type of Facilities Required

The type of facilities is influenced by the scale of traffic as well as its type, and airports for large volumes of all types of traffic need certain facilities which are unnecessary for airports provided for smaller amounts of traffic or traffic of particular categories only. The flow systems must be analysed to define the facilities required before consideration can be given to their arrangement within the master plan. The facilities required should be determined by the characteristics of the passenger of the aircraft and ground transport..

Air Traveller Characteristics and categories

There are two types of persons in the terminal, passengers and persons accompanying passengers. Further there are four distinctive categories which apply to the passenger.

a) Departures

Passengers using an airport for the purpose of departing from it by air.

b) Arrivals

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

c) Transit

Passengers in an aircraft which uses the airport as an intermediate stop on its route.

d) Transfer

Passengers arriving at an airport for the purpose of connecting with another flight.

Distribution of Number of Persons Traveling together by Air

Number of Persons in group	Percentage of total trips
1	85%
2	11%
3 or 4	3%
5	1%

Source 19

Distribution of Single Passengers within Age and Sex Group

Age Group	Distribution	
	Male	Female
12-19	3%	2%
20-54	62	17
55 and over	11	5

Source 20

Number of Persons Accompanying Enplaning Passengers to the Boarding Area

No. of Accompanying Persons	Percent Enplaning Passengers
0	69%
1	14
2	9
3	4
4	2
5 or more	2

Source 21

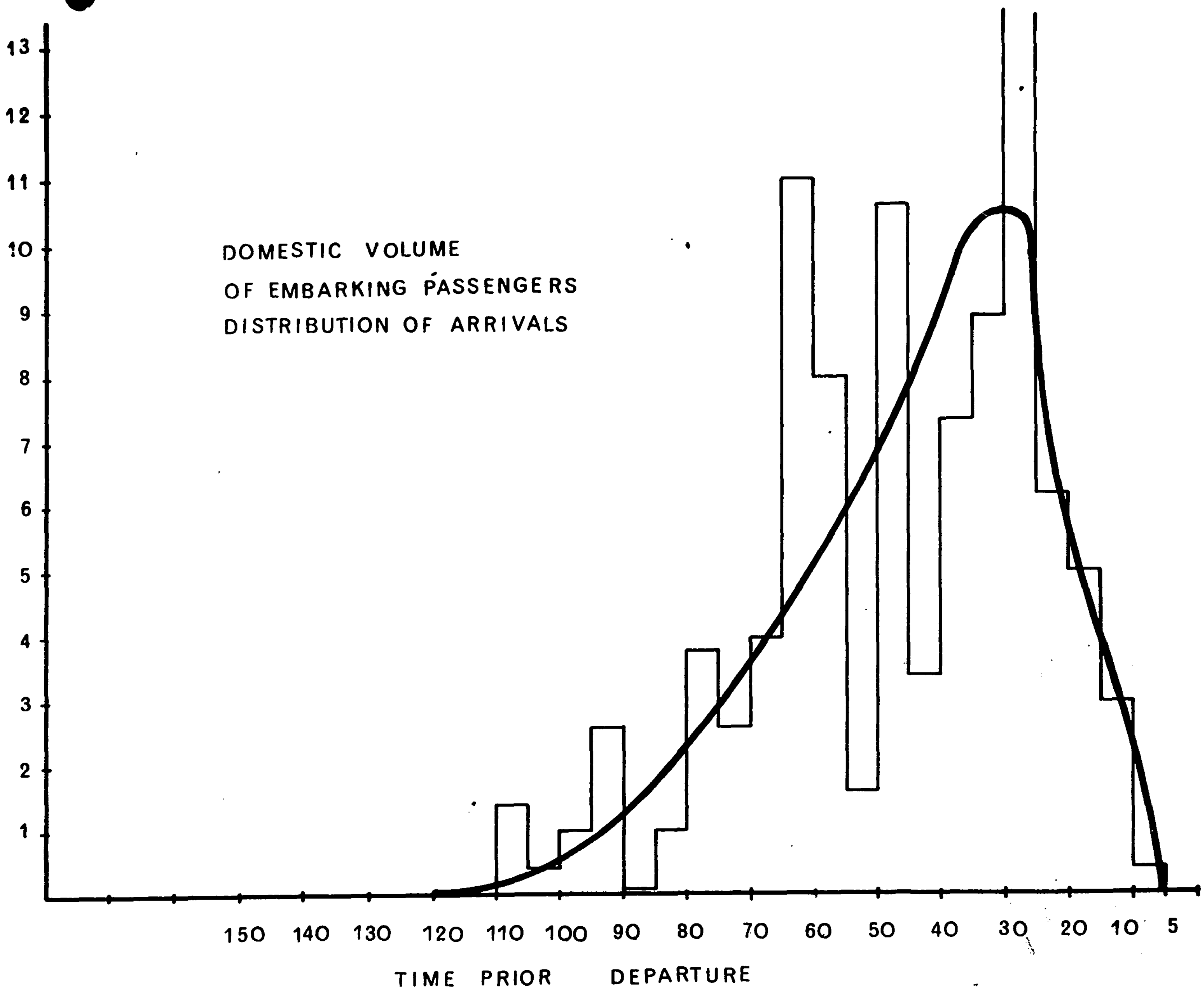
Relation of Sex and Age to the Walking Speed of the Pedestrians

Age and Sex of Pedestrian	Level Walking Speed (feet per second)
Men under 55 years of age	5.4
Men over 55	5.0
Women under 50	4.5
Women over 50	4.3
Women with small children	2.3
Children between 6 and 10	3.7
Adolescents	5.9

Source 22

The planning of the passenger area should be based on passengers and their baggage. It is necessary, without any preconceived ideas, to assemble all the characteristics readily attributed to air travellers, however contradictory they may appear, before working out a model for the relationship between them and the operating facilities. This embraces such considerations as transport to and from the airport, car parking facilities and the processing concepts employed by aircraft operators and control authorities. Passengers should be able to arrive at airports and find their own way to and from aircraft without asking directions and with minimum effort. Passenger facilities can only deal with mass traffic by treating passengers as a constant flow, not as individual units. To be efficient they must deal with people in bulk but the planning of public utilities can all too easily be authoritarian and impersonal and it is as well not to let the term "passenger" take on the same impersonal overtones as 'seat miles', baggage or cargo.

The small, simple and intimate airports are usually the most highly thought of, but large size is necessary to accommodate new large aircraft and bulk movement of people. Thus part of the passenger area planning requirement is to mitigate the impersonality and confusion which arise when passengers find themselves among


DOMESTIC VOLUME
OF EMBARKING PASSENGERS
DISTRIBUTION OF ARRIVALS
13
12
11
10
9
8
7
6
5
4
3
2
1
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
5
TIME PRIOR DEPARTURE

crowds of people in huge and complex spaces and they should be planned to give clarity, reassurance and human scale. Whatever the compromises necessary to meet all the various and sometimes conflicting requirements which make up the passenger area, the subjective reaction of passengers should be borne in mind and used as the measure of acceptability.

Passengers should be persuaded to do what airport authorities and aircraft operators want them to do by making it as convenient as possible to do so. They should be persuaded by good planning and subjective design. Airports which rely on plans which are authoritarian in concept and require passengers to conform strictly to pre-arranged instructions, or which are so large or complex that they overwhelm, create resentment, confusion, delay and complaint. Whether the airport is small or large, it is part of the system provided for the transport of human beings who may be confused, lonely and homesick.

The greatest benefit for the greatest number is the basic requirement, but the minority should not be ignored. The greatest benefit is a matter of passenger interpretation and not a superior judgement of the airport planner and designers. Passengers' reactions should determine the treatment of the whole environment and the basic nature of facilities.

Passenger Physical Limitations

The key to the intricate maze of variable factors which are involved in planning passenger areas is the physical limitations of passengers, Human engineering should be considered before civil or other engineering and architecture. At many airports passenger areas have reached proportions that cause passengers considerable physical discomfort. Physical stress will arise from passengers having to walk too far, too fast, climb stairs and carry too heavy loads, i.e. baggage. Particular groups of passengers have more severe and specific physical limitations, e.g. the aged, sick, infirm and the very young. In many cases, special provision has to be made for these people, but good subjective planning for the physical requirements of passengers in general often provides suitably for more specifically limited passengers as well.

The passenger area should provide an environment in which noise and air pollution are limited to acceptable levels of human tolerance. Although this will be most directly controlled by building design, passenger area planning can also assist by suitable siting of buildings, and flow routes which protect passengers from exposure.

Separation of Functions

The key to achieving the planning objectives is simplicity. This is often interpreted as meaning minimum comfort and absence of applied decoration. It can mean these things but in the context of passenger planning it means simple, obvious flow routes. Complex flow routes usually arise from complex plans and buildings. Complex buildings are usually costly and inflexible and not readily expansible as a logical extension of the plan and operating system. Therefore, the objective should be simplicity of plan, simplicity of flow routes, simplicity of operating concept and systems. The facilities could still be costly if so desired, but this will not be an unavoidable consequence of the plan and operating concept. Separation of functions is the principal aid to achievement of simplicity. If other facilities, for example multi-storey office blocks, car parks, control towers, etc., are incorporated with passenger buildings, not only does the flow plan tend to be distorted but flexibility is seriously compromised by the presence of these facilities, and also by the structural features they impose on the building.

Size of Passenger Buildings

For passenger convenience, a large passenger area should be broken down into units or modules, since it is difficult to construct a single building which can accommodate aircraft parking positions for high runway capacities and still maintain passenger walking distances whithin reasonable limits. A walking distance of about 1000 feet from the passenger building to the farthest aircraft parking position has been generally accepted as the reasonable limit. However, even this can result in passengers having to walk long distances to make connexions between one aircraft and another, although judicious allocation of traffic can reduce such cases to a minimum. The size of the modular passenger unit is very important and should be the best compromise between the limits set by the physical limitations of passengers and the economics of construction and operation of the passenger building and apron. It appears most desirable for each passenger building to be related to an apron to accommodate up to a maximum of twenty aircraft with a capacity of 150 passengers. The apron area for this number of aircraft could alternatively accommodate nine high capacity aircraft (Boeing 747 category). Apron units of this size could generate a passenger movement rate of up to 3000 arrivals and 3000 departures an hour.

Source 23

Layout of Passenger Area

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

They should be arranged in the simplest manner possible to provide an easily comprehensible environment, facilities free flow of vehicles and people and to provide a flexible and expansible layout to permit adaptation to future possible requirements. Transfer routes will be required for passengers and baggage on the

the airside, within customs bond, and landside. The nature of these transport systems, should be considered in conjunction with town centre/airport public transport systems to which all the passenger buildings should be conveniently linked. It may be advantageous to combine any public transport systems with an inter-passenger building landside transport system.

Passenger Amenities

Passengers regard the availability of certain amenities as adjuncts to their journey and they should be provided even though the journey can be efficiently made without them. The facilities so regarded may vary somewhat between various parts of the world but generally they include: coffee, snack and liquor bars, duty free goods and liquor shops, letter post, flight insurance sales, bookstall and newspapers, souvenir and gift shops. They may also include: restaurant, nursery, barber shop, sleeping accommodation, etc. However, provision of amenities should be secondary to the maintenance of fast, free and continuous passenger flow. A majority of passengers may require access to some amenities which should, therefore, be located on the flow routes. Only a minority of passengers may be attracted to others and they should, therefore, be located adjacent to the flow routes so that passengers wishing to use them may do so without interfering with the principal flows. Consideration should also be given to the provision of a range of amenities in the waiting areas. Amenities which are highly popular with passengers, but which are too small and of insufficient capacity, can cause congestion and delay and create passenger criticism because they cannot be used when required. These complaints may be greater than if the amenities were not provided.

CAPACITY

Definition of Capacity

The principal measure of capacity for passenger facility planning is the movement rate of people and vehicles. But for some parts of buildings it is also necessary to define a population for an area. Passenger building capacity is a movement rate and does not define the population of the building, or its individual parts. It is the rate at which passengers pass between landside and airside. The population figures for which the building should be planned are functions of the operating concepts and resultant processing times.

Movement Rate

It has been customary to define movement rates in units per hour, i.e. people and/or vehicles. The 'standard busy rate' is the capacity concept normally used for planning passenger facilities. Although some authorities use different descriptions the concept is the same. It is a level of activity somewhat below the absolute peak, which can be sustained continuously, is reasonable in economic terms and which accepts a foreseen, measurable and tolerable degree of delay or congestion for short periods at busiest times. The standard busy rate is defined as the hourly movement rate which is reached or exceededoon thirty occasions in the busiest period of the year. It is rarely possible to plan for absolute peak demands because of the cost involved and space required.

Capacity is not only a rate of flow but is also a function of the unit size of the groups in which passengers and baggage are delivered to the airport. Facilities planned to accommodate a specific hourly flow of passengers, baggage and vehicles will be hopelessly overburdened if the flow is concentrated into a few short periods during the hour. The rapidly increasing size of aircraft unfortunately tends to concentrate movement of passengers into shorter periods and larger groups and accentuate peaks in flows. This aggravates the processing problems and demands more space for the more concentrated flows produced. Therefore, passenger building capacity cannot be considered only in relation to the runway capacity, which is expressed as a number of aircraft movements an hour. An even distribution of aircraft movements throughout an hour may produce a very uneven passenger flow if the capacities of the aircraft vary considerably. Over periods of less than an hour this flow may exceed the average hourly rate.

Therefore, in order to forecast the passenger flow rate it is necessary to construct a diagram based on runway movement rates, types of aircraft and their frequency distribution, which canbbe derived from aircraft operators' forecast schedules. Apron utilization may not necessarily be identical with runway utilization. Taxiing distances from all parts of the apron to runways may vary together with operators' aircraft handling procedures. As a result surges may occur in aircraft apron movement rates and these would create surges in the passenger flow. The maximum potential passenger flow for an apron and associated passenger building can be derived from the number of apron stands of each size category, the passenger loads of the largest aircraft which can use them, and the stand utilization rate, i.e. stand occupancy time. Runway movement rates and types of aircraft should be applied to the apron stand capacity. From this the rate of passengers entering and leaving the building can be derived and hence the passenger, baggage and ground vehicle movement rates. The peaks will indicate the surges caused by high capacity aircraft. In this context high capacity is a measure of aircraft capacity compared with the hourly standard busy rate.

For the future an hour may not be the appropriate standard period to be considered for all airports, or for all parts of a passenger area. When the passenger capacities of aircraft which will use the airport are large relative to the passenger building capacity, and aircraft movement rates are high, it will be necessary to use a much shorter period. Generally, the appropriate period would be that necessary to clear a passenger through each successive procedure in a regular flow. For example, an average time for an arriving passenger to pass from the aircraft to landside vehicle might be twenty minutes. Whatever time unit is chosen, the 'standard busy period' concept should apply forrealistic considerations of cost and space.

Capacity to be Provided

Airport authorities may be faced with a number of alternatives in deciding the capacity for which passenger facilities should be planned. The introduction of new very high capacity aircraft makes it much more necessary to consider the effects of each alternative because their passenger capacity represents a very large proportion of the hourly capacity of many passenger buildings and thus the concentration of passenger flow will be considerably accentuated. All four alternatives have disadvantages and the choice should be made by progressive elimination of the least desirable.

(i) Assume that all aircraft are of the largest type forecast to use the airport and plan the building for that passenger capacity. This is the maximum passenger capacity of the runways. The operational and economic forecasts will indicate the aircraft mixture for which the airport should be planned which will generally produce a passenger flow rate below maximum capacity of the runways.

(ii) Allow delays and congestion caused by surges in the flow to rectify themselves during one hour, as provided for by the standard busy rate which assumes that peaks of up to 20 percent will occur for short periods. As traffic increases at busy periods, and with high capacity aircraft, it may be expected that congestion in one hour would spread to succeeding hours and it would soon be necessary to restrict the traffic demand. Acceptance of such excessive delays is contrary to all concepts of passenger conveniences and efficient operation.

(iii) Spread the traffic evenly throughout the hour by specifying a capacity for a shorter period, for example, fifteen minutes. This would restrict aircraft scheduling so that the passenger flow is evened out over the hour. This is practised by some airport authorities and has advantages. It spreads the utilization of the airport and facilitates more efficient and economic use of facilities and staff. It may not be favoured by some aircraft operators because it limits the use of any preferred departure and arrival times. However, every airport and passenger building has a finite capacity which when reached requires schedules to be spread. The disadvantage of this procedure is that it cannot be applied to arrivals traffic. Conditions en route, e.g. winds and delays at other airports, introduce a considerable element of irregularity in arrival times and small variations can have a large effect on the passenger flow and accentuate surges rather than control them.

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

Processing Rates

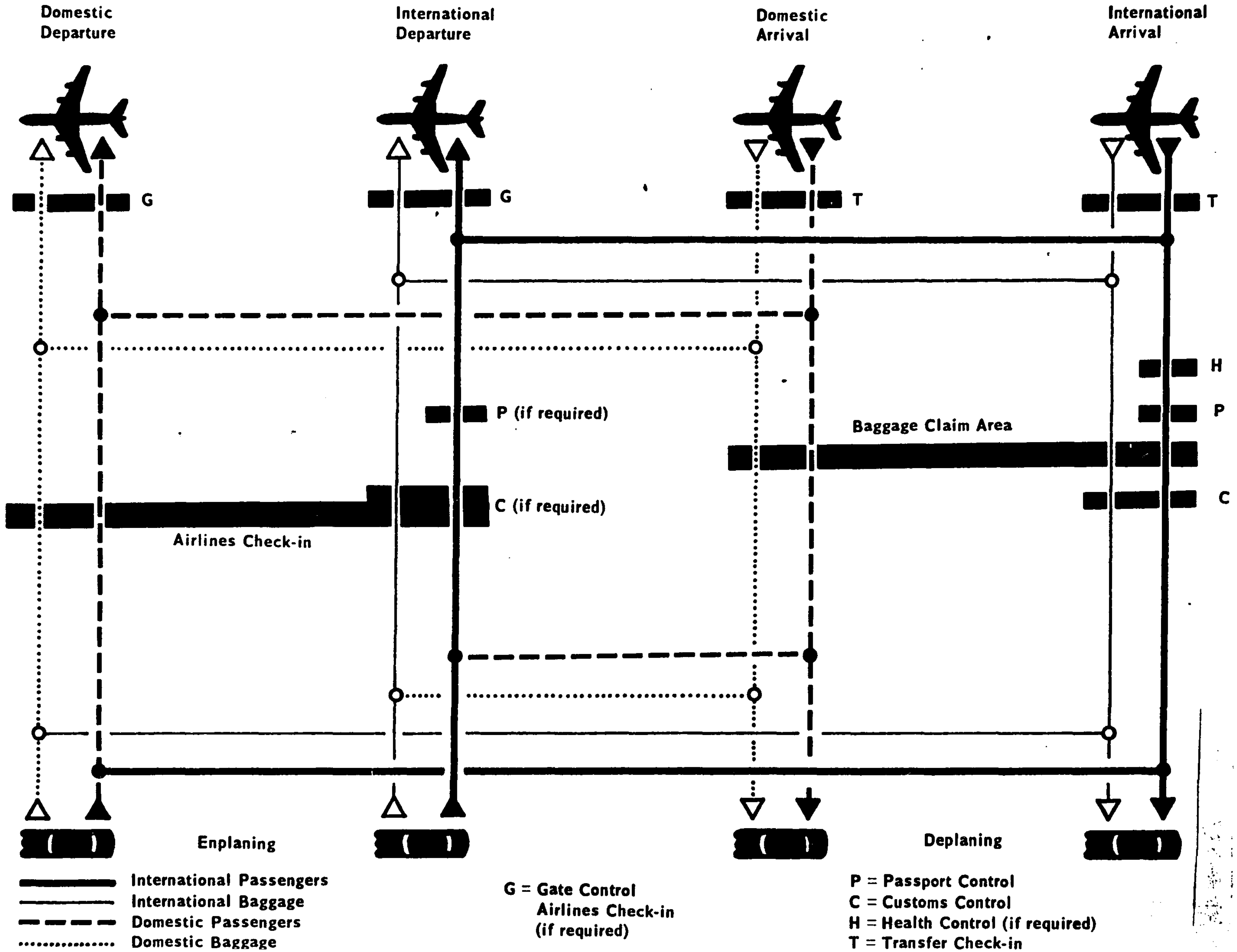
The appropriate measurement of capacity may not be the same for all individual facilities. The rate at which passengers flow to a facility is determined by the rate at which they flow through the previous part of the route. For example, the rate at which passengers leave an aircraft is determined largely by the number and size of the aircraft doors used. The rate at which they flow into the passenger building depends upon the method used to transport them to the building. Passengers flowing through a pier will spread out according to their walking speeds and will arrive at the first control point, i.e. port health or immigration for international passengers or baggage reclaim for domestic passengers, in a stream. Passengers conveyed to the passenger building in a vehicle, either from the aircraft or population centre, will arrive at the frontier controls or check-in position in a group. The average time required to process one passenger at any specific facility depends upon the nature of the procedure. The processing time for each facility and control on the flow routes can be determined by operational research observation and evaluation. It is not possible to define standard processing times for all airports although the times achieved at other airports are often a good guide to the flow rate which can be achieved. The processing rate is primarily influenced by the procedures undertaken and these vary, both in content and method between countries. For example, at some airports immigration officials undertake health documents inspection or preliminary customs control. At others each of the controls is carried out by different officials at separate locations. Sometimes customs controls are established for clearance of passengers and baggage separately. At others both are cleared at the same point. Similarly, some aircraft operators check-in passengers and their baggage at one point, others check-in baggage at one point and passengers at another. These are only examples of the wide differences in existing passenger control procedures and a comparison of processing times is invalid without analysis of the methods and procedures used.

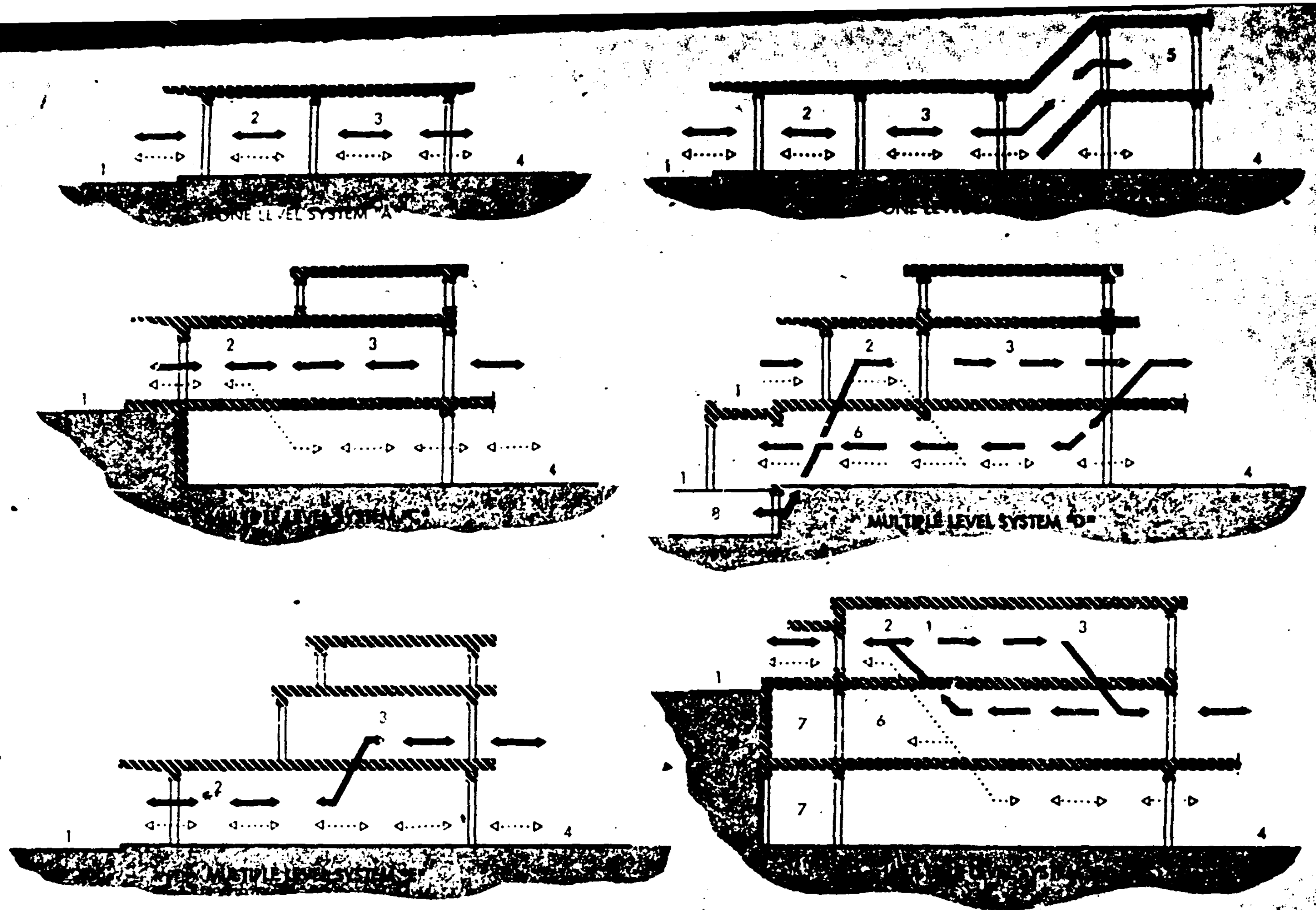
TERMINAL BUILDING CHARACTERISTICS

Shape

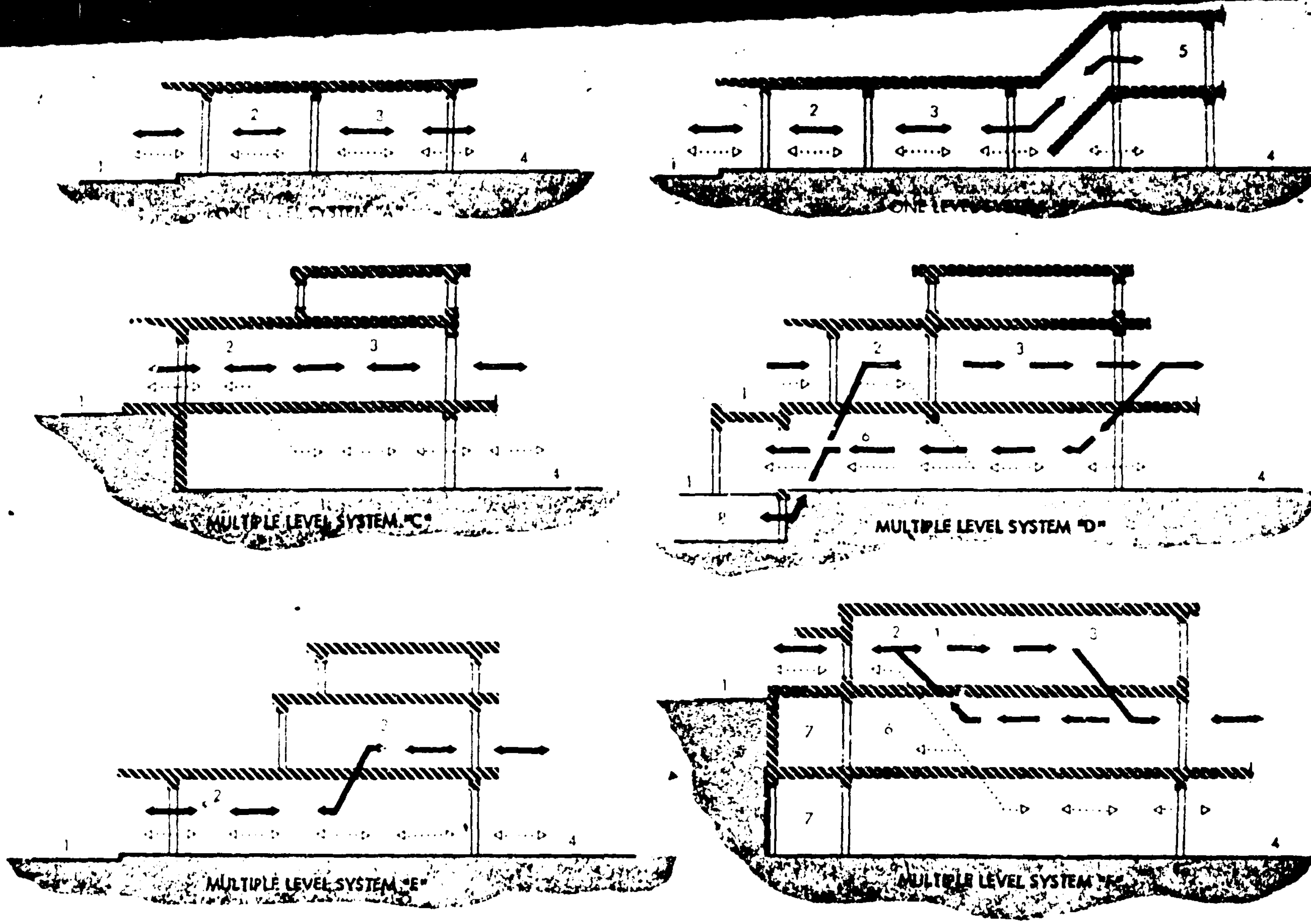
The passenger flow begins and ends with ground vehicles and aircraft and the more closely they can be brought together, the shorter and quicker the transition between the two. The overriding characteristic for the passenger building plan is, therefore, the shortest possible distance between ground vehicles and aircraft and this should be reflected in the planning of the individual facilities. At the same time space is required for the facilities necessary to process passengers and baggage at the required rate. Thus, a linear frontage for maximum simultaneous flow rate is required.

DIAGRAM OF PASSENGERS/BAGGAGE FLOW





1 VEHICLE PLATFORM(S)
2 TICKET LOBBY
3 WAITING ROOM
4 APRON
5 FINGER
6 BAG CLAIM
7 TRUCKING
8 UNDERPASS TO AUTO PARK
PASSENGER FLOW
BAGGAGE FLOW



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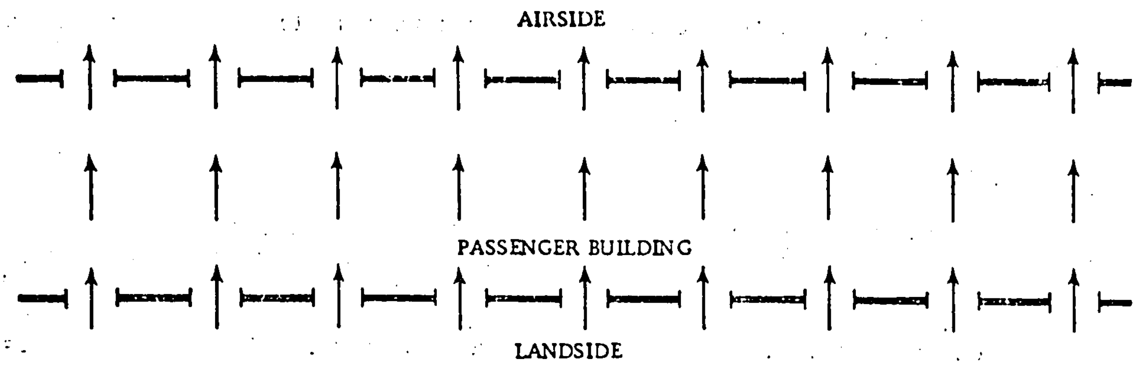

Figure 19

Size

The planning task is not only to arrange the individual facilities in the optimum relationship to each other but also to plan each functional facility for passenger convenience, the required capacity and maximum efficiency. The criteria by which efficiency is assessed includes minimum use of space necessary to accomplish the other objects. Excessive size involves uneconomic expenditure and creates longer than necessary walking distances. Facilities which are overlarge can also adversely affect and complicate other functional areas and systems, for example, by creating longer baggage routes with consequently longer flow times. The optimum layout for each type of facility will indicate the space required for that purpose. The arrangement of these spaces in the best relationship to each other and in accordance with the planning and flow principles will define the dimensions of the passenger building.

FLOW PRINCIPLES

The passenger flow plan should be the first to be considered. Baggage is of equal importance since it should be integrated with the passenger flow but, because baggage is inanimate, it is easier to make the baggage flow compatible with the best passenger flow. In practice the flow plans should be tested against one another at all stages.

Passengers

(i) Routes should be short, direct and self-evident. They should not conflict with nor cross the flow routes of any other passenger, baggage or vehicular traffic.

(ii) Pedestrian routes should as far as possible be on one level only. Where a change of level is unavoidable it should be downwards and not upwards.

(iii) Passengers should be able to proceed through a building at their own initiative without the need to rely on guidance or instruction from staff. The flow system should be for 'trickle flow' and not controlled movement in groups.

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

(v) Passengers should be disencumbered of their baggage at the earliest possible point and to the maximum possible extent.

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

Every control point in the flow system has a potential to delay and also to irritate and confuse passengers. Therefore, controls should be concentrated at a minimum number of points to facilitate the free flow of passengers over as much of the route as possible and to increase passengers' convenience by avoiding repeated searches for documents, etc. This also assists staff utilization by allowing transfer of staff from lightly to to heavily trafficked sections of the controls. The delay is not only the time needed for officials to carry out their procedures but also the reaction time of passengers. The reaction time is composed of the time taken to realize that a control has to be passed, understand its nature and find the necessary documents, etc. This time will be increased in the case of some passengers by lack of understanding of foreign languages, illiteracy, confusion, etc. These effects tend to be reduced as the number of separate control points on the route is reduced.

The use of control points to regulate access to specific areas is an aid in reducing the number of separate controls. Reduction of the number of points on the flow routes at which authorities carry out their procedures need not imply any necessity for amalgamation of functions between officials of different services. Such arrangements can tend to delay flows by increasing average service times. All controls should provide positions for passengers who can pass through quickly to do so. Thus it is disadvantageous, for example, to combine customs declaration with immigration clearance unless positions are also provided for passengers with no dutiable goods to declare. No advantage is gained by delaying all passengers at the passport control by customs procedures which may not affect them all.

It is also necessary to analyse carefully the clearance procedures to define the best methods. If two processes can be carried out simultaneously it is advantageous to combine them, but this may usually require two officers of the control authorites to operate together at the same position, for example police and immigration. It is disadvantageous, however, for one officer to combine the functions of two authorities if he carries out these functions sequentially. A longer average service time results from immigration officers carrying out initial customs clearance after they have completed immigration clearance, than is possible if the two clearances are carried out by separate officers operating at positions close to each other.

(viii) Controls through which passengers have to pass on the flow route should be arranged on the 'comb' principle.

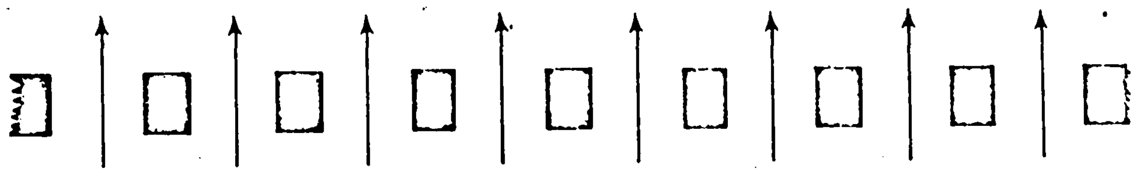

Figure 20.

(ix) Passengers should not have to pass through the same type of control more than once. Thus, if procedures or controls are established in more than one place the flow routes should be planned to permit passengers to bypass all subsequent controls of the same type. For example, passengers checked in off the airport should bypass passenger building check-in. Passengers checked-in in the passenger building should bypass gate check-in, etc.

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

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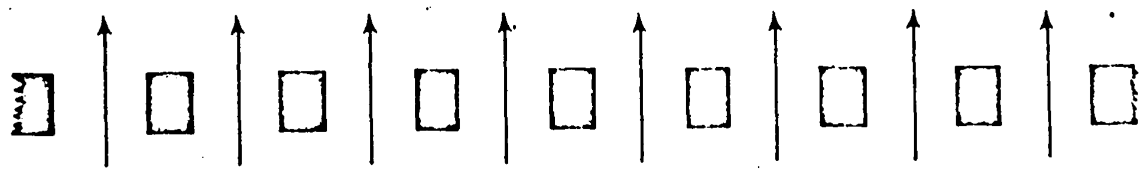

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(xi) Flow routes should be planned to provide the freest, uninterrupted flow. Thus, features which cause hesitancy, e.g. choice between using an escalator or stairs, or travelator and walking, ambiguous terminology on signs, flow routes, which appear to lead in the wrong direction, multi-directional junctions, etc. Passengers are irritated and frustrated by periods of waiting and delay. Thus, flow routes should be planned for steady continuous progression.

(xii) The speed of flow and capacity of the passenger routes should be matched to that of other systems, e.g. baggage flow, and aircraft turnaround, and to the capacity of the airport overall. The fastest possible passenger flow or highest possible capacity, far from being an advantage will create frustration, delay, congestion and criticism if it is not balanced by all parts of the airport system. Thus if a passenger route is so short and fast that passengers arrive at baggage reclaim before their baggage, delay will be caused and a bottleneck will occur leading to congestion which may well slow down movement in the next stage of the flow route, and which will certainly cause complaint and criticism even if the baggage system itself is the best which could possibly be provided. Optimum speed and capacity and maximum passenger convenience should be the planning objectives.

Baggage

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

(i) The baggage and passenger flow should be matched in speed and capacity.

(ii) Flow routes should not conflict with passenger or vehicular flows.

(iii) Flow routes should be reversible so that baggage can be recovered when necessary.

(iv) The flow system should involve a minimun number of individual handling operations, e.g. transfers between different types of vehicles, etc., and the flow should be steady and uninterrupted.

(v) Flow routes should be arranged so that passengers are disencumbered of their baggage at the earliest possible moment and to the greatest possible extent.

(vi) Baggage reclaim systems should provide continuous presentation to passengers and personal recovery of their baggage.

(vii) Flow routes may be influenced by the type of handling system adopted, e.g., manually or mechanically propelled trucks, conveyor belts, etc. The handling system should be compatible with aircraft baggage holds and loading systems.

DEPARTURE FLOW

Passengers travel to airports by car - private, hire or taxi, or public transport - coach, train or similar vehicles, e.g. monorail. Passengers travelling by any form of airborne vehicle, i.e. helicopter, air taxi, etc. are considered as transfer passengers. The rate of the departures flow is affected by the type of landside ground transport used, traffic conditions outside the airport and passengers'habits. It is, therefore, to some extent random and unpredictable. Congestion at the passenger and baggage unloading and check-in positions could cause delays and prevent passengers being processed by the designated time and consequently cause them to miss flights. The distribution of passenger arrival times before flight departure should be determinedand from this can be derived the unit period over which the rate of flow should be defined to determine the capacity to be provided.

LANDSIDE ROADS

Passenger building landside roads serve two purposes - access to and from the building for passenger and service vehicles; and access to vehicle parks associated with passenger buildings. Flow systems for the roads and passenger building interact and should be considered together. The road pattern should be considered in relation to any passenger processing carried out off the airport and should enable passengers to enter the passenger building without passing through the same procedural areas again.

The functional use of roads should, as far as possible, be separated. Service vehicles need access to particular locations and, most importantly, should be provided with routes and facilities to ensure that passenger flow is not obstructed by service vehicles and their loading and unloading. A major influence on the road pattern is the passenger vehicle unloading positions.

PASSENGER VEHICLE UNLOADING POSITIONS

For passengers travelling to the airport by car, taxis and buses, unloading points for people and baggage are required at the landside entrance to the passenger building.

Capacity

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

Layout

The shape of ground vehicles and the numbers to be accommodated makes the provision of sufficient space of a suitable shape for vehicle unloading one of the most difficult elements of passenger building planning. For the shortest flow route the unloading points should be as close as possible to the first processing positions in the passenger building. For straight and direct flows it should be possible to enter the builing directly from the unloading points at any point along its frontage. The unloading area should be on the same level as the passenger departure floor and its depth should be the minimum possible. The capacity of the unloading area can be increased by additional levels higher than the road levels. Passengers descending from the upper levels to the passenger building departure level can best do so by ramps. The concept is similar to conventional multi-storey car parks. If it is necessary to consider the alternative merits of increased depth or more levels - the choice should depend on the horizontal and vertical length of the passenger route.

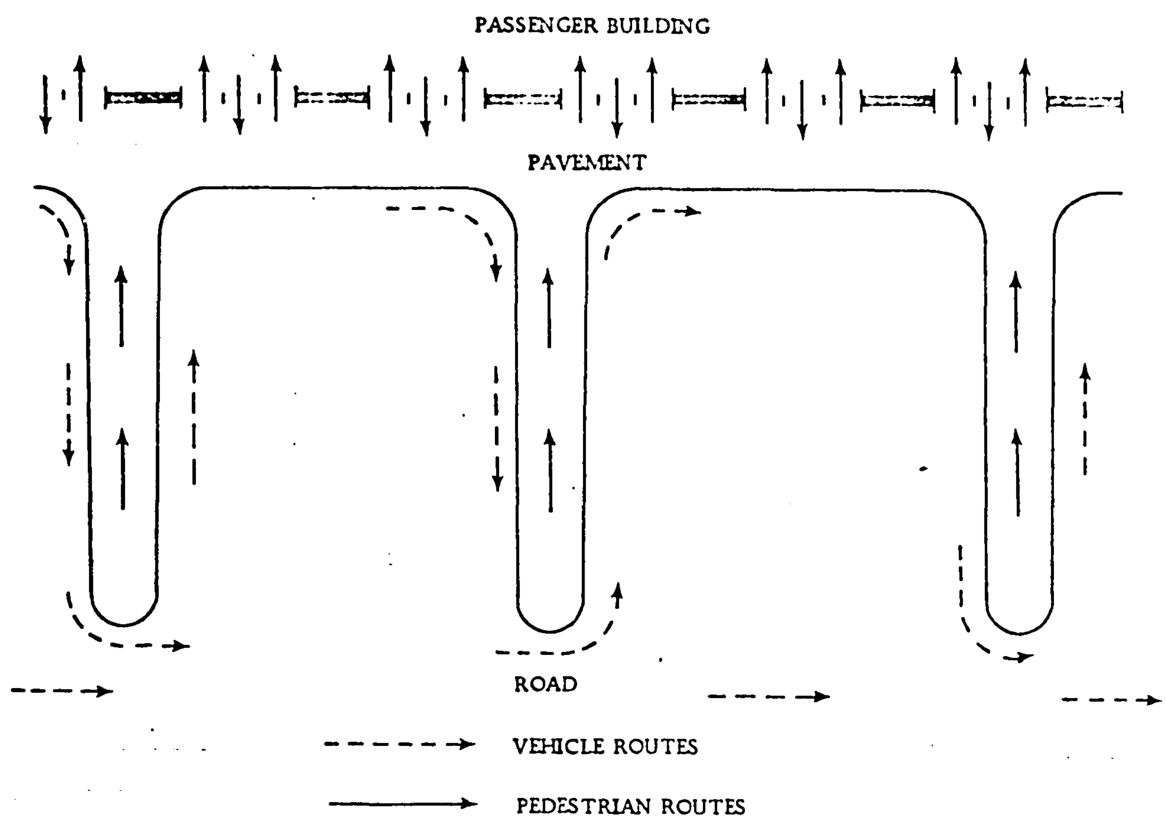


Figure 21

CHECK-IN CONCOURSE

The area between the passenger building entrance and the check-in positions is the check-in concourse. The primary flow is passengers holding flight tickets and proceeding directly to check-in. Separation of functions is most important in this area to ensure that the primary flow to check-in is not compromised.

Check-in is the most important of the passenger processing procedures. Until they are checked-in, passengers have no assurance of being able to travel and cannot proceed through any subsequent controls. Passenger and baggage check-in has to be completed some time before flight departure to provide sufficient time for subsequent procedures such as aircraft operators' documentation and aircraft load computation, loading baggage into the aircraft, passenger clearance through government controls and for passengers to board aircraft. Aircraft operators' documentation and baggage handling are usually the limiting factors which determine the time by which check-in must be completed. Any obstruction which delays passengers and prevents them checking-in by the scheduled time will cause them to miss their flights. Therefore the passenger route from the landside entrances to the check-in positions should be the shortest possible.

The space between the landside entrances and check-in positions should be sufficient to provide free access to check-in and other facilities. About 30 feet is generally adequate but this may need to be increased according to the numbers of friends accompanying passengers. It should be kept to a minimum size for the shortest flow route. Congestion should be avoided by achieving a continuous and high rate of flow through the check-in facilities to the airside.

The concourse should be as visually any physically unobstructed as possible throughout its length and breadth.

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

<u>Aircraft Operators' Ticket Sales, Stand-by Reservations and Information</u>

Passengers purchasing tickets or making stand-by reservations have to carry out these processes before they can check-in. Similarly, passengers may require information from aircraft operators before purchasing tickets or making reservations. To ensure unobstructed flow to the check-in positions these facilities should be located between, and clear of, the primary flow streams.

Currency Exchange

Passengers making payments for ticket purchase, "stand-by reservation or airport tax may require to each cheques or change currency to make the payment and a bank or currency exchange facility is, therefore, required in the check-in concourse. It should be accessible from the ticket sales and stand-by reservations desks, and from the check-in positions for payment of airport tax and excess baggage fees. It may be difficult for a single facility to be ideally located to serve both the primary and secondary flows, but should normally be related as closely as possible to the primary flow route.

Aircraft operators' procedures should also be considered in relation to siting the currency exchange. Some aircraft operators check-in staff also act as cashiers. Others have one or more designated cashiers who handle all eash payments. This latter practice complicates the smooth check-in flow by setting up a passenger cross flow from the check-in desks to the cashiers' positions and back again. It is incompatible with the passenger flow principles and should be avoided as far as possible. However, if such an arrangement is permitted, location of the cashiers' positions and currency exchange should be considered in relation to each other.

CHECK-IN

Capacity

The number of check-in positions required is a function of the service time (time required to process one passenger) and the rate of flow to the check-in positions. Surges within the hour occur on the same basis as for the landside vehicle unloading positions and the unit period for rate of flow measurement should similarly be obtained by an operational research measurement. It is necessary to ensure that passengers arriving just before the designated final check-in time can be processed without delay to avoid missing their flights. Thus, there should always be check-in positions available for immediate use, this is equivalent to providing capacity equal to the absolute peak flow rate.

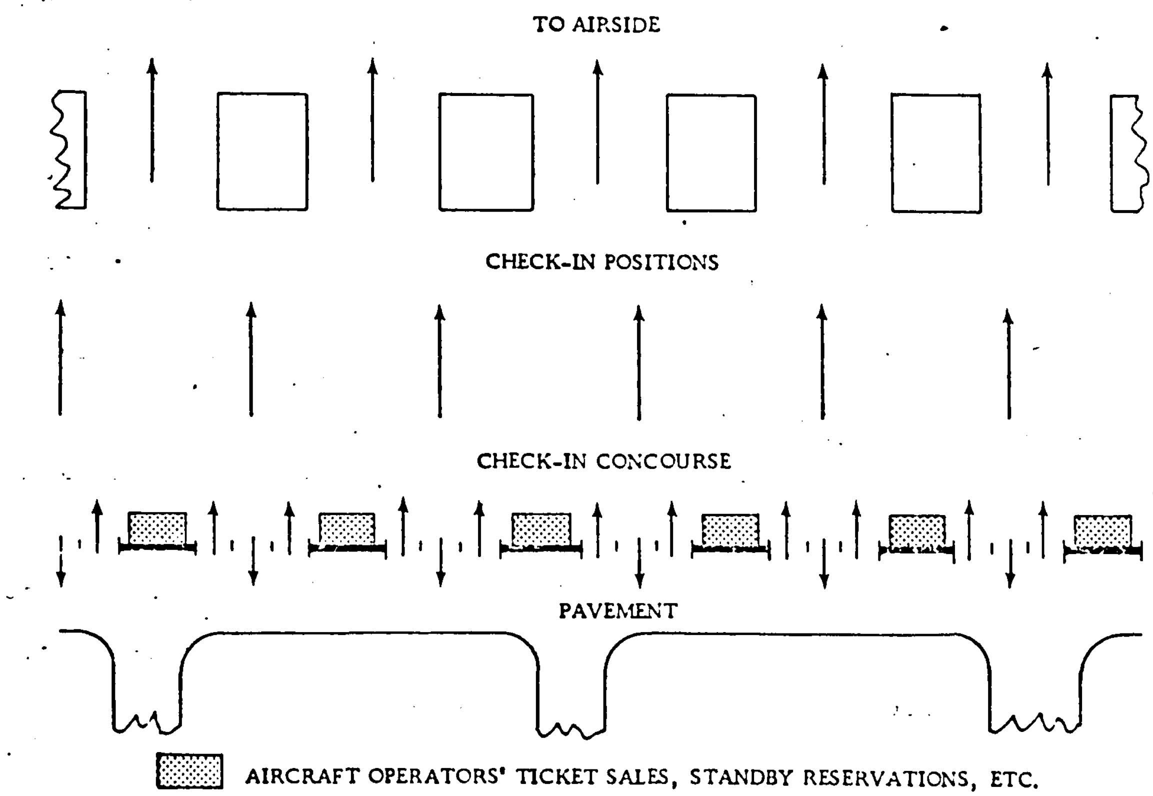


Figure 22

Late check-in can be carried out at the aircraft gate in circumstances where passengers would otherwise miss their flights, [redacted]. This places the burden on passengers of transporting their baggage to the gate but the system is permissive and it is for passengers' own decision whether to accept the burden or miss the flight. This arrangement should, however, only be used to supplement the provision of appropriate check-in facilities in the check-in concourse. It provides a means of offering passengers an additional opportunity of catching their flight which they would otherwise miss.

Further considerations having a major influence on check-in capacity are the number of aircraft operators, their shares of the traffic and frequency of operation, the allocation of check-in positions and operating systems adopted. The minimum facilities will be required when all positions are used homogeneously and many passenger can check-in at any position for any flight. Utilization of the facilities, and hence the total capacity required, varies in proportion that particular positions are designated for specific purposes. For example, allocation of specific check-in positions for domestic as opposed to international services, or separate positions for each operator. The check-in capacity to be provided is a matter both for aircraft operators' and airport authorities' judgement and check-in positions should not be provided simply in response to individual aircraft operators' demands.

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

Average check-in service times vary according to the route and category of traffic and should be determined in consultation with aircraft operators. Based on the service time a sustainable check-in rate can be defined as the capacity for each position and thus the number of groups of check-in positions, parallel flow streams and landside entrances required can be defined.

Systems

The check-in system can exert a major influence on planning. The conventional check-in system of manual ticket control and baggage weighing and labelling which is currently in worldwide use may be subject to future radical changes. Various possible improved systems for check-in are being considered by aircraft operators. One is a computerized system which could ultimately enable passengers to check-in by inserting their ticket in a machine, thus eliminating check-in staff. All operators are unlikely to find it economically justifiable to install computer check-in at all airports, but already computer controlled reservation systems with inputs from airport check-in desks are being increasingly widely used. A possible concurrent development is the elimination of baggage weighing. This already applies on some domestic routes, where the passenger baggage entitlement is assessed by a specified number of pieces of defined size and eliminates the need for baggage scales.

These new operational systems can affect passenger building planning by imposing different space requirements for the check-in positions. They may also reduce the passenger service time so that the capacity (flow-rate) of the check-in positions would be very considerably increased. The capacity of any particular section of the passenger flow routes should not be increased without a corresponding increase in the other sections. To do so merely causes congestion and consequent delay in the subsequent lower capacity sections of the route, or under-utilization of the high capacity section, because passengers cannot flow to it fast enough.

Future check-in systems are liable to have a much greater range and higher level of capacities. These will not be usable unless all parts of the flow system and building are planned with the necessary flexibility to enable the capacity of each separate flow stream, as well as the total flow rate, to be increased. Expansibility may also be required to provide additional check-in and flow capacity beyond that afforded by the higher flow rate of each check-in position, but that is a separate matter.

Changes in check-in systems can also affect their utilization and the systems of allocation. The extent to which new high capacity check-in systems can, or need to be adopted, will vary among aircraft operators and the routes and types of traffic which an airport serves. At many airports a number of check-in systems may be used ranging from the present manual methods, although perhaps without baggage weighing, to fully computerized passenger operated systems. This could restrict the interchangeability of use of the check-in positions leading to allocation of specific positions for certain systems. The appropriate balance between numbers for each type of system and the appropriate system of allocation should be determined by the airport authority in the light of local circumstances.

However, allocation of check-in positions for specific purposes can reduce their utilization to very low levels. The total capacity of the check-in facilities which it is then necessary to provide can greatly exceed the hourly capacity of the passenger building, and airport as a whole. Where check-in systems are technically incompatible with each other and some specific allocation of facilities has to be made, a loss of utilization may be inevitable. But this should not be accentuated by allocations not necessitated by technical factors, and which are based on routes, types of traffic or aircraft operators which further reduce utilization and cause facilities to be provided which are disproportionate to the overall capacity of the building.

Layout

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

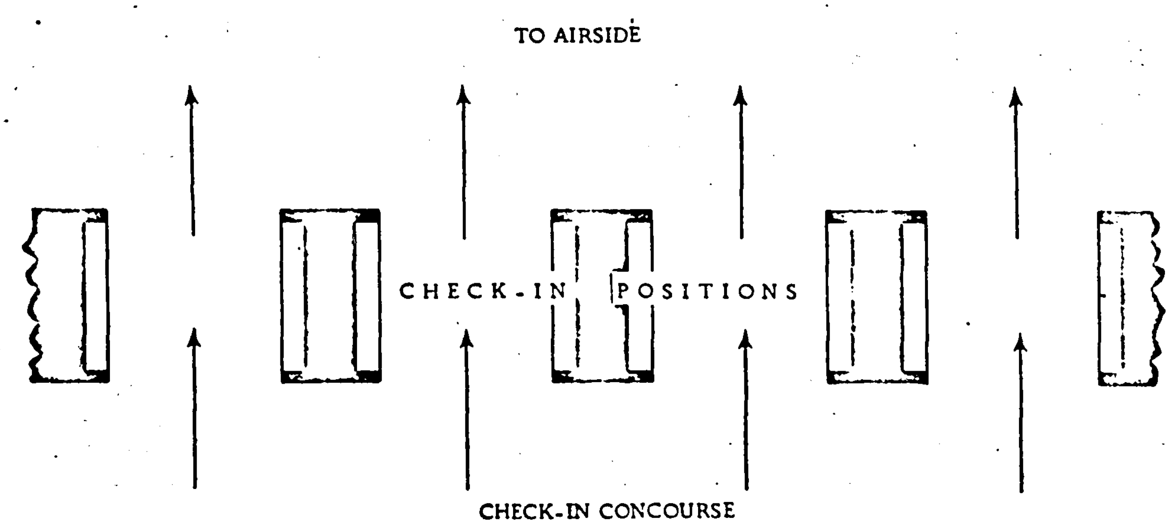


Figure 23

Passengers flow to the check-in positions in a number of parallel streams formed by the layout of the landside vehicle unloading positions, and the passenger building landside entrances. The layout of the check-in facilities is, therefore, influenced by two considerations - preservation of the straightness of the parallel flows across the check-in concourse through to the airside, and minimum distance between landside and airside. Check-in positions should be immediately obvious on entering the building and should be arranged parallel to the line of the passenger flows. For straight, direct flows passengers should pass between them as through a comb. Long continuous lines of check-in positions at right angles to the flow are incompatible with the flow principles.

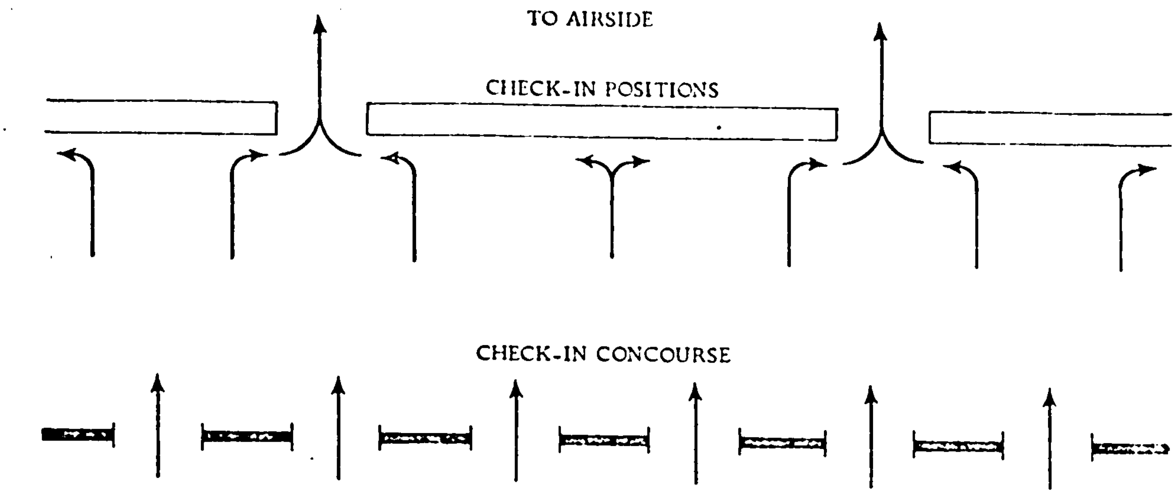


Figure 24

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

The optimum arrangement which provides reasonable staff groupings and the straightest and most direct passenger flow, is four positions in each group arranged back to and sideways to the passenger flow.

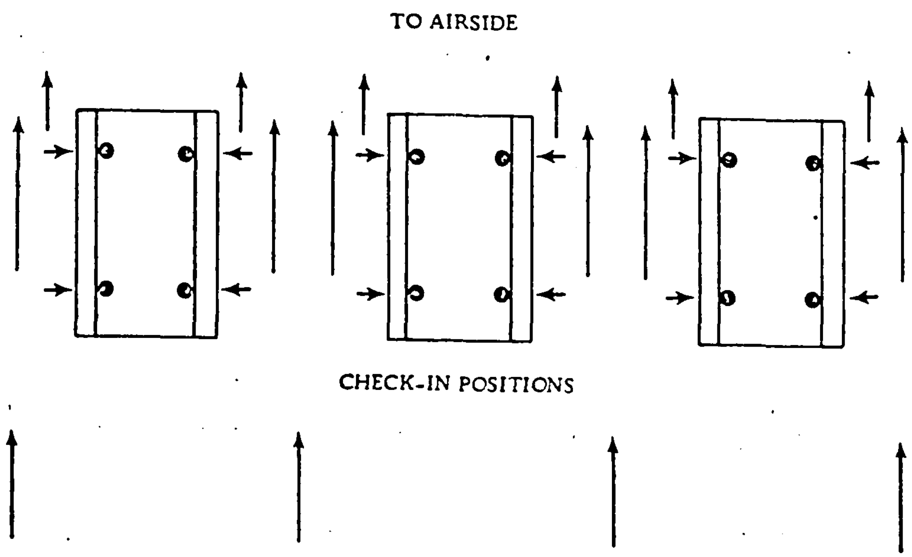


Figure 25

Flight Information

Passengers have to be informed when their aircraft is ready for boarding and when delays occur. This has generally been done by loud speaker announcements. However, at busy airports such arrangements can cause problems. Due to the constant flow of announcements passengers tend to miss those applying to their particular flight. The high ambient noise level in buildings containing a lot of people necessitates a high volume for the loud speaker announcements and this can cause severe discomfort for staff working in the building. It is often difficult to ensure that announcements can be heard in all parts of a building intelligibly and at a volume which does not cause discomfort to the occupants.

Visual presentation of flight information should, therefore, be considered. Flight indicator boards should be considered integrally with the basic planning of the check-in concourse and waiting areas. They should be located so that flight information is visible from all principal parts of the areas, and also to ensure that they do not create visual obstruction or cause passengers to obstruct the primary flow routes.

In large buildings, the size of indicators necessary for viewing from all parts of the areas may be incompatible with these considerations and more than one indicator at each location may be necessary.

DEPARTURES CONCOURSE

The space between check-in and the entrance to airside waiting area is the departures concourse.

Ideally, the passenger flow should be continuous through each successive stage of the building so that when all procedures are completed passengers should be immediately able to board their aircraft. A number of factors conspire to prevent realization of this ideal arrangement. Passengers arrive at the airport at varying periods before flight departure time depending on their mode of travel, traffic conditions and personal wishes. They pass through the passenger building procedures and controls at varying rates depending upon the category of traffic, passengers' nationality, correctness of their documents and their familiarity with procedures, etc. Aircraft operators are not always able to make aircraft available for boarding at a fixed time before flight departure because of delayed arrival of aircraft, unserviceability or any of a number of other reasons. Thus a waiting area is necessary in which passengers may accumulate pending boarding their aircraft.

Passengers are often accompanied to airports by relatives and friends. The numbers vary in different parts of the world according to local customs and the nature of the journey, but are often large. In mass traffic conditions and with high capacity aircraft if relatives and friends are allowed to accompany passengers to the airside exits the numbers of people and delays to passengers in leavetaking will inescapably cause incontrollable congestion and delay. It is essential that the flow out of the passenger building to aircraft should be rapid and unobstructed and the flow routes should, therefore, be kept clear of everyone other than passengers proceeding to their aircraft. The passenger flow to the aircraft is subject to greater surges than the flow from check-in, Therefore, passengers should take leave of people accompanying them before aircraft boarding time. To achieve this an area for passengers only should be provided between the departures concourse and airside exits:- this is the 'AIRSIDE WAITING AREA'.

The plan should encourage gradual movement from landside to airside as the waiting period decreases and flight departure time is approached.

Capacity

The capacity for the departures concourse depends upon the activities it is to accommodate and the facilities to be provided. Primarily, however, it should have a flow capacity equal to the flow streams passing through the check-in concourse. The waiting area required is affected by the flow system and the time passengers remain in the area, and the numbers of relatives and friends who accompany passengers to the airport.

Layout

The functions of the departures concourse are to continue the parallel flow streams from landside to the airside waiting area, to provide a landside waiting area and amenities for passengers and friends, and access to other parts of the building. Thus it is both a milling area (area of random movement) and a direct flow area. To preserve the passenger and flow principles in this area careful attention to the separation of functions is necessary. The primary flow streams from check-in or customs baggage inspection should continue in parallel so that the flow is distributed over as broad a front as possible and congestion is avoided by dispersing passengers throughout the area.

The width of the concourse from landside to airside should be as short as possible but should allow flow streams to merge gradually and easily where necessary to accord with the entrance to the airside waiting area.

Waiting Area

The waiting area should be between the primary flow streams and should not cause reverse or cross flows. Passengers wishing to pass directly to airside should be able to bypass it.

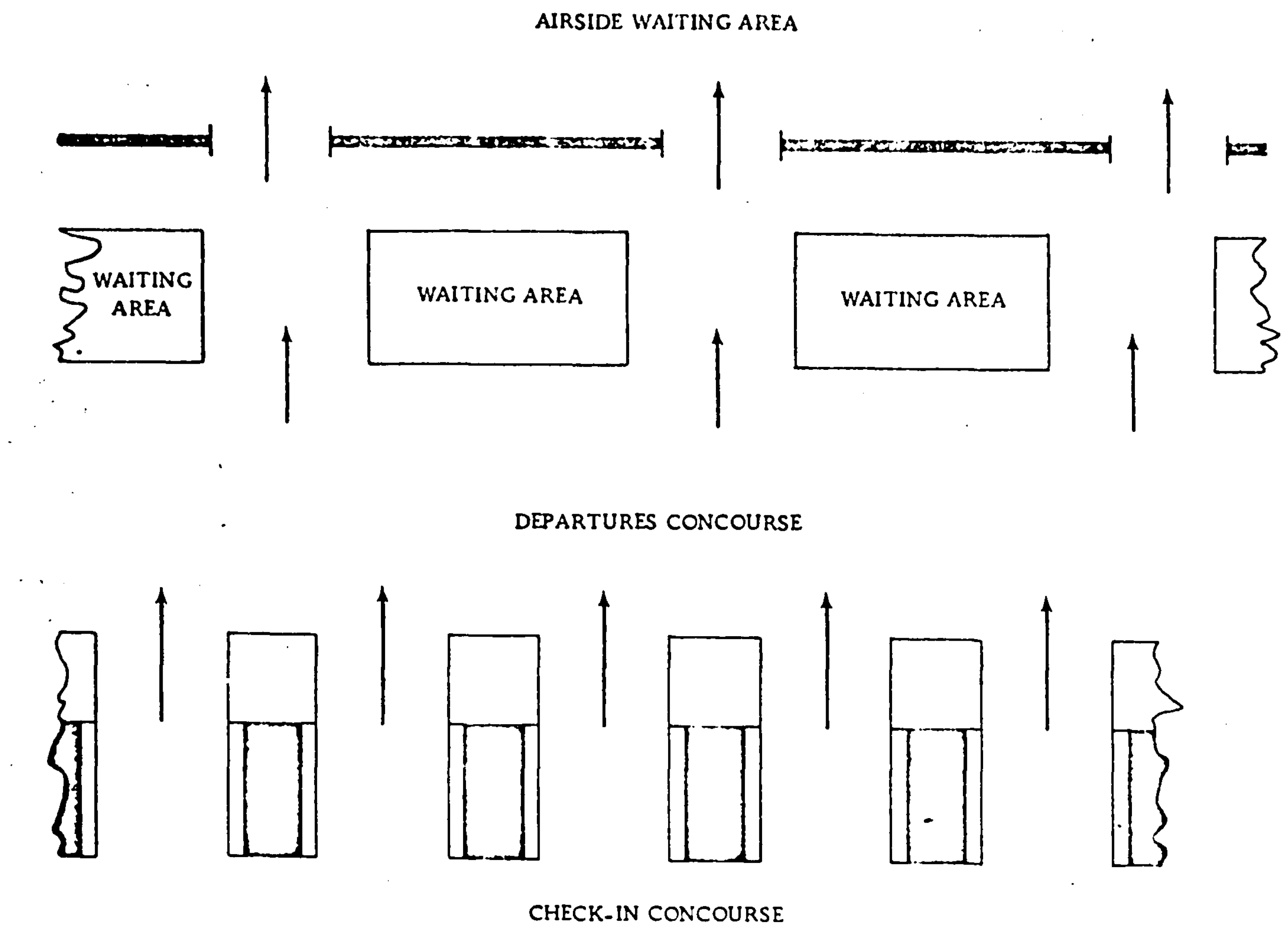


Figure 26

The capacity of the waiting areas should, therefore, be assessed in accordance with the average numbers of friends and relatives who customarily accompany passengers.

Connexion to Public Transport Links

Passengers who have completed check-in and customs baggage clearance off the airport should enter the building in the departure concourse at a point as close as possible to the entrance to the airside waiting area. These passengers are part of the main flow stream and should, therefore, enter the building on - or adjacent to, the primary landside/airside flow routes.

AIRSIDE WAITING AREA

For certain passenger procedural systems airside waiting areas at, or close to, the aircraft gates may be required. The feasibility of providing them and the form and use of such area depends on the systems used for connecting the passenger building to aircraft. Where waiting areas are provided at forward positions they may affect the form and mode of use of the main airside waiting area in the passenger building. The airside waiting area is also a direct flow area, and can be the appropriate location for certain passenger amenities. It is, however, of the utmost importance to separate functions and preserve clear, unobstructed routes for the primary flows.

Capacity

The capacity required is a function of the passenger rate of flow, the average period spent in the waiting area and the functions carried on there. The capacity should be sufficient to absorb the difference in flow rates between check-in and aircraft boarding.

Flow Rate

The flow rate out of the airside waiting area is determined by aircraft apron movement rates and aircraft operators' procedures. The flow into the area may reflect influences from landside ground transport systems. Each should be separately assessed where either of these influences is dominant.

Waiting Areas

Passengers not proceeding immediately to board their aircraft pass to the waiting areas which should be sited to the side, and clear of, the direct flow to aircraft. The general planning principle should be to site waiting areas and amenities so as to keep passengers with the longest waiting periods clear of the exit routes to the apron. The concept of flow planning still applies even for the waiting period which passengers spend in this area.

Passenger circulation within the waiting area, i.e. to and from seating, amenities, toilets, etc., is random and adequate access space is required. Interior circulation routes should run longitudinally and parallel with the airside with the primary flow routes intersecting them at right angles to provide the shortest connexions to the airside exits. To preserve free circulation the waiting areas should be clear of all structures and obstructions other than seating and there should be visual continuity throughout the entire area.

It is necessary to avoid interference between passengers leaving the waiting areas to board their aircraft and those circulating within the area, Passengers often wish to board their aircraft immediately it is available for them to do so and this leads to surges in the exit flow from the waiting areas. When flights have been delayed and complete passenger loads are waiting surges in the flow can be large and will be accentuated with the introduction of very high capacity aircraft. Thus routes to the exits are required which will ensure the speediest and easiest flow out of the waiting areas to aircraft. If queuing or congregation of passengers in the routes to the exits causes obstruction the departure of aircraft from the apron stands may be delayed. Cumulative delays in aircraft movements can then result in passenger congestion in the whole airside waiting area. To enable passengers to leave the area as directly and quickly as possible there should be routes to the exits along the whole airside frontage. Any procedures or controls which aircraft operators wish to apply - boarding pass inspection, etc., should be carried out at a point outside the airside waiting area.

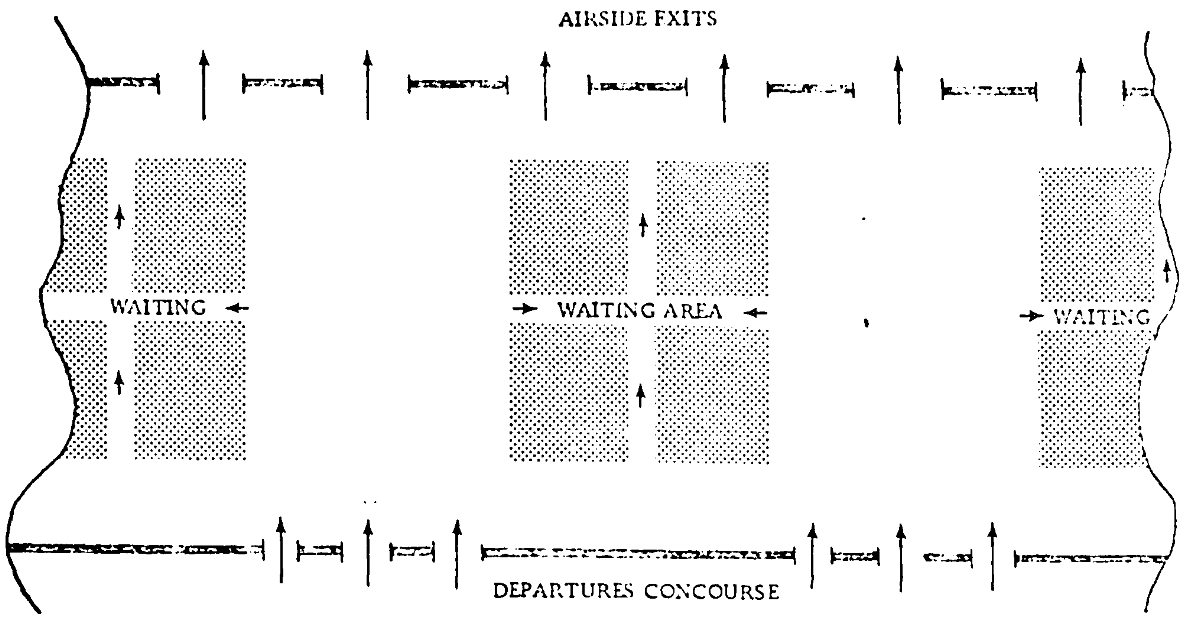


Figure 27

Problems arise in planning when an area is very large. Visual continuity is difficult to achieve when distances become too great. Passengers are attracted to positions from which there is a view of the apron and aircraft. Thus, if the distance from landside to airside is too great the landside of the area will tend to be underused whilst the airside will be overcrowded and the exit flow obstructed. For large passenger buildings, it is often difficult to achieve an optimum compromise because the space necessary for the number of passengers to be accommodated may make the landside/airside distance greater than desirable from a visual point of view.

In these circumstances a satisfactory alternative is the provision of a balcony above the main waiting area.

This allows the landside/airside distance to be as short as possible and is advantageous in separating the longer term waiting area from the main flow streams. There are, however, certain prerequisites to ensure satisfactory use of such an arrangement. Passengers tend to be reluctant to separate themselves from the main flow area. Therefore, the balcony should be planned as an integral part of the main area and to give a sense of complete unity between them. There should be no physical separation other than the vertical separation of the floors, and this should be as small as possible subject to preservation of visual continuity and suitable environmental conditions. In general the landside/airside dimensions of the balcony should not be greater than one-third of the main area. Access should be from the main airside waiting area.

A balcony waiting area should be planned to attract passengers to use it. Two features are likely to be principally attractive to passengers with some time to wait. Some may seek peace and quiet and escape from the general movement of the building. Others will be attracted by shopping facilities, catering and other amenities. A balcony area can be planned to provide for both these requirements. Considerations applying to the siting and provision of passenger amenities have been given previously and a balcony waiting area can be of considerable help in applying them. Whenever a balcony airside waiting area is provided the planning of the ancillary landside facilities, should be considered in conjunction with it.

Passenger Amenities

Shops

The airside waiting area can, like the departures concourse, be an appropriate location for some amenities, but only those which passengers regard as essential to their journeys should be provided in the primary waiting areas. The principles which should govern the provision of amenities were considered.

Amenities should be sited to ensure that passengers using them do not interfere with the primary flow streams and they should not obstruct visual continuity throughout the area. Appropriate siting of the amenities relative to each other and the flow routes can be of considerable assistance in distributing passengers throughout the whole of the waiting area and in reducing circulation within the area. The nature of each amenity provides a general indication of the degree and type of use it will receive. For example, duty free goods and liquor shops should be adjacent to the main flow routes for easiest access by a large number of passengers and to provide fast service.

The greatest use of other amenities is generally made by passengers with the longest periods to wait. Passengers whose aircraft boarding is imminent tend to gravitate to those parts of the waiting areas nearest the exits. It is important, therefore, to site amenities so that the passengers who are likely to remain in the area for the longest period are attracted away from the busiest areas nearest the flow routes.

The areas of least activity, which are the appropriate sites for passenger amenities are between the main flow routes and adjacent to the landside boundary of the waiting areas.

The siting should also be related to service accesses for supplying goods, and with storage areas. To preserve flexibility and economy in the use of space all main storage areas should be located elsewhere in the building and only sufficient for immediate purposes should be provided in the waiting areas. The principal amenities which should be provided in this are are snack, coffee and liquor bars, duty free shops, flight insurance, letter post and bookstall.

Snack, Ooffee and Liquor Bars

The nature of refreshment facilities presupposes that passengers using them have some time available before boarding their aircraft. Therefore,

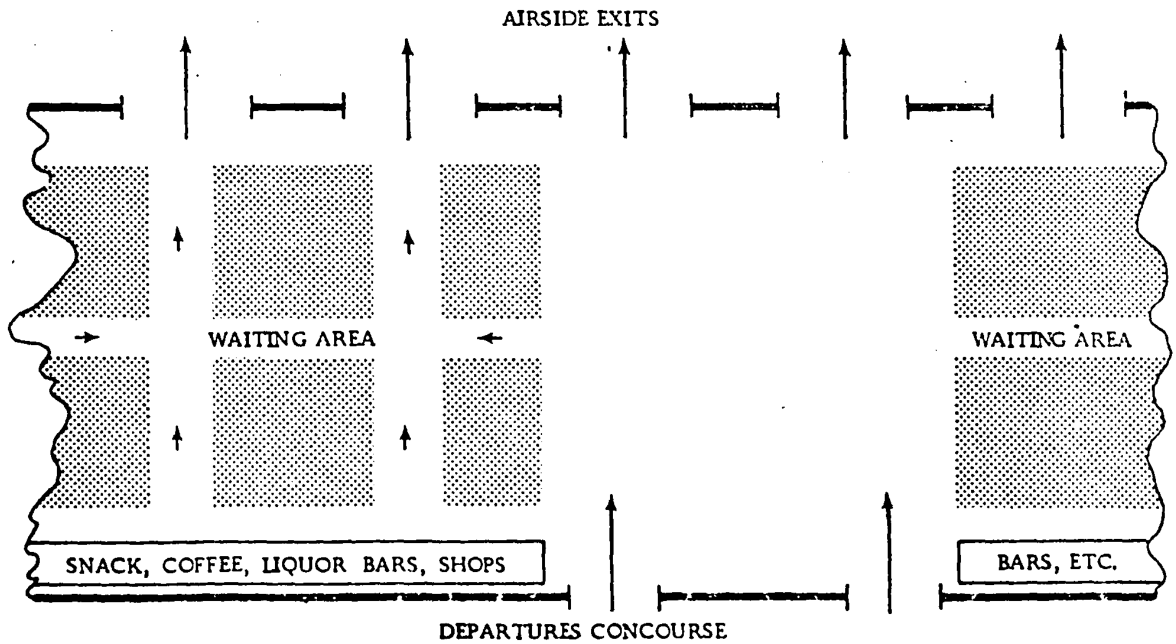


Figure 28

they should be sited furthest from the flow routes to attract passengers away from the busiest parts of the area. Catering facilities require plumbing and drainage services and often lifts or hoists for delivery of stores, and, therefore, tend to be more inflexible than other facilities. For maximum short term flexibility of the area all catering installations should be located adjacent to the least flexible elements of the building.

The service concepts should be chosen to ensure the quickest possible service and highest capacity relative to the space occupied and not only in relation to local custom. The time occupied by passengers in consuming refreshments is within their own control and may be adjusted in accordance with the time at their disposal. But the longer the time taken to serve passengers the more likely it is that they may be prevented from obtaining refreshment because of the shortness of time at their disposal, and dissatisfaction and criticism will ensue.

All refreshment facilities adjacent to the main flow routes should be open counters to avoid obstruction to the visual continuity along the flow routes and throughout the area.

Kitchens and other catering services require plumbing and drainage services and often lifts or hoists for delivery of stores and, therefore, are inflexible elements. Care is required in locating them to preserve maximum flexibility in the building, such as external walls which cannot be moved because of site limitations, heavy plant rooms or other inflexible installations. Access for service vehicles for the delivery of stores and removal of refuse is essential and should be arranged so that there is no conflict with, or obstruction to, the movement of passenger vehicles. For creating of the best environment it is also desirable that service accesses should not be visitble from the passenger areas. The stores and offices associated with catering installations should be the minimum necessary for day to day operation and bulk stores should not be sited in the passenger building.

AIRSIDE EXITS

The form of the connexion between the passenger building and aircraft may determine the precise form of the exits, but they should be arranged to form the passenger flow into a linear pattern on a narrow front compatible with the size of the aircraft or apron passenger vehicle doors.

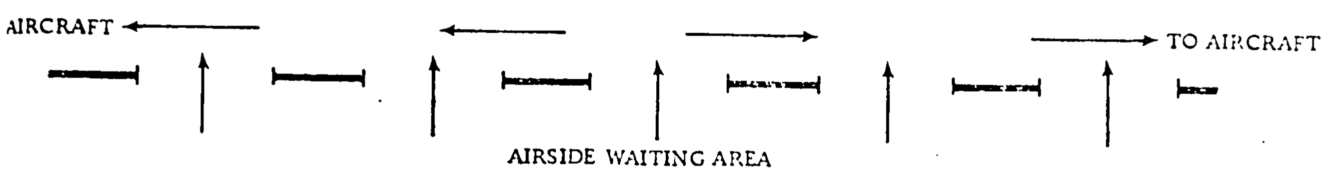


Figure 29

Some form of control is necessary to ensure that only bona-fide passengers are allowed to board aircraft. This is usually carried out by aircraft operators at the exits from the building or at the aircraft gates. Positions may be required for this control to be undertaken. They should be arranged so that passengers can flow freely and easily out of the airside waiting area and past the control without obstructing other passengers or forming queues in the waiting area. The form and location of controls also depends upon the form of the connexion between the passenger building and aircraft and is considered in conjunction with this below.

CONNEXION BETWEEN PASSENGER BUILDING AND AIRCRAFT

The system for moving passengers between the passenger building and aircraft is an integral element in the choice of the aircraft parking system and apron plan. A number of different systems can be used to connect the passenger building to aircraft. The most appropriate system may vary according to the traffic for which the individual airport is provided, and other local conditions. The most important considerations are to protect passengers from apron vehicles and aircraft and to maintain free movement of aircraft, vehicles and passengers by avoiding conflict between them.

Flow routes should be planned to achieve this without imposing unacceptable burdens on passengers. The basic alternatives are for passengers to walk or be conveyed by some form of vehicle. The routes for either of these systems can be over the open apron, enclosed routes at or below apron level, or at passenger building and aircraft floor levels. Any specifically defined route over which passengers walk, i.e. other than over an open apron, is a pier. Thus a pier can be at, above or below apron level.

For closest compatibility with the flow principles the choice should be determined in conjunction with the passenger building floor levels and the optimum level should be chosen at the earliest stages of planning. Thus for single level passenger buildings routes at apron level can be appropriate because the change in level between the passenger building and aircraft floors is the same whether it takes place at the building or at the aircraft stand.

For multi-level passenger buildings the connexion between building and aircraft should minimize any changes in level. Because of the variety of aircraft floor heights it is impossible to define a single suitable level, The choice should be determined by the form of passenger access into aircraft, the circulation and passenger building floor levels.

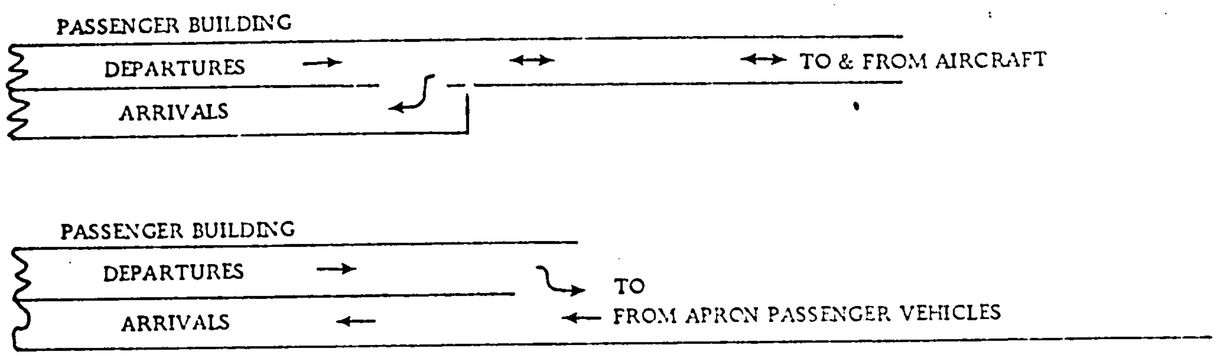


Figure 30

Capacity

Surges which are caused by apron utilization and the aircraft movement rate may be accentuated or decreased by the form of the connexion between the passenger building and aircraft. The planning objective should be the steadiest possible flow at a rate equal to the rate at which passengers can enter and leave aircraft. This is influenced by passenger control procedures which aircraft operators may wish to undertake, the number of aircraft doors and the form of passenger access to the aircraft.

Apron Passenger Vehicles

The primary advantage of apron vehicles is that they provide an almost perfectly flexible system which most easily permits aprons to be adapted for new aircraft types and larger numbers of aircraft. However, they have some disadvantages. They limit the extent to which passengers can trickle flow and create surges in the flow because of group delivery of passengers. The size of vehicle and methods of access between vehicles and aircraft may have to vary with changes in the size and passenger capacity of aircraft using the airport. The large numbers of vehicles necessary for very high capacity aircraft may cause vehicle congestion on aprons. The operating costs may be high.

In general, although apron passenger vehicles afford almost ideal flexibility from the apron planning point of view, they tend not to be compatible with the passenger flow principles. They may, however, be useful to serve aircraft which differ from the general types of aircraft for which the airport is planned.

Piers

For optimum utilization all aircraft parking positions should at any time be usable by an arrivals or departures flight. Thus piers have to provide for simultaneous flow of passengers in both directions between the passenger building and aircraft. The width necessary for this depends upon the passenger flow rate and type of aircraft, a clear flow corridor of 20 feet is generally adequate, but for flow rates of about 1,500 an hour in each direction and for aircraft with passenger capacities higher than 150 the width should be of the order of 25 to 30 feet. Piers should be planned to provide flexibility for adjustments to be made to the aircraft gates, i.e. the access between the pier and the aircraft stand, in accordance with changes in aircraft design and the apron plan. This should be considered in association with the provision of apron buildings.

Pier layouts should avoid multi-directional junctions as far as possible.

AIRCRAFT GATES

Passenger processing and aircraft handling systems influence the form of the gates. The gates may be no more than doorways giving access to the aircraft stand, but they can also appropriately accommodate a number of departures facilities. The precise form should be determined by the nature of the passenger traffic, the flow rate and the processing system adopted for the passenger building.

Systems

The fullest implementation of the trickle flow principle should be the basis of planning. Trickle flow can be implemented over any section of a passenger route, with some form of group or controlled flow over the other sections if necessary. The full benefits of the system are achieved when passengers can flow freely, at their own speed, through all parts of the route. Ideally, this should include, in the case of departures, a flow directly into aircraft. However, it is not always possible to admit passengers to aircraft as soon as they arrive at the gate because, for example, aircraft are delayed, or cabin servicing is incomplete, etc., and, therefore, a waiting area is necessary. For quick aircraft turnrounds it is necessary for passengers to be at the gate ready to board the aircraft immediately it is available. A waiting area is necessary, therefore, for this purpose also.

Forward Waiting Areas

The size of waiting areas and their layout depends upon the functions to be performed. With the increasingly rapid introduction of larger aircraft it is essential that the plan should provide maximum expansibility without need for rearrangement or reconstruction of the basic areas. Forward waiting areas should only be used to facilitate trickle flow to the gates. If aircraft operators' controls are undertaken in the forward waiting area they may be applied, either as passengers enter the area - or as they exit from it to board the aircraft. They should be arranged so that passengers are not prevented from leaving the area again if they wish to do so unless the time to be spent in the area before boarding the aircraft is very short. Unless amenities such as toilets and refreshments are provided it is incompatible with passengers' interests for them to be confined in forward waiting areas and not be permitted to leave. The provision of such facilities rapidly becomes uneconomic where there are more than a few gates, and creates inflexibility in the plan.

Provision of waiting areas at the gates can influence the requirement for the airside waiting area in the passenger building. The space required at each location is determined by the passenger processing system but space provided at the gates does not permit an equivalent reduction in the passenger building airside waiting area because some passengers will linger in the building to use the passenger amenities.

Climate can also affect the size and location of waiting areas. At airports where aircraft are subject to protracted delays because of weather conditions, passengers will wish to return to the airside waiting area in the passenger building to use the amenities. Waiting areas at the gates will not permit any reduction in the size of the airside waiting area in the passenger building in these circumstances.

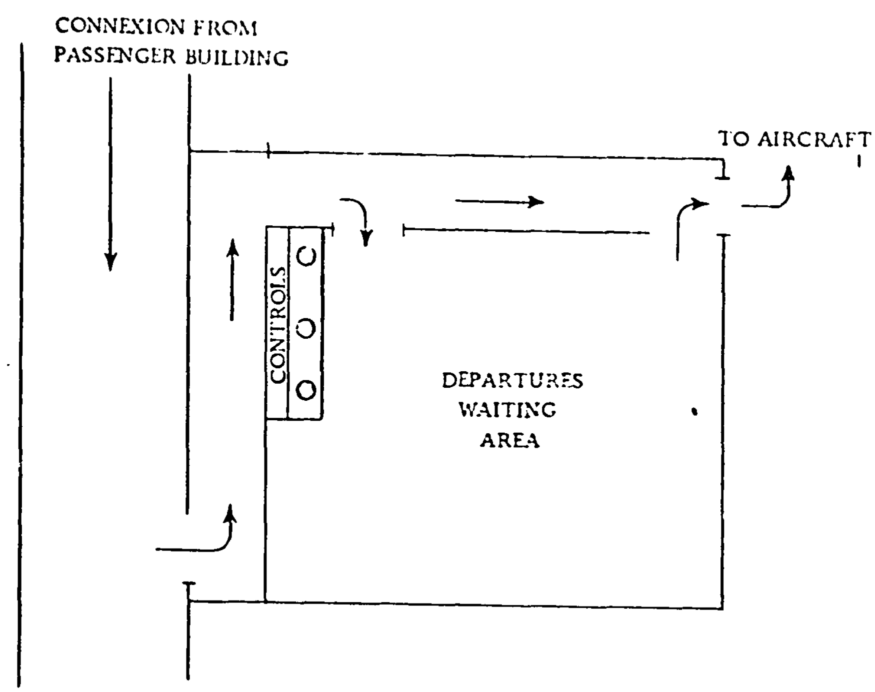


Figure 31

Layout

A clear route to the aircraft should be provided, with positions along this route for any control procedures which are to be applied. Care is necessary in siting the control positions to ensure that queues of passengers do not obstruct the flow to and from the other gates. The waiting area should be arranged to the side of the flow route.

Capacity

The capacity required depends upon the passenger flow system. The capacity of the forward waiting areas need not be equal to the aircraft passenger capacity because the flow of passengers to the gates is random and the aircraft should be available for loading before flight departure time.

When aircraft boarding is delayed proper managerial control should ensure that this is indicated in the passenger building so that passengers do not continue to flow to the gate. In the case of quick turnround transit flights, although all passengers have to be at the gate they are only a proportion of the aircraft's total passenger capacity. It will generally be sufficient to provide a capacity equal to 75 percent of the forecast aircraft passenger load, i.e. the aircraft seating capacity abated by the aircraft passenger load factor.

PASSENGER GANGWAYS

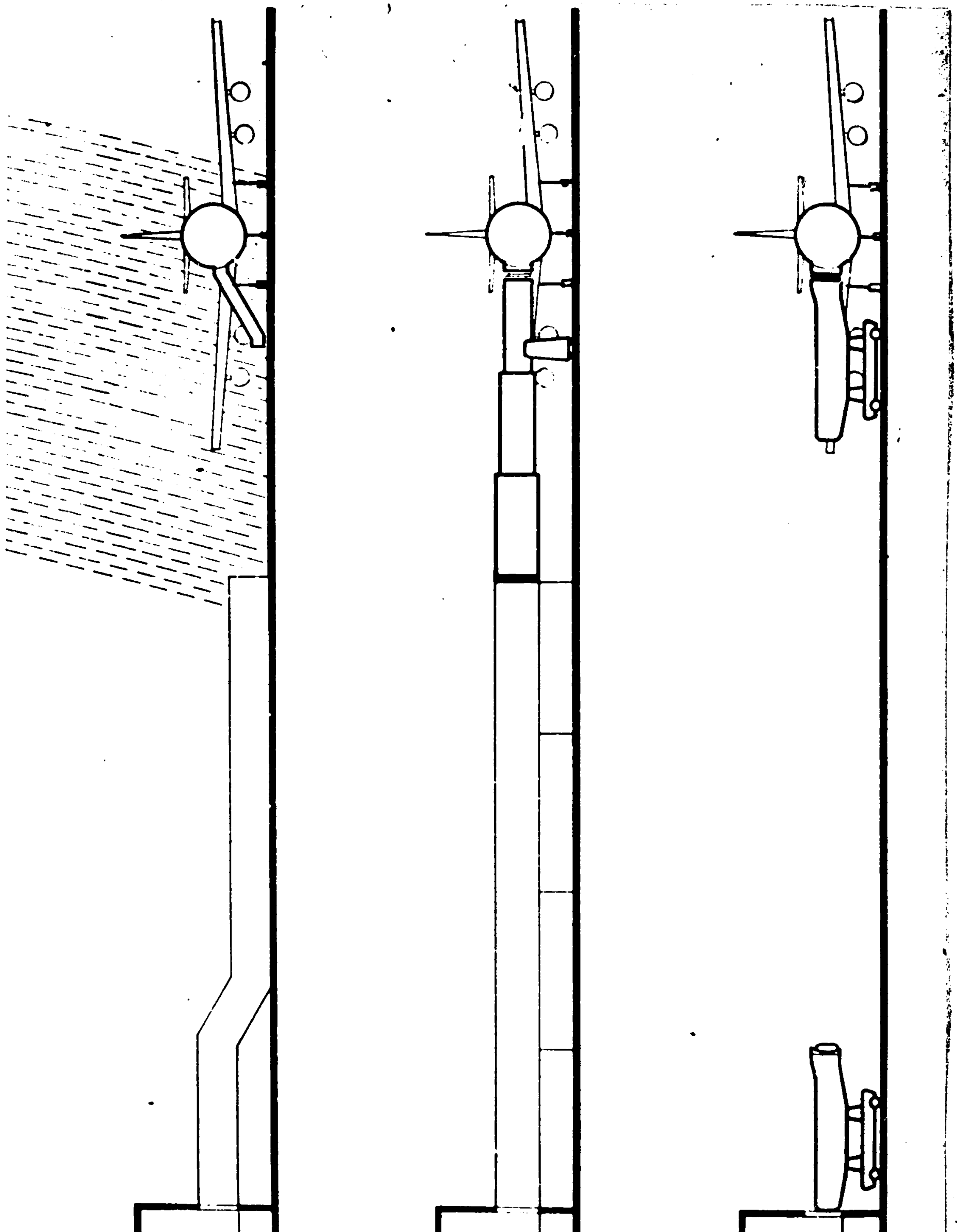
Gangways can provide quicker, more even passenger flow between aircraft and passenger buildings and protect passengers from weather, noise and fumes.

The primary factors to be taken into account in planning gangways are aircraft floor heights and door positions. The size and form of gangways should be chosen to provide sufficient flexibility to serve types of aircraft other than those indicated in the operational forecast, and for resiting at new gate positions in accordance with changes in apron plans.

For the best passenger flow the interior width of gangways should be sufficient for at least two people to walk side by side so that children and the aged or infirm can be suitably assisted. The flow rate should be at least equal to the capacity of the aircraft door. Floor slopes should generally not exceed one in ten and in no case should be steeper than one in seven.

APRON PASSENGER VEHICLE LOADING POSITIONS

The specific form of loading positions depends upon the vehicles to be accommodated. Generally, the positions should be considered as aircraft gates and the



same planning considerations apply as described above, except that vehicles will occupy the loading gates for a much shorter period than aircraft occupy the stands. Therefore, the degree of trickle flow to the vehicle loading positions which is possible may be much less and the time spent in the waiting area may be correspondingly short.

Loading positions should be as close as possible to the passenger building airside waiting area to reduce the walking distance and hence the time required for passengers to get from the waiting area to aircraft. The specific location of the loading positions will usually be determined by the airside vehicle traffic circulation and the need to provide unobstructed access between the loading positions and the apron roads. The number of positions required depends upon the utilization of apron stands, size of aircraft, etc.

DEPARTURES BAGGAGE FLOW

The flow systems for baggage and passengers have been considered as a single system over those parts of the route where baggage accompanies passengers. However, after check-in, or departures customs inspection where this is applied, the routes separate.

After being checked-in, baggage has to be sorted into flight groups. It may also be further sorted into sub-groups according to the destination airports of each flight, and/or the aircraft holds in which it is to be carried. After sorting it may have to be stored for a period prior to delivery to aircraft. Where such controls exist it may have to be submitted to customs inspection, see page . The baggage system is, therefore, required to provide facilities for each of these functions. There should be complete separation between baggage and passenger routes. Except for the smallest airports this is best achieved by baggage handling being undertaken on a separate floor below the departures passenger flow.

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

Systems

The shortest baggage handling time which can be achieved should be defined at the earliest possible planning stage. This should then define the passenger processing time for which the passenger areas should be planned. The choice of baggage handling systems will depend upon the size and nature of the traffic and local considerations such as the cost and availability of manual labour and the skills of local labour for the operation and maintenance of mechanical equipment. The rate of traffic movement and quantity of baggage can soon exceed the capacity of manual systems and mechanical and/or automatic sorting systems are often required. These may have the advantage of requiring less space than manual systems.

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

Layout

No single layout offers such overwhelming advantages that it can be recommended for use for all baggage areas. The choice of system relative to the size and shape of the passenger building usually indicates the best arrangement but the overriding factors to be considered are the handling time, which is usually a direct function of the distance which the baggage has to travel, and the provision of sufficient positions at the airside of the building for the delivery of baggage to aircraft. If an airport operates in conjunction with baggage check-in facilities off the airport a direct route from the transport link airport terminal to the baggage sorting or loading area would be required to integrate the baggage with baggage checked-in at the airport. It may be possible to transfer baggage from a transport link directly to the aircraft stands for loading but this depends upon the form of the transport link and system of operation and does not require any additional special facilities other than an access route to the airside road system.

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

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

CUSTOMS BAGGAGE INSPECTION

Government regulations may require inspection of registered baggage, i.e. baggage checked-in for carriage in the aircraft hold and/or passengers' hand baggage. Hand baggage moves with the passenger and is, therefore, available for inspection at any point. But registered baggage is given up at check-in and despatched to airside for loading into the aircraft. Government regulations may require alternative procedures, depending on whether checks are random or continuous and the method by which they are imposed. Customs baggage control should be located to avoid the need for repeated handling of baggage by aircraft operators and the consequent longer ground handling times and higher costs.

If all baggage is subject to inspection, the control positions should be sited at the point where the baggage and passenger flow routes separate - that is immediately after check-in. Thus customs inspection should be sited behind and close to check-in and baggage should be conveyed to it from checkin without being returned to passengers. When passengers open bags for inspection, customs can prevent any items being added and thus ensure that aircraft operators' baggage charges are not avoided. If random or selective checks of individual passengers' baggage is required, including pre-clearance under bilateral arrangements which provide for arrivals customs baggage inspection to be carried out at the foreign airport of departure, the control should be similarly sited. If customs inspection is carried out at check-in the service time is considerably increased, the utilization of the check-in facilities correspondingly reduced and additional check-in facilities thus made necessary. Passenger convenience and flow speeds would be compromised by the longer flow routes arising. The functions should be separated.

Ideally, each group of check-in positions should be complemented by a customs control, but whether this is possible depends on staff utilization and costs. The primary aim should be to preserve, to the maximum possible extent the separate, straight parallel passenger flow streams through the check-in positions. However, it may be necessary to merge the streams into fewer larger streams according to the number of customs control positions provided. Where this is necessary, the marging should be gradual and on the line of the direct landside/airside route. In order to preserve an acceptably direct and obvious flow the landside/airside distance may need to be marginally increased. Sharp turns are uncompatible with the flow principles. Free flow routes past and between the customs inspection positions are essential for passengers without registered baggage, friends and staff. The inspection positions should be arranged as a comb, in the same manner as for check-in.

If regulation require inspection of whole flights chosen selectively or at random the inspection points should be located at a position on the passenger flow route where passengers and baggage can again be brought together for inspection after all the baggage for one flight has been sorted and assembled. For shortest baggage handling times this should be as close as possible to the passenger flow routes is adjacent to the airside waiting areas.

Customs Accommodation

In association with the baggage inspection control, customs may require offices for their administrative procedures, and interview and/or search rooms for passengers found in contravention of regulations. The same considerations should apply to the siting and form of these offices as to the airline check-in offices described previously. It will usually be possible and advantageous to integrate the planning of offices for these two purposes.

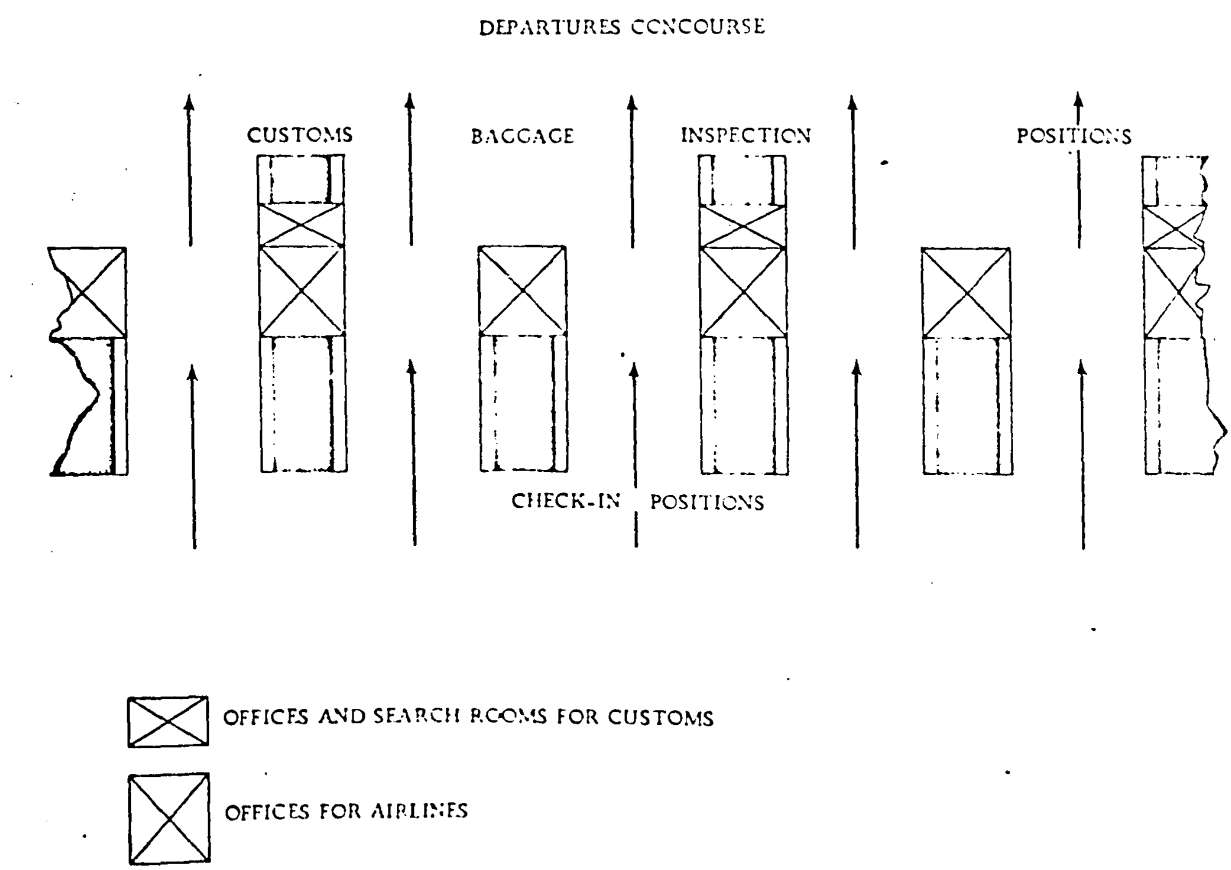


Figure 32

Office accommodation for customs in this area should be restricted to the absolute minimum necessary for application of baggage inspection. Supporting administrative offices, rest rooms, etc., should be provided elsewhere in the building.

GOVERNMENT FRONTIER CONTROLS

[redacted]

From the departures concourse passengers flow to the airside waiting area. Passengers may be subject to government controls on leaving the country and these controls constitute the frontier. After passing the controls, passengers may not re-enter the landside areas and are segregated from all persons, other than staff authorized to enter the airside areas. The controls should be grouped together at one location and should form the entry control to the airside waiting area, thereby avoiding an additional control positions which would be an irritation to passengers, a hindrance to flow and involve additional space and staff costs.

Location

The location of frontier controls and the stage in the passenger processing system at which they are applied is important in maintaining free and continuous passenger flow. They should be located between the departures concourse and the airside waiting area. This is the point on the passenger route where the rate of flow is most regular. Controls located at theexit from the airside waiting area would be subject to large surges and would delay passenger flow to aircraft.

The most frequently applied government exit controls are immigration and police, but some States also impose customs inspection of passengers and/or their hand baggage. Passport and police clearance should precede customs inspection. Passengers with incorrect or incomplete documents cannot pass the passport control and may need to return to the landside areas. If they pass customs inspection before immigration and then have to return to landside before completing immigration clearance, they would be liable to customs inspection again when returning to immigration.

Other considerations to be taken into account are the same as for arrivals frontier controls.

ARRIVALS

The previous pages traced the flow of departures passengers and baggage from landside to aircraft. This section now similarly follows the flow of arrivals passengers and baggage from aircraft to landside of the passenger building. Many of the details and considerations already described in the 'DEPARTURES' section are also applicable to 'ARRIVALS'. These will not be described again but cross references will be given where appropriate.

Certain parts of the flow routes cannot be self-contained either for departure or arrivals and have to serve two-way traffic. The facilities to which this applies are passenger gangways, piers and/or apron passenger vehicles. For the sake of clarity the considerations applicable to the planning specific projects all analysed for departures and arrivals separately but in planning specific projects all aspects have eventually to be considered together and a compromise made between any conflicts which may arise in providing in the best manner possible for each category of traffic.

PASSENGER GANGWAYS

The route should be clear and unambiguous and, if possible, should avoid multi-directional junctions where the gangway joins the building. Departing passengers are aware that gangways lead to the aircraft but arriving passengers, on leaving the aircraft, will usually not be familiar with the routes they are to follow. The gangways should be arranged to lead passengers directly to the main flow routes into the passenger building.

AIRCRAFT GATES

The facilities required at the gates for arriving passengers depend upon the passenger processing system. Some airport authorities may elect to carry out health documents, or other inspections, at the gate. The service rate for such inspections is slower than the passenger flow rate out of the aircraft and could, therefore,delay the disembarkation of passengers and also delay the loading of departures passengers, or aircraft servicing. Thus, where any arrivals passengers controls are carried out at the gate a waiting area should be provided in conjunction with the control positions. The area should be arranged to hold arrivals passengers clear of departures passengers and the main passenger flow. The space required depends upon the nature of the traffic and the controls to be undertaken, the proportion of terminal and transit flights and the aircraft average passenger load.

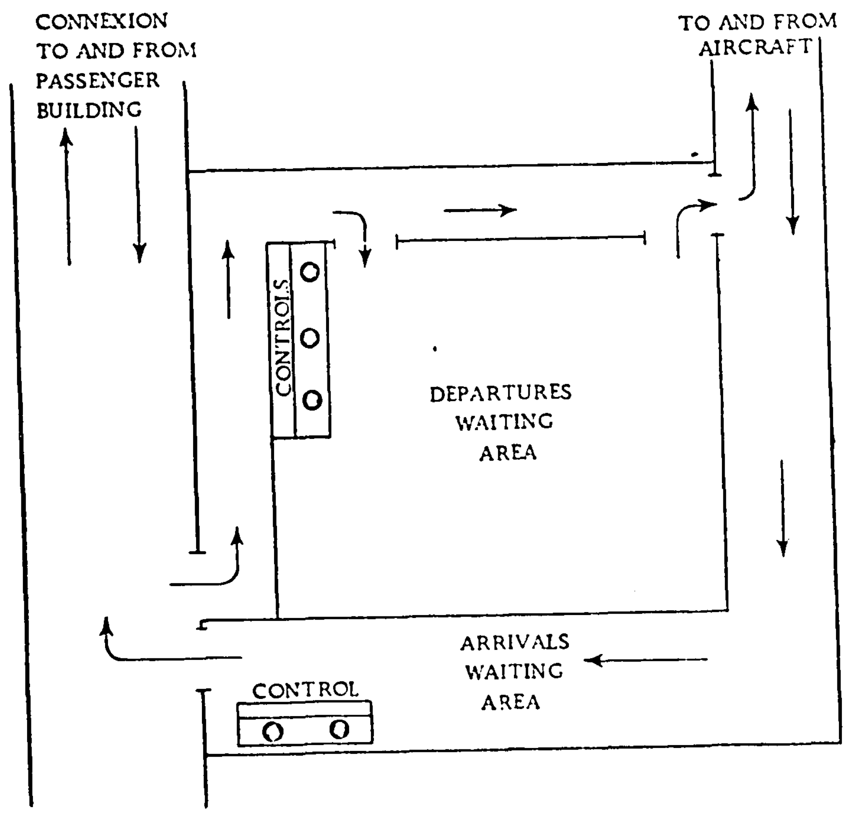


Figure 33

Generally, arrivals controls at aircraft gates are expensive in utilization of staff and delay passenger flows. At centralized controls in the passenger building it is possible to spread surges in the flow among a number of control officers. It is not possible to provide the same numbers of staff at each gate as in a central control and thus a general slowing down of the passenger flow may be caused.

AIRSIDE ENTRANCES

From piers or apron passenger vehicle unloading positions passengers flow into the passenger building. Although two-way flow of departures and arrivals passengers is unavoidable and tolerable in piers, in no circumstances shouls arrivals flow routes pass through departures areas in the passenger building. The airside entrances should, therefore, give access directly to the arrivals areas of the building. These may be on a lower floor in multi-level buildings or by the side of the departures areas in single level buildings. In multi-level buildings the descent should be direct, obvious and easy.

Passengers entering the building include transit and transfer passengers as well as terminal arrival passengers who end their air journey at the airport. The airside entrances should be arranged to separate passengers into the appropriate flow streams. The entrances for each category should be arranged consecutively along the flow route so that passengers do not have to choose between more than two alternatives at any time. Confusion is usually caused if special categories are not segregated from the main flow before the first control point. Thus all arrivals passengers should flow through a common route as far as possible but when transfer and transit passengers are not subject to controls, they should be diverted before the main route reaches the frontier controls.

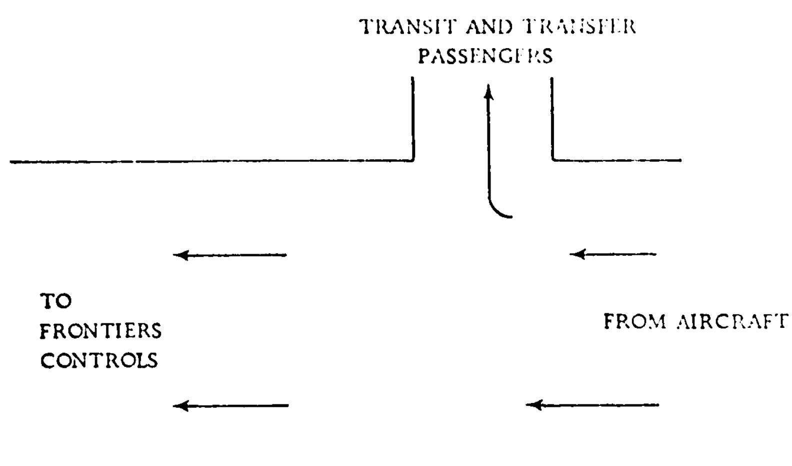


Figure 34

TRANSIT PASSENGERS

Transit passengers only stay at the airport for the duration of the aircraft turnround. They have no requirements beyond those of arrivals and departures passengers. Usually they should follow the main arrivals route but pass directly into the departures airside waiting area before reaching the entrance to the arrivals frontier controls. However, some transit flights change category, and in these circumstances transit passengers may be subject to frontier controls. Their requirements are then the same as transfer passengers and the same facilities can be used for both. Transit passengers who arrive and depart on international flights should never be subjected to frontier controls and should remain in the airside area. All amenities which they may require are provided in the departures waiting area. On departure of their flight they follow the normal routes and procedures of departures passengers.

TRANSFER PASSENGERS

The flow route for transfer passengers depends on whether the transfer is between flights of the same or different categories, i.e. domestic to domestric, international to international, or between international and domestic. When the traffic is between international and domestic transfer passengers are subject to the normal arrivals or departures controls and should follow the main arrival route to the landside where they then pass through the main departures flow route and follow the normal departures procedures. At airports where there is more than one passenger building, a transfer passenger vehicle route on the airside road system is required. Requirements for the vehicle unloading and pick up positions are the same as for other apron passenger vehicles, and the same positions can be used for both.

Where traffic is entirely domestic or international, transfer passengers should not pass through arrival controls. They should be segregated from the main arrivals flow and pass directly to the departures airside waiting area and can usually follow the same route as transit passengers. Unlike transit passengers who leave the airport on the same flight on which they arrive, transfer passengers change flights. Thus it is necessary for them to check-in for the departure flight. This can either be undertaken at the gate, if such facilities are provided, or preferably on the route to the departures waiting area. At airports serving a number of airlines some form of shared use of transfer check-in positions is necessary to avoid the provision of facilities which are overlarge and thus uneconomic and which distort the building plan.

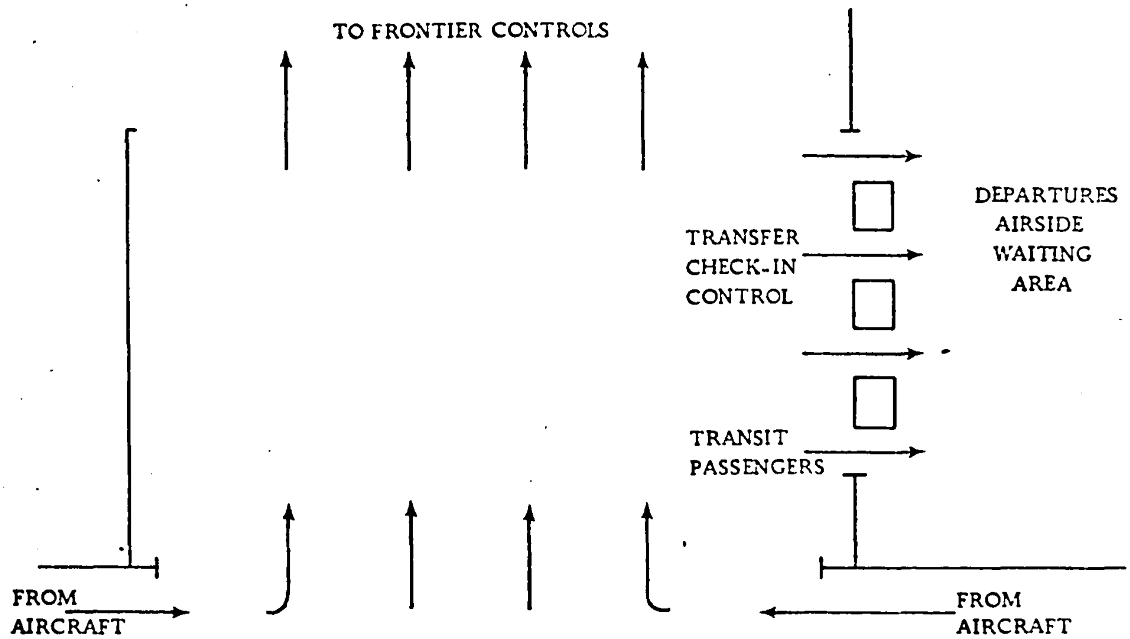


Figure 35

GOVERNMENT FRONTIER CONTROLS

The sequence of controls depends upon the statutory regulations they are intended to enforce. Many international flights are subject to health control and, therefore, provision should be made for health documents inspection to precede passport and police controls. Customs baggage inspection cannot be carried out until passengers are accompanied by their baggage.

Sufficient space should be provided between the airside entrances and the frontier controls for any merging of the low streams which may be necessary, and for short queues. A waiting area may be required at the side of the flow streams for passengers subject to passport investigation and medical inspection. Inspection positions should as far as possible be dispersed equidistantly across the lines of the parallel flow streams from the airside entrances. However, economic utilization of government staff may require them to be grouped into one or more units to produce the optimum compromise between operating costs and passenger flow efficienty.

The control positions should be arranged as a comb, and preferably sideways to the flow routes.

Capacity

The capacity required for each authority and procedure is a function of the service time, passenger flow rate and proportion of passengers inspected. It is important to achieve a high rate of passenger clearance by reducing frontier controls service time and reducing cross and reverse flows of passengers seeking to complete and/or obtain the required documents. Although some passengers may always require longer than average service time because of particular problems, it will not be possible to handle increased rates of passenger flow, including surges in average flow rates, unless passengers whose documentation, etc., is complete can bypass the problem cases and thus maintain the average service time and flow rate.

Health Control

In addition to inspection of vaccination and inoculation documents some States apply personal medical inspection to certain passnegers. The facilities required should be defined by the medical authorities concerned and may include X-ray rooms. The medical facilities should be restricted to those required for passenger control and should not be a general first air or medical centre for the airport.. The location of passenger medical inspection facilities should be immediately adjacent to, but at the side of, the frontier control. A circulation route between the passport control and medical facilities should be provided which is compatible with the main arrival flow.

Immigration and Police

Passport clearance often includes, or is associated with, police inspection. The passenger flow rate can be significantly increased by immigration and police officials working in conjunction and inspecting passengers' documents together instead of consecutively. Opening passports and other documents, searching for visas and entry stamps represents a considerable proportion of the total service time. It is, therefore, a help in maintaining rapid passenger flow to reduce the number of occasions on which this has to be done. Where immigration and police control cannot be operated with simultaneous inspection the controls should be arranged consecutively on the line of the airside/landside flow route. If the service rates are different it is preferable for the inspection requiring the longest time to be placed first. Thus delays at the second control will not cause obstruction and prevent operation at the first control, and minimum distance will be required between the two controls.

The straightest flow routes are obtained when the inspection positions are entirely homogeneous and any position can be used by any passenger. However, some States require varying degrees of inspection of documents depending on the category of traffic and nationality of passengers. A faster overall flow and some economy in the number of positions can be achieved if some positions are allocated for the use only of those categories of passengers who are subject to minimal inspection. The capacity of these positions would as a result be very high, thus allowing more positions to be allocated exclusively to the categories of passengers subject to more difficult inspection and which, therefore, have a slower rate of flow. Where such arrangements are applied it is important that the positions for each category are proportionately related to, and evenly dispersed among, the parallel flow streams.

Control Authorities' Accommodation

The control authorities usually require offices, search and/or interview rooms in conjunction with the frontier control inspection points. These should be restricted to those essential for passenger processing and should be arranged on the flanks of the control position to maintain the widest unobstructed area for the controls. This ensures flexibility for future rearrangement and operational changes and the clearest, unobstructed flow routes. Search and interview rooms will probably need to ensure absolute privacy of both sound and vision. In providing this it is most important that visual continuity through the passenger flow route is not obstructed. General administration, etc., should be located elsewhere in the building.

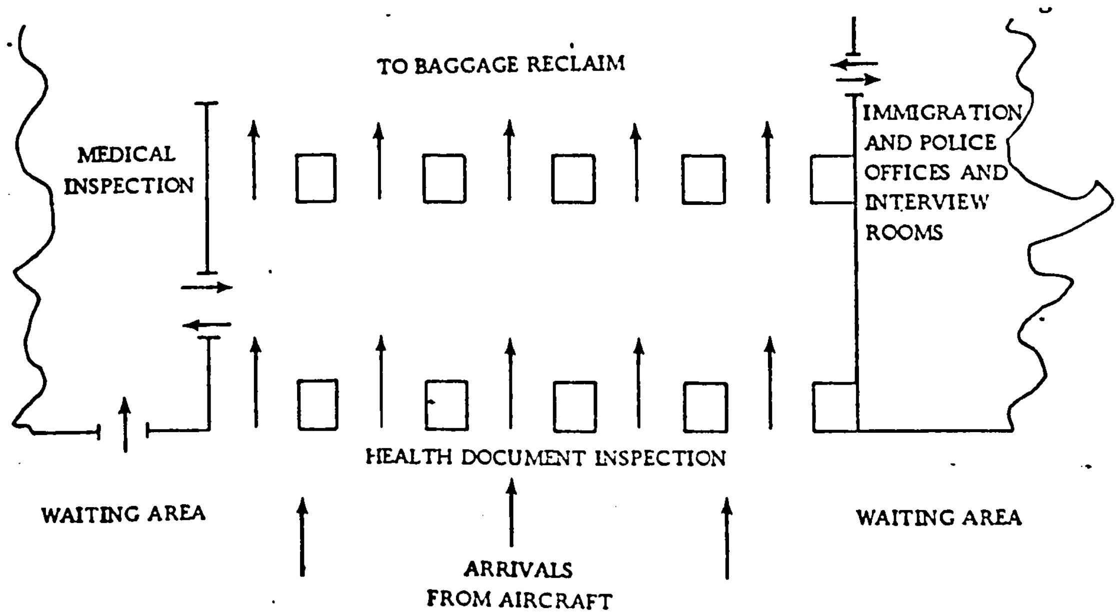


Figure 36

BAGGAGE RECLAIM

A variety of mechanical and semi-automatic systems are vailable and in use throughout the world. The guiding principle to the choice of manual or mechanical reclaim systems should be to reduce the amount of milling (random movement) of bags and people. Where the numbers of bags or passengers in the area at any one time is fairly small, simple manual systems which rely on passengers moving to their bags are satisfactory. However, this is not satisfactory when more than twenty to thirty passengers are reclaiming their baggage simultaneously.

For flow rates higher than this it is necessary to reduce the movement of passengers and this is achieved by presenting baggage on a moving display which passes in front of the passengers, i.e. some form of revolving turntable or belt. As passenger flow rates and aircraft sizes increase baggage reclaim systems should be arranged to eliminate the random movement of passengers and this can only be achieved by their remaining in the principal flow streams and baggage being presented to them. Thus the equipment should be located across the line of the flow so that passengers pass between it similarly to control combs.

Space should be provided, behind the frontier controls, and in front of the baggage reclaim, in which passengers can wait if baggage delivery from aircraft is delayed. Facilities should also be provided in the reclaim are for the storage of baggage belonging to passengers who are delayed by health or passport controls. Misrouted or unclaimed baggage should not be stored in the reclaim area. These facilities should be provided elsewhere outisde the passenger processing areas.

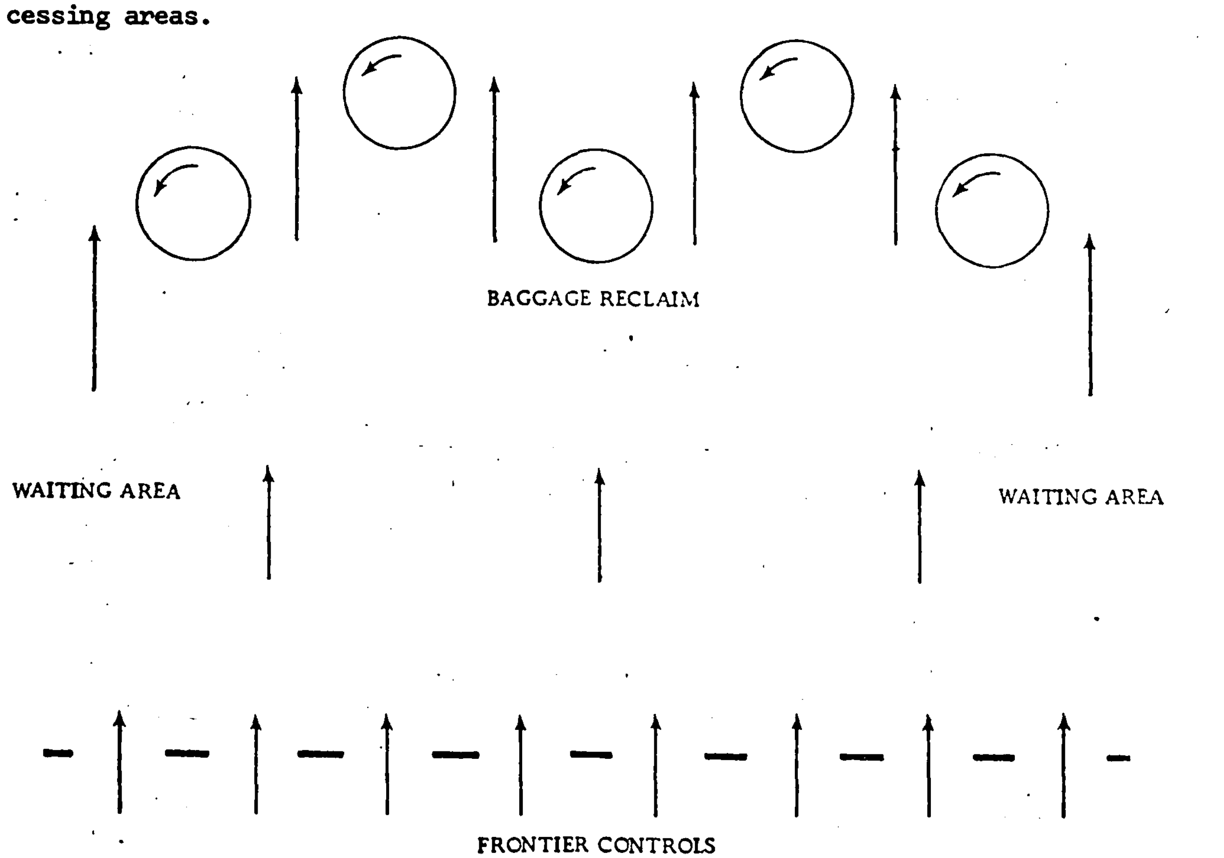


Figure 37

CUSTOMS INSPECTION

At international airports passengers flow from baggage reclaim to customs baggage inspection. Various inspection systems are possible but the choice is usually dictated by the statutory regulations to be enforced. As for all passenger controls the customs inspection positions should be arranged as a 'comb'. Flow streams through the control should be arranged in two categories - one for passengers with goods to declare and the other for those without. The streams for those without dutiable goods should flow freely past the control points and use of these streams by passengers should be regarded as a declaration that they have no goods to declare. It is possible to apply random or selective checks to these streams as may be required without interrupting the normal fast unimpeded flow. The streams in the second category should flow past customs officers in the normal way.

The number of streams required in each category should be determined by analysis of local conditions and each category should be arranged alternately over the whole width of the flow route.

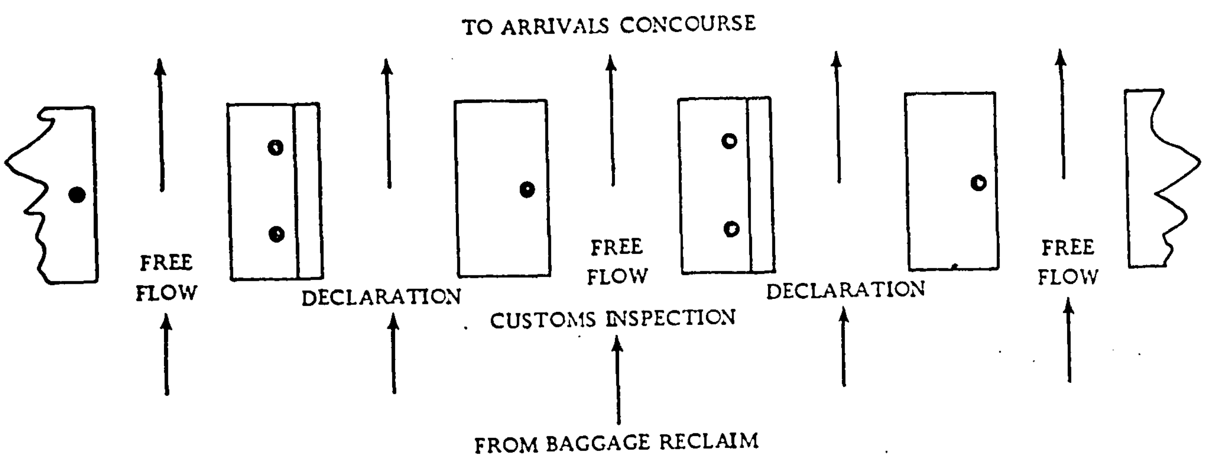


Figure 38

ARRIVALS CONCOURSE

The arrivals concourse serves two primary purposes. It is the point at which friends and relatives meet arriving passengers. It is also the point of connexion between the air and land sections of the journey. The area required for the public meeting passengers depends upon local habits and conditions. The area should be arranged so that the public cannot obstruct the free flow of passengers out of the customs inspection or baggage reclaim areas to the landside transport points. This can be achieved by providing a balcony above the flow streams and this will enable the earliest view of passengers to be provided. It should be entered from the landside boundary of the building. Arrivals flight information should be displayed in this area. Arriving passengers should flow directly to the landside exits, or to separate exits where they can be joined by people meeting them, or to an area in the concourse where such amenities as they require can be provided together with connexions to the airport terminals of public transport systems.

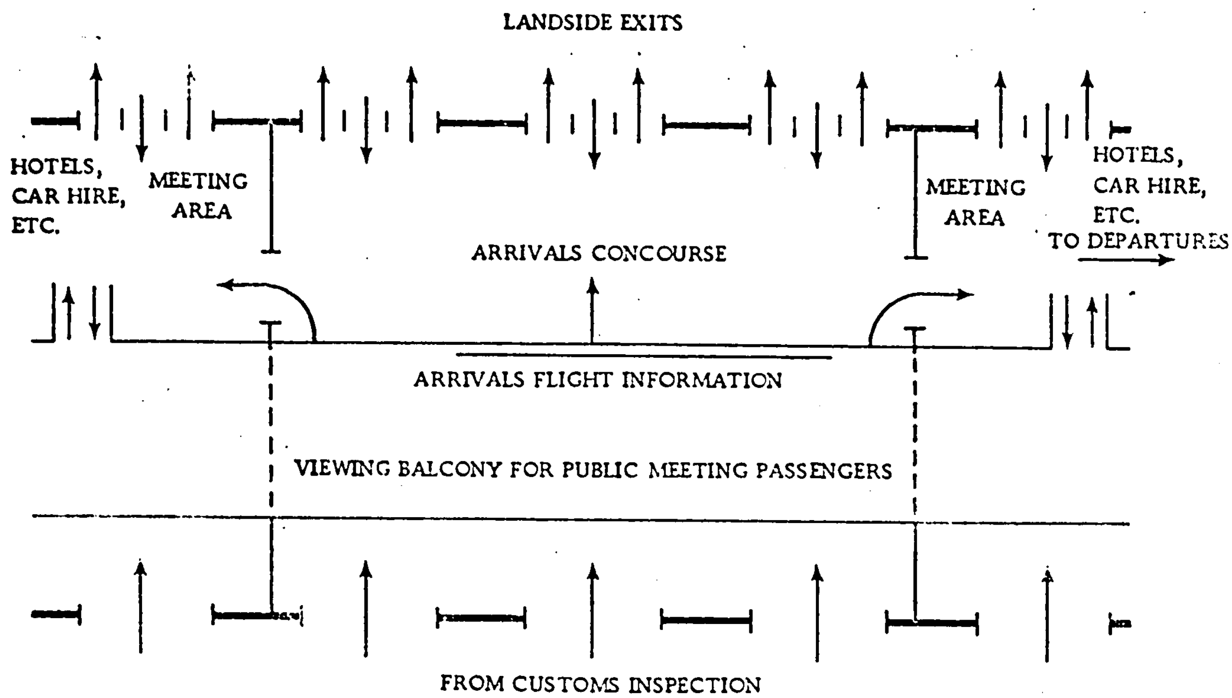


Figure 39

The amenities generally required by arriving passengers are currency exchange, hotel reservations, car hire, information and left luggage store. Connexions should also be provided to the airline ticket sales facilities in the check-in concourse.

LANDSIDE PASSENGER VEHICLE LOADING POSITIONS

Similar considerations apply as described for the departures flow. Arrivals passengers either flow directly to car parks to pick up their own vehicles, or are picked up at the passenger building landside frontage by taxis, buses, chauffeur driven cars, etc.

A waiting area is required for buses and taxis to which passengers can go to board a vehicle. Only a sufficient number of vehicles for immediate use should wait at the passenger building. A longer term waiting area should be located elsewhere to supplement the building waiting area and from which vehicles can be called up as required. For vehicles meeting specific passengers or groups of passengers, a waiting area is required in which vehicles can be left whilst drivers meet passengers in the building. After being met passengers can either go to the vehicle park with drivers or wait for drivers to collect vehicles and proceed to the front of the passenger building to pick them up. Three minutes is a sufficient occupancy period for cars picking up passengers.

However, the appropriate occupancy period for the vehicle parks is often difficult to assess because of the delays which often occur to arriving aircraft. Periods between ten and thirty munutes have been found satisfactory and should be dictated by the availability of space. The vehicle parks should be adjacent to the passenger building with good pedestrian access for drivers. Although ideally they should also be located for general passenger access, this not essential because passengers can be picked up at the front of the passenger building.

BAGGAGE

The considerations which need to be taken into account in respect of the containers and vehicles in which baggage is loaded and transported between aircraft and passenger buildings are the same as described in the departures section. After arrivals at the passenger building baggage has to be unloaded from vehicles and containers and delivered to the baggage reclaim system or transferred to the departures area in the case of some transit and transfer passengers. Sufficient space for easy manoeuvring of vehicles is requried and also for storage and removal of empty containers. A one-way vehicle flow is desirable to provide unobstructed access for vehicles arriving from aircraft. Delays in baggage handling often occur at this point and delivery of baggage to the reclaim area at the same rate as the passenger flow is one of the most important elements of airport operation.

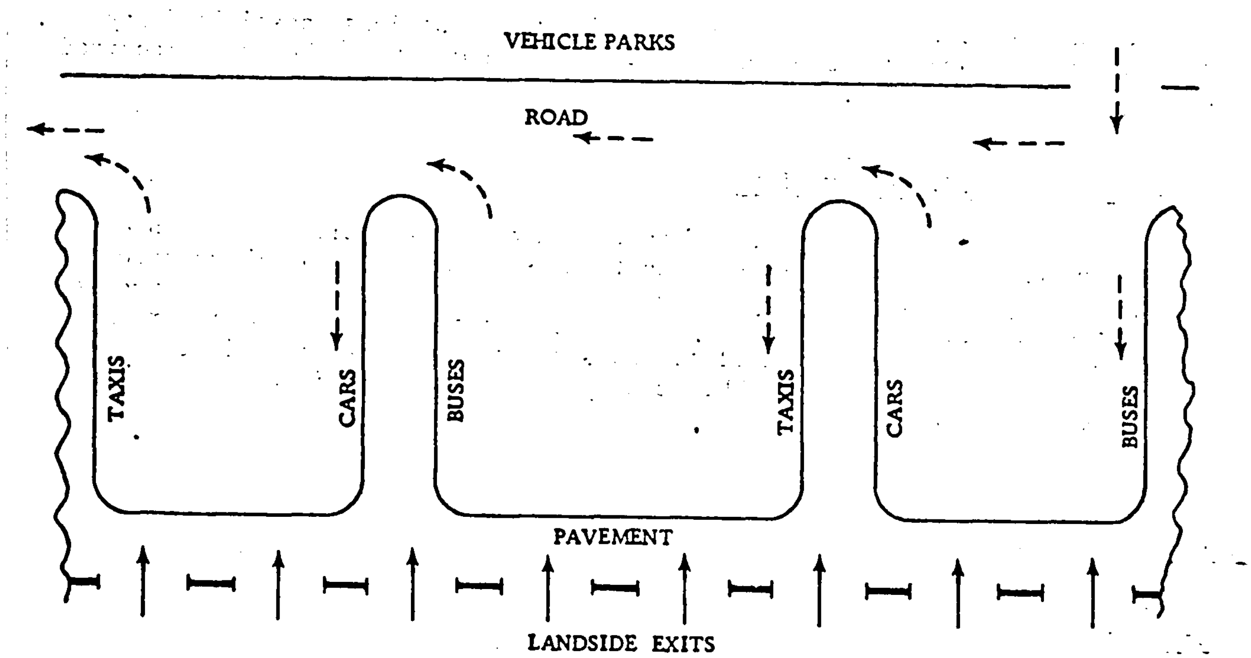


Figure 40

Transfer

Passengers transferring between flights should not have to reclaim their baggage until they reach their ultimate destination. However, passengers transferring from international to domestic flights are usually subject to customs inspection and their baggage is, therefore, treated as normal arrivals baggage and delivered to the baggage reclaim area. This also applies to transit passengers on flights changing category. The baggage of all other transfer passengers should be identified in the baggage vehicle unloading area and transferred directly to the departures baggage sorting area where it is integrated with all other departures baggage. The route and system of transfer should be as direct and fast as possible to enable passengers to connect between flights with the least possible delay. This not only improves passenger service, but also reduces the space required.for them and their baggage.

Population Centre Transport Link

The form and the system of operation of a transport link may prevent passengers carrying their baggage with them. In these circumstances a baggage reception point would be required in the arrivals concourse from which baggage should be conveyed to the transport link airport terminal for loading in the baggage vehicles. Passengers would then reclaim their baggage at the link terminal. This can apply in the case of bus services as well as more complex systems.

GENERAL FACILITIES

Offices

In addition to the functional facilities described in the preceding pages which are required for passenger and baggage processing, a number of other facilities are also required for the general administration and operation of passenger buildings. These include administrative offices for the building management, police, government control authorities, aircraft operators and public transport system operators, etc. Staff rest rooms and catering facilities are also sometimes necessary. The general principle in providing such facilities should be to restrict them to the minimum necessary for the day by day operation of the building. By this means the size of the building is kept to the minimum necessary for passenger processing, and, if the building is expanded to the optimum size, all of it would be vailable for passenger purposes. In addition the population of the building is reduced to the minimum possible and frequently the vehicle movements around the building are also reduced.

Separation of functions should be firmly applied and the passenger processing areas should only be used to accommodate those facilities which are immediately necessary for passenger and baggage processing. Other facilities necessary for the daily operation of the building to which passengers do not require access. This is normally best achieved by providing a separate floor or space adjacent to the least flexible elements of the building. Administrative offices often accommodate expensive and complex communication systems and should, therefore, be regarded as fairly inflexible features of the building.

All other offices for administrative purposes and accommodation for users of the building, including aircraft operators and the airport authority, should be sited outside the passenger building.

Plant Rooms

Passenger buildings often require considerable plant and servicing equipment for electricity, heating, ventilation and mechanical equipment and systems such as baggage conveyors, lifts, etc. It is important that such plant be located to avoid compromising the flexibility of the building, and to provide access and facilities for servicing staff and equipment which is clear of, and does not involve passage through, passenger areas.

Restaurant

A restaurant is often required for passengers who have to spend long periods at the airport because of flight delays, long connexions between flights, etc. It can also be a useful source of revenue for the airport authority. It should be sited with considerable care in order to provide a suitable environemnt and servicing access and to avoid introducing people who are not passengers into the passenger routes. This is especially important where the restaurant attracts a large clientele from outside the passenger building and/or airport. The same considerations apply as to the siting of administrative officers.

Toilets

Toilets should be located so that they are easily accessible from all parts of the flow routes. Any area to which access is controlled should contain toilets and under no circumstances should passengers be confined in any area in which toilets are not available. Water and drainage services tend to create some inflexibility in the building structure and, therefore, toilets should be located at the fewest possible points and adjacent to the least flexible elements of the building. Concentration of toilets into large units at a small number of locations is often of considerable assistance to airport managements in providing proper cleaning and supervision.

CHAPTER FIVE

THE CARGO AIRPORT

AIR FREIGHT TRAFFIC

In 1966 the U.S. scheduled airline industry flew two billion freight revenue ton-miles and earned slightly over 411 million dollars[22]. Median forecasts indicate that this ton-mile figure will increase by a factor of 10-14 by 1980. These data underscore the obvious importance of the air freight business in the development of the air transportation system.

Air freight is the fastest growing segment of the commercial air transportation system. Shippers are rapidly becoming aware of the total distribution cost concept, that is, the trade-off between higher ton-mile transportation costs and lower nontransportation costs such as warehousing, inventories and obsolescence, all of which are important factors in the overall economic system of the shippers.

In addition to all-cargo aircraft, there are the jumbo jets, which will allow large freight in the hold while carrying a full complement of passengers, and quick-change aircraft, which can be operated under passenger configurations during high-demand hours and as all-freight carriers during the night.

Increases in air freight shipments will impinge directly and adversely on the anticipated surface movement crisis. At present, 75 percent of all air freight shipments go through the major hubs. Increased volume will add appreciably to road congestion and terminal access problems and may prove to be the proverbial last straw.

Federal, regional, state, and municipal authorities, in conjunction with the air transportation industry, will have to examine in depth not only the adequacy of centralized air freight-cargo terminals in airport complexes but also concepts for pure air freight terminals located away from passenger airports yet within easy surface transportation reach of shipping centers or industrial park complexes. Any such study will also have to give full consideration to the role of future VTOL-V/STOL aircraft in freight haulage.

In point of fact, an important opportunity to make singificant improvements in the handling of freight in urbanized complexes is at hand. Since we are now considering wholly new ground transport systems for inter- and intracity passenger trave, the possibility of handling freight in such a way as to increase the economic viability of such systems should be carefully considered. The following salient factors should be borne in mind:

- New systems will tend increasingly toward fully automatic operation, a large plus factor for any freight system since labor costs can be reduced.
- Passenger transport systems are subject to severe peaking characteristics; the system is used only lightly for part of the day and is almost unused during certain night hours. Freight movements might be dovetailed into the passenger movements to increase economic viability of the system and to decrease costs for each.
- The designing of terminals and other facilities for combined passenger and freight handling will be more difficult than designing for either one alone.

Air Cargo Terminals Expansion

The evolution of air cargo terminals, based on normal growth patterns experienced before the present air cargo boom, is shown in Figure 41. Blocks 1 and 2 show a normal historic growth pattern in which passenger (PAX) terminals share space with air cargo operations. At the end of block 2, the air cargo operation is forced to depart from the passenger facility as a result of passenger traffic growth, air cargo traffic growth, or a combination that exceeds available space.

Summarization of the listed factors indicates that a case can be made for off-terminal consolidation terminals when combination of the factors results in a higher total-system cost for an on-airport complex than for an off-airport one. Some of the factors could force consideration of an off-airport complex for reasons other than economic, e.g., complete unavailability of land or heavily congested surface transport links.

In general, cost of an off-airport consolidation terminal (excluding land cost) would be similar to an equal capacity on-airport facility, less the aircraft loading system, and less surface vehicle loading systems (for transfer of unitized loads to and from the airport). Total cost for a combination of on-airport aircraft-loading facility and off-airport consolidation terminal may prove slightly higher than that of a single on-airport terminal. Despite this, other factors may force the cargo terminal off the airport.

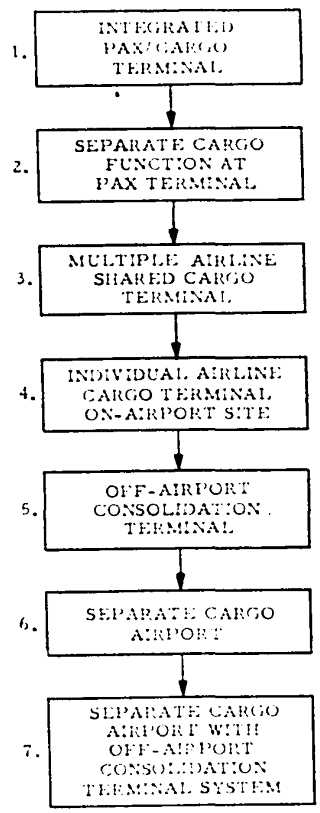
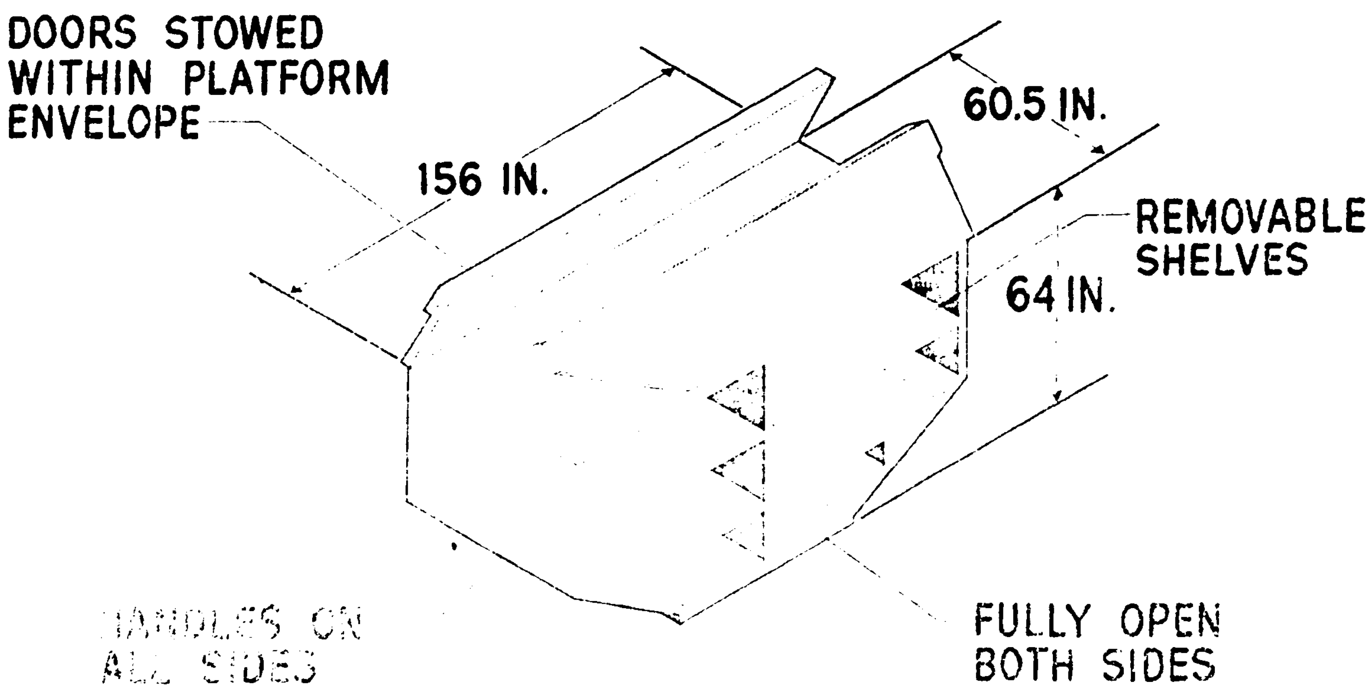


Figure 41

The shipper-to-terminal link may be improved by a centrally located consolidation terminal and could conceivably attract a considerable amount of business because of location convenient to shippers or consignees.

In evaluating blocks 6 and 7 (separate cargo airports) analysis progressively becomes more complex and may require slight modifications expanding the cost analysis. The basic model, however, is generally adequate to handle these cases, provided sufficient data are developed. Certain localities with heavy community support in attracting air cargo business are promoting all-cargo airports. During the next

BAGGAGE / CARGO SYSTEM
STANDARD CONTAINER



20 years all-cargo airport concepts are expected to become increasingly popular at high-volume locations, with some form of interest from the community, state, or federal officials.

The Separate All-Cargo Airport

Because of the good possibility that the concept of the separate all-cargo airport will be followed in certain localities, it becomes worthwhile to consider alternate ways of accomplishing this and some constraints affecting operation of an integrated cargo system.

First, if an all-cargo airport is to be developed, the decision must be made whether to start from scratch or to develop gradually a mixed operation into an all-cargo function at an existing airport. The more likely approach will be to convert airports gradually from passenger service to freight service - particularly those near metropolitan shipping points that have reached practical expansion limits for passenger service.

Second, the decision to build or convert for a separate cargo airport must be considered in light of the large "belly loads" of cargo possible with passenger-carrrying aircraft, such as the Boeing 747. Possible mixed configurations for cargo and passengers have been proposed for the same aircraft. Examples are shown in Figures 42 and 43.

These miexed configurations and larger belly loads will provide a considerably greater cargo capacity than today's passenger flights. Moreover, this cargo capacity must be filled at the passenger terminal. Operational economies of these large aircraft cannot be realized if the aircraft must make multiple stops for cargo and passenger loading. As a result, these craft will require that a significant amount of cargo still be handled at the passenger terminal complexes and will generally limit the all-cargo airport to loading and processing of air cargo consigned to freighters or to quick-change aircraft configurated for all-freight operations.

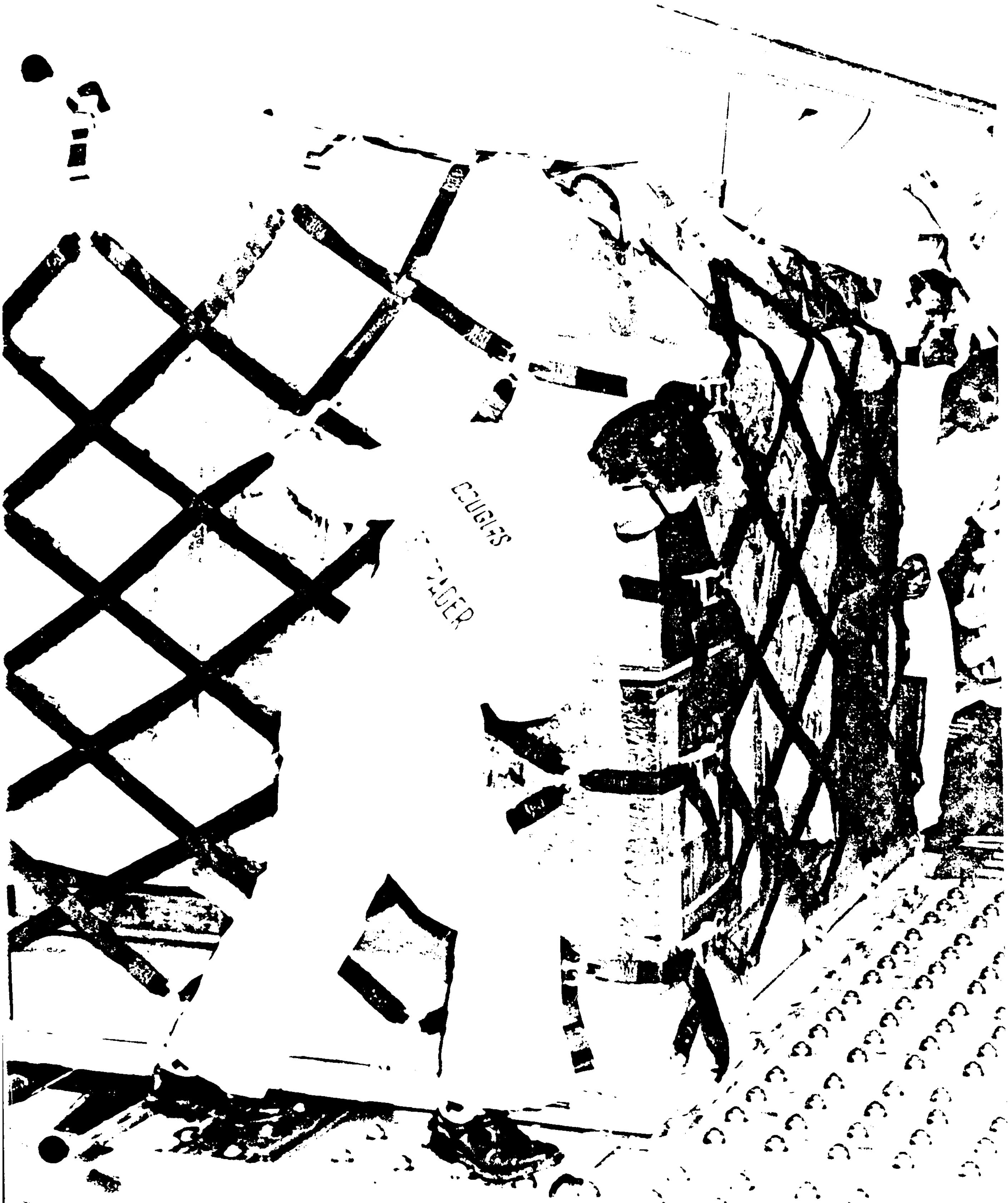
Various studies have shown that cargo revenues should exceed passenger revenues by sometime between 1976 and 1980. In other transportation modes, such as the railroad industry, a downgrading of passenger service has resulted when cargo-carrying revenues exceeded between cargo and passenger, especially as a result of the large belly-load capabilities of jumbo aircraft, must be carefully reviewed to expose the inherent problems. Indeed, the air transport system must render continuously improved service both to the passenger and to cargo. Demurrage and "in bond" cargo problems should be studied. Also, air transportation's seven-day week is a problem, since in many instances bondsmen, customs agents, and inter-facing transportation modes function on a five-day week. This disparity helps create demands for additional storage space and acts as another inhibitor to the free flow of goods.

Improved Cargo-Handling Procedures and Equipment

In addition to the expansion of facilities, it will be important for air-cargo operators to develop and install more efficient equipment and procedures for handling of cargo and attendant paperwork.

The airlines' present investment in mobile and fixed cargo-handling equipment and loaders at air-cargo terminals is high. For the most part, this equipment is especially designed to move air-shipment pallets and containers in and out of aircraft that have been designed primarily as passenger-carrying transports. Thus this expensive special-purpose equipment is tied closely to the characteristics of the aircraft that it serves. Many airlines own equipment used with their aircraft. In the future, carriers may consider pooling equipment to increase utilization, reduce costs, and permit wider distribution to airports lacking such equipment.

Alternatively, if a method can be found to handle containerized and palletized cargo from both short- and long-haul freighter aircraft, using primarily general-purpose conventional equipment such as flat-bed trailers and pickup trucks, then the investment in material-handling equipment will be greatly reduced at major terminals. Just as important, low-volume containerized shipping will be brought



within the reach of the small but steady shipper located in the vicinity of many feeder-line or nonhub terminals.

The use of rail transportation for freight deliveries would relieve surface roadway traffic in and out of airports. Many airports have rail lines leading directly to the airport property or terminating nearby that could be extended to individually owned or collectively operated air-freight terminals on the airport. Special high-speed, diesel-powered or electric trains could be employed to handle both loose bulk cargo and palletized or containerized cargo from and to off-airport locations.

In the case of loose cargo, airline collection trucks or individual shippers could deliver cargo to one of several convenient marshalling points throughout the urban area. In the simplest form, the marshalling points could consist of merely a railway siding at the proper level for easy transfer of the cargo from the truck to the railcar, and a small office or shelter for use by the agent. In more sophisticated form, the marshalling point could include loading decks to allow some presorting of cargo prior to its arrival at the airport terminal, and to allow receipt of cargo without the necessity of having a car always present at the siding during "business hours".

Containerized freight could be handled by specially equipped railcars shuttling direclty from the off-airport consolidation terminals to the plane-loading location, where cargo could be transferred directly to and from the aircraft using a minimum of real estate, equipment, and terminal facilities.

Effective capacity of existing terminals can be increased by increasing the processing rate through these terminals and onto aircraft. This can be achieved by a combination of improved material-handling equipment within the terminal and warehouses, improved equipment for safe, faster loading of large-capacity aircraft at major hubs, and initiation of new control and paperwork procedures. Computer-controlled material-handling and sorting systems, similar in function to those described previously for baggage handling, can improve air-cargo flow rates.

More significantly, high-speed transmission coupled with data processing will eliminate time-consuming paperwork at the shipment source so that paper processing can be completed while shipments are in transit. The various inefficiencies that now occur in documentation and communications in such areas as shipment tracing, routing, and rate information can be eliminated. Greater use of data systems can also enable carriers to provide customs brokers with advance data on imported shipments, thus facilitating earlier customs release. The systems can also provide real-time information on availability of space on all scheduled flights and make automatic invoicing a reality.

Figure 44 depicts a conceptual distribution system for air cargo, utilizing electronic data-processing systems for collection and distribution of information on cargo movements within the United States and overseas. Heavy block lines indicate the flow of goods. Dashed lines show information flow on cargo movements.

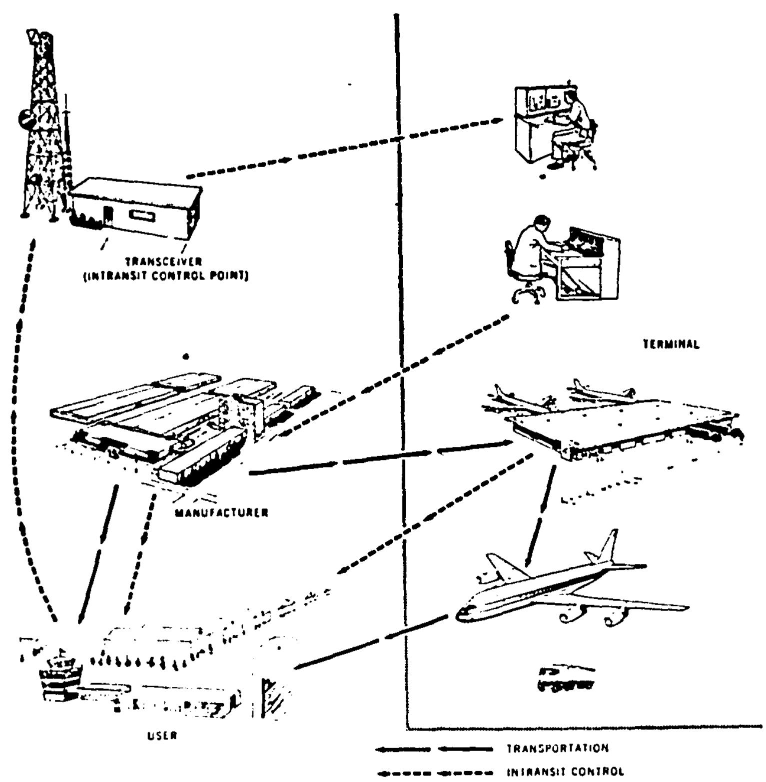


Figure 44

Improved Intermodal Compatibility

Processing capacity of air-cargo facilities can be improved by greater compatibility between different modes of transportation - aircraft, ship, truck, and rail. This will require joint industry efforts to standardize containers and container-handling equipment as is shown in Figures 45 and 46. When this has been done, shippers will have new incentives to containerize their own shipments where

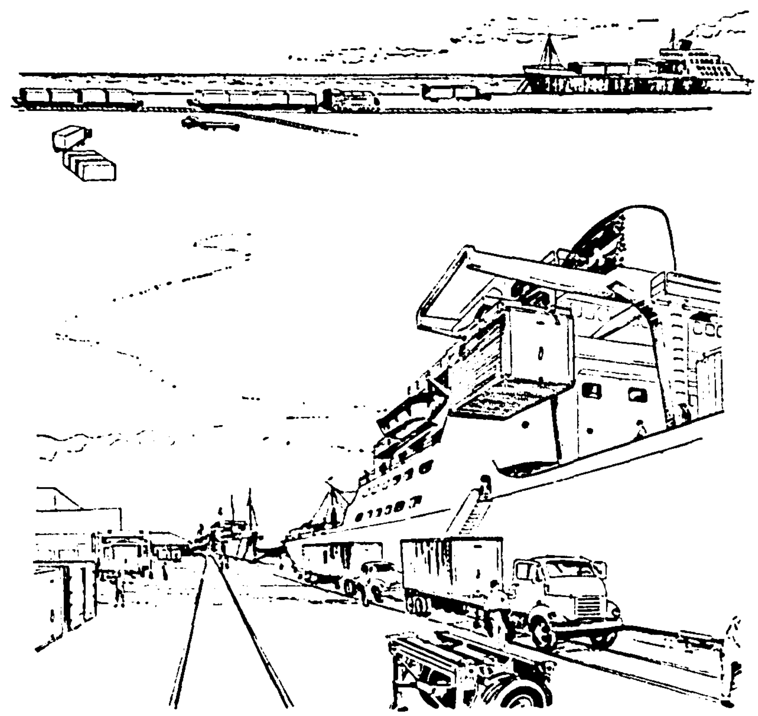


Figure 45

intermodal distribution is required, thus removing this function from the time-sensitive air freight system.

Improved Airport Access of Cargo Vehicles

Although movement of cargo in and out of airports has been discussed in previous sections it must be emphasized that monumental traffic jams will occur if the future volumes of cargo and passengers attempt to arrive or depart from the airport over existing roadways at anticipated vehicle densities.

At some airports, it is already too late to start planning and constructing new roadways in time to relieve the traffic situation. Although it would be functionally desirable to separate incoming passenger vehicle traffic from incoming truck traffic, the increased capacity achieved by this expedient would probably be slight. Under limited circumstances, capacity may in fact be reduced by separating passenger and freight traffic, since the two requirements do not peak concurrently. A more effective expedient to gain full utilization of existing

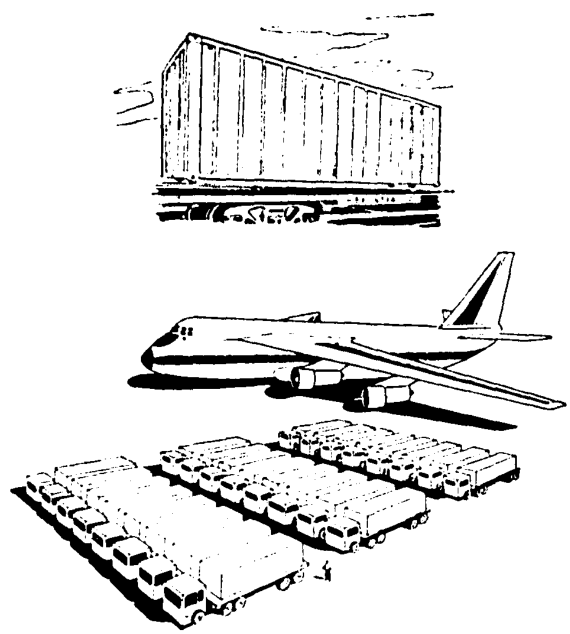


Figure 46

access and egress routes may be the implementation of skillful real-time traffic management and controls, to optimize the traffic flow according to the specific situation existing at the moment.

Other means of moving freight to and from the airport should be considered in the event that access to the airport with existing means becomes a limiting factor on terminal capacity. Flying-crane helicopters, similar to those being used for military transport (and proposed for moving the Los Angeles skybus passenger vans to and from the airport) could be used to transport cargo containers from off-airport sites. The economies of this approach will require further investigation and study.

CONTAINERIZATION SYSTEMS FOR AIR CARGO

In order to provide information necessary for optimum facility planning, it is recommended that the entire containerization problem be examined, with specific emphasis upon filling some of the gaps that now exist in containerization planning. Specific questions to be answered by such a study are as follows:

- Who owns the containers ?
- How are containers distributed to the point of need, and how is their flow controlled ?
- Can rental of containers to the shipper who wishes to do his own containerization be a profitable enterprise for air carriers ? For specialized rental companies ?
- Will a sufficient amount of container deadheading be required in the future to justify knockdown or collapsible containers ?
- Can an acceptable disposable one-way container be developed ?
- To what extent can a true intermodal capability for containerized air freight be achieved ?
- Can the different structural requirements imposed upon air containers be made compatible with the structural requirements (or practices) of sea, rail, and highway containers and container-handling equipment ?
- What is the balance between benefits in terms of potential increased revenue to airlines and increased costs which will result from weight penalties imposed by container compatibility ?
- To what extent might facilitation costs be reduced and speed of handling improved at the expense of reduced airlift efficiency ? Can aircraft afford to carry some of their own material-handling equipment ?
- What premiums can be paid for special-purpose short- and long-haul air freighters designed specifically to improve speed and ease of loading and unloading with minimum use of special-purpose ground handling equipment.

Although these recommendations for study areas of containerization touch on many aspects not specifically related to airports and terminals, the impact of such studies on service both at airports and at other intermodal transfer points is great. For this reason, facility planners should make major contributions to such studies.

CARGO TERMINALS

Basic Requirements

The following basic requirements are of particular importance in the development of the cargo terminal complex and all parties concerned should co-operate fully in implementing these requirements.

- efficient and economic handling of cargo and mail
  simple, safe and rapid traffic handling procedures for air cargo and mail
- short and direct flow of air cargo and mail
- overall functional requirements of airlines and authorities
- compatibility with airport long-range plans for future runway, road systems, ancillary airport developments, and facilities for agents, brokers and forwarders.
- clear and concise directional routing instructions for traffic arriving and departing at the terminal area

Planning Requirements

Forecasts and Planning

Realistic planning for cargo terminal facilities should be based on the best possible forecasts that the airlines can provide on future growth. This could include the relationships between import, export, and transfer cargo, aircraft payload capacities, terminal and airport capabilities. The preparation of accurate estimates of future air cargo is a somewhat complex task since it involves not only industry-wide growth patterns but also estimating the development of air cargo to and from individual airports. It also involves consideration of seasonal and peak traffic volumes and future trends in the average number of packages and average weight and volume of consignments.

At the outset, it is of prime importance to determine where the responsibility lies for planning and for subsequent development of the cargo terminal. Such planning data must be obtained from the airlines and should form the basis for the planners in preparing a realistic estimate of the scope of the project.

Space Formula

It could be misleading to present a general formula for converting forecast cargo traffic volumes into physical space requirements because of large variations in local conditions, such as delivery patterns, storage times in terminals, use of pallets and containers, use of all-cargo aircraft, ratio between domestic to international traffic, and different handling systems, used. Nevertheless, it is extremely important for the planners to get the best possible indication of total space requirements at the earliest possible stage. Therefore, some sort of formula should be developed, based on daily and/or hourly peak volumes of air cargo, for each particular location where new cargo terminal facilities are being considered. The preparation of a formula should be done jointly where the facilities are to be used by more than one airlines.

Siting of Terminal

In choosing a site for cargo terminal and supporting facilities, the following factors should be taken into account if cargo operations at airports are to be efficient and future problems are to be avoided:

- the site should be in accord with the long-range master plan for the entire airport which should be reviewed and up-dated at periodic intervals
- sufficient area should be provided to meet requirements for existing facilities planned initially and future expansions for the next 20 years
- the site should be adequate to accommodate new or planned aircraft, as well as enlarged cargo terminals and facilities required to handle large volumes of cargo, and to implement new automated handling concepts
- the site should be easily accessible from existing and future ground transportation links

- taxying distances for aircraft should be as short and direct as possible
- the positioning of the terminal should take into account prevailing winds during inclement seasons.

Operating Levels in Cargo Terminals

In the past, most cargo terminals have been designed around a single level operation, but the design of new equipment has made it possible to employ systems to utilize vertical storage of cargo, therefore requiring higher structures. Furthermore, large capacity aircraft may necessitate second level loading or nuloading directly to, or from, the cargo terminal or elevated cargo dock loading facilities at the cargo terminal. These developments hold particular interest where difficulties exist for horizontal expansion or where vertical expansion is more economic.

Cargo Flow

Cargo Flow Principles

The following basic requirements should be satisfied in the design and layout of the cargo accommodation and facilities:

- cargo aircraft should be loaded and unloaded at the cargo terminal
- the flow of cargo to and from aircraft and of transfer cargo between aircraft should be smooth and uncomplished
- distance between the various points in the flow sequence should be as short as possible
- direct access between passenger aircraft apron and cargo terminal is necessary
- access to the cargo terminal from both the apron (air-side) and the road (land-side) should be direct, convenient and under cover
- physical barriers between handling areas for the import and export of air cargo should be avoided where possible to permit maximum flexibility in utilizing available space in the cargo terminal, particularly with

respect to storage areas

- adequate provision should be made for the handling of large containers and pallets between trucks, cargo terminals and aircraft.

AIR CARGO BUILDING

FUNCTIONAL FLOW OF GOODS AND DOCUMENTS (OUTBOUND)

Documents	Action	Goods
Letter of Instructions Export Declaration (Licence, etc.)	↓ SHIPPER	to Agent or to Reception Area of Airline's Warehouse
Issuing of AWB Completion of Export Declaration	↓ AGENT AIRLINE	Checking of Weight/Packing Labelling
Clearance Processing of Export Decl. Examination (Sampling System)	↓ CUSTOMS AGENT AIRLINE	Customs Check Point for Bonded Area Airline's acceptance check point (if received from Agent) Examination (Sampling System)
Check and final Completion of AWB (Routing Booking Special Cargo) Distribution of AWB copies	↓ AIRLINE	Assembly in Warehouse according to Flight Destination
Final Release to appropriate Flight Completion of Manifest Running off copies	↓ AIRLINE	Loading Area Tally against Manifest/Load List and Assembly on carts/bins/pallets
Preparation of Flight Doc. (AWB/Manifest copies) (a) for Customs File (b) for ship's bag on board a/c	↓ AIRLINE CUSTOMS	Conveyance to aircraft Customs Supervision (Load check)

NOTE: This is the anticipated maximum requirement; in practice, the actual requirements at certain airports are already less.

Figure 47

Cargo Flow in Cargo Terminals

The efficient handling of air cargo is largely dependent upon the flow patterns within the cargo terminal. An illustration of the flow characteristics through the cargo terminal is shown in Fig. 19. However, this does not include functional details, but only the broad principles for achieving a continuous and direct flow of air freight within the cargo terminal.

Cargo Documentation and Processing

The movement and processing of air cargo is of great importance to the overall efficiency of the cargo handling process. Functional flow diagram for both inbound and outbound documents and goods are illustrated in Figs. 48 and 49.

AIR CARGO BUILDING

FUNCTIONAL FLOW OF GOODS AND DOCUMENTS (INBOUND)

Documents	Action	Goods
Doc. (AWBs/Manifest) to Cargo Office Check for completeness of Doc.	↓ AIRLINE	To Reception Area (Bonded) Numerical Check
Sorting and Distribution of AWBs and Manifest copies (Import/Transfer)	↓ AIRLINE	Breakdown and Segregation of Import and Transfer Cargo
Issuing of Transfer Manifest/Customs Doc. (in Bond Doc., etc.)	↓ AIRLINE CUSTOMS	Transfer Cargo conveyance to proper place (Export Section/other airline)
Completion of AWBs with Customs/Airline Rotation No. Flight Nr. and Date	↓ AIRLINE CUSTOMS	Physical check (Identification) of Import Goods against Doc. (Manifest AWB Copy Load List Customs List)
Sorting of AWBs for processing (Brokers/Special Cargo, etc.) Notification to consignee/ Delivery of AWB to Broker	↓ AIRLINE	Storage/Packing in Bonded Area according to Consignee/Broker and Nature (Special Cargo – Perishables – Cold Storage, etc.)
Preparation and Filing of Entry with Customs Examination (Sampling System)	↓ BROKER AIRLINE CUSTOMS	Conveyance of selected items to Examination Area (Sampling System)
Release Check/Stamp Preparation of Doc. for Delivery/ Reforwarding	↓ AIRLINE CUSTOMS	Customs Release Check Withdrawal of Goods from Bonded into Cleared Cargo Area/Delivery to Consignee/Reforwarding

Figure 49

Government Control

In the planning of cargo terminals, consideration should be given to the governmental requirements. However, excessive governmental Controls can drastically affect the ability of the cargo terminal complex to handle efficiently large numbers of consignements at a given time. Therefore, the application of government Controls should be kept to the absolute minimum and any such Controls

DIAGRAM OF FLOW IN CARGO TERMINAL

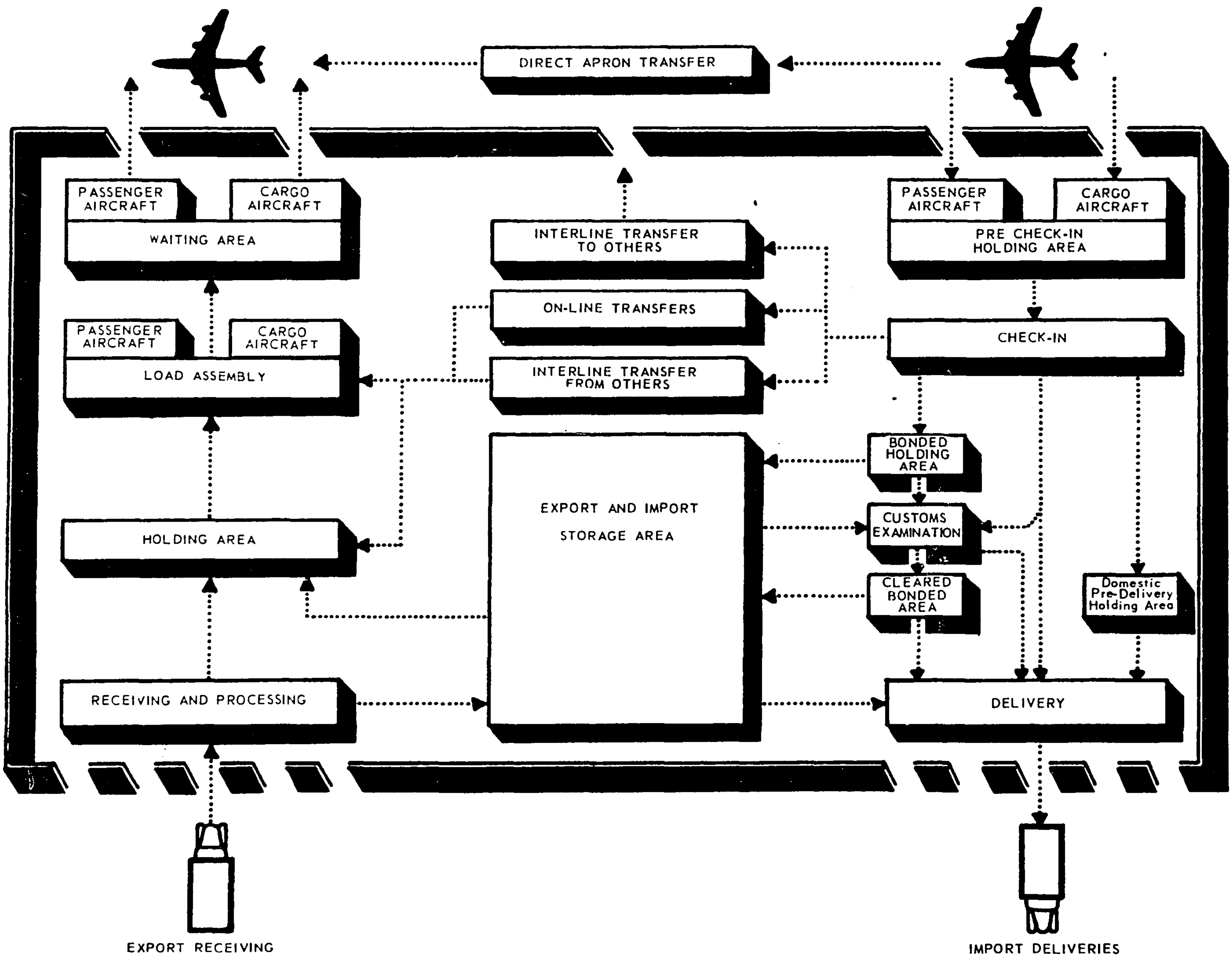
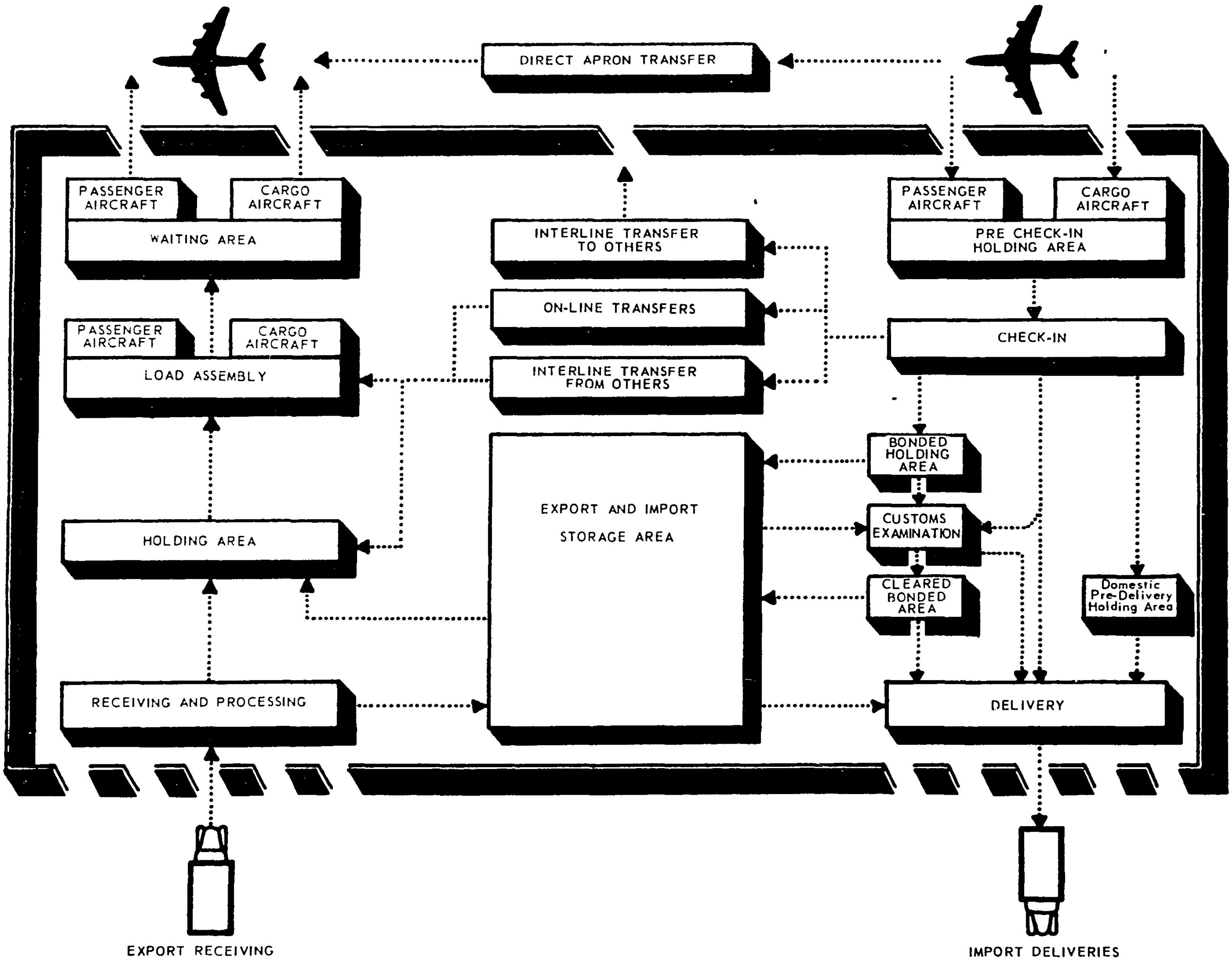


DIAGRAM OF FLOW IN CARGO TERMINAL



should be so applied as to permit the airlines to introduce the most efficient system and thereby assuring a direct and continuous flow of air cargo through the cargo terminal.

Any government Controls should be fully compatible with the flow pattern and handling concepts established by the airlines. Therefore, the overall importance of Customs Control and its great influence on the flow of goods in and through the cargo terminal cannot be over-emphasized. Consequently, architectural design and layout of the cargo terminal should be based on the most efficient government Controls and clearance procedures.

To ensure direct and continuous flow through the cargo terminal for both outbound and inbound shipments with a minimum of delay for clearance, the following basic requirements should be observed:

General- Customs Control and clearance procedures should be fully compatible with the operational activities of the airlines.

Outbound - No general physical Customs check should be imposed, either on acceptance or upon loading. In case of odcumentary Control, there should be a systemwhich will ensure Customs final release at the moment the goods are being delivered from the agent to the airline, so that there will be no subsequent check or examination. In any two systems (documentary or physical Control) the practice of post clearance. i.e. to file with Customs subsequently after departure of the goods, should be made applicable to the fullest extent possible.

Inbound - Only one check with Customs should be required when the goods are being released for consumption or reforwarding in bond via surface. During flow cargo should be supervised visually in the bonded area. Clearance operations should be speeded up as much as possible by introducing procedures for low value shipments and bulk shipments (provisional entry for immediate release). Special clearance facilities should be available for urgent shipments such as pershables, livestock, newsreels, press photos and newspapers.

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non-structural nature. Entrances to the cargo terminal should also be sufficient in number, location and size to ensure compatibility with the type of mechanical handling system used. Gangways should be provided at the side of these entrances to allow for personnel movement and manual handling.

In the case of a cargo terminal with a raised floor for the handling of air cargo which, due to its size or nature, cannot be moved through the normal process, provisions should be made both for separate entrances on the land-side and for vehicles to proceed to the ground floor level of the building by means of inclined roads (with gradients not exceeding 1 in 10) on both sides of the building. Where space for these is not available elevating platforms of lifting the vehicles and their loads should be provided.

While it is not intended to provide detailed advice on design and construction, the following design characteristics are considered important:

Basic Areas - The building should contain, as necessary, the following sections:

- segregation area
- airlines' storage area
- airlines' Customs examination and repacking area
- airlines' cleared and delivered area
- a commonly used through-channel to facilitate the continuous flow of perishable goods to the cleared area

Dimensions - The shape, height, width and length of the cargo terminal should be subject to detailed study according to the local circumstances, but should take account of at least the following factors:

- the flow routes or channels for the movement of air cargo should be as short as possible
- structural design should allow for the possibility of providing a further floor level for offices
- the height and overall design of the cargo terminal should allow for the

maximum possible use of mechanical handling systems and their extensions as the volume of air cargo handled develops

- the width (depth) of the cargo terminal should be dependent upon the volume of air cargo handled and the capacity of the aircraft

Flow - The design should conform to the functional flow and be consistent with the flow patterns shown in Figs 48 and 49.

Canopy - The canopy should be designed to afford maximum protection from rain and snow during loading and unloading operations. The vertical clearance of the canopy should be no less than one and one-half feet over the maximum truck height. The projection of the canopy in relation to its height must be determined by local weather conditions. The canopy drainage should be designed to avoid water shed on parked trucks

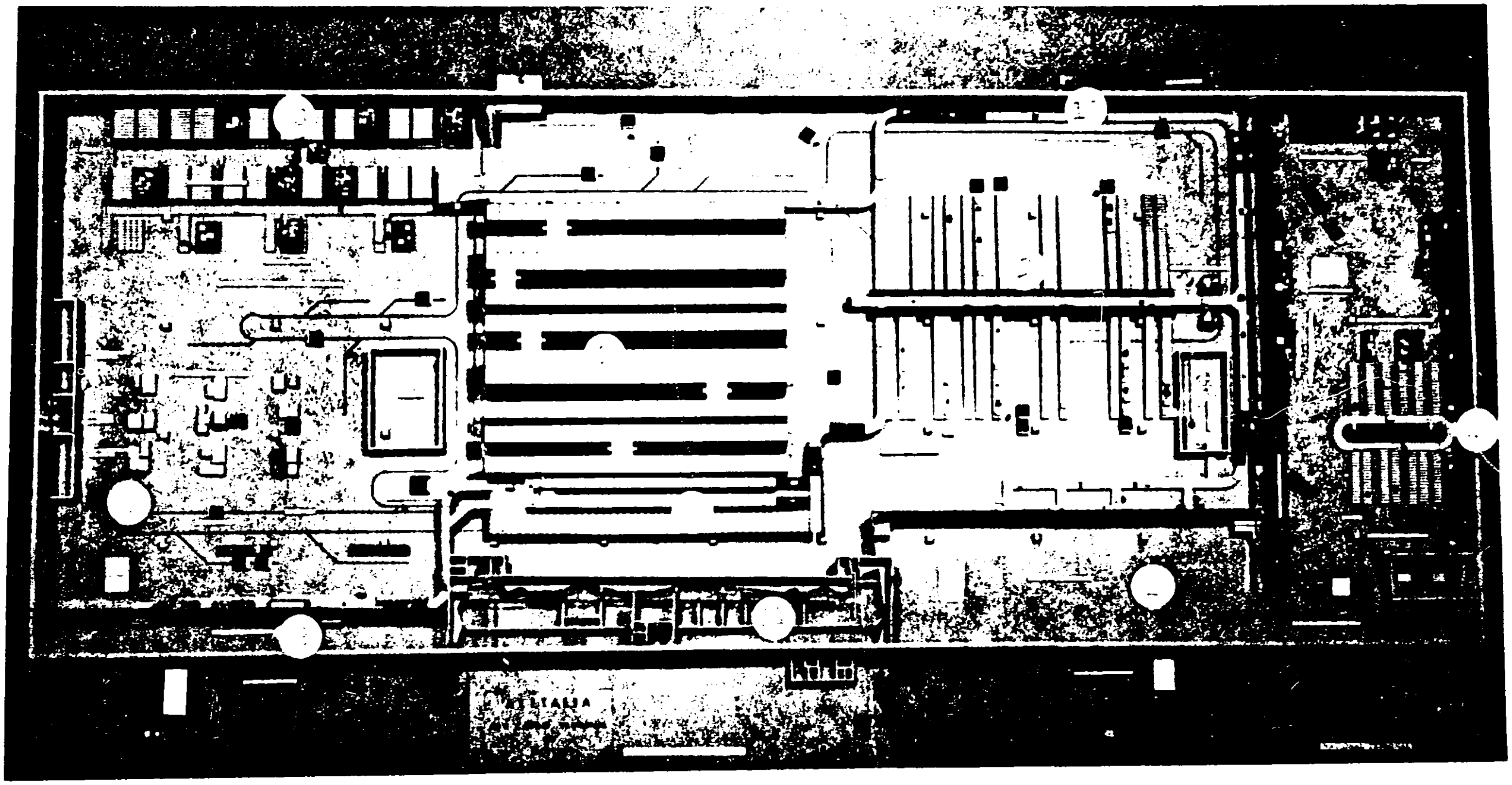
Doors - The cargo terminal design should provide for a maximum number of door positions on both land- and air-sides. On the land-side, each door should be of sufficient height and width to accommodate the largest trucks which will be receiving and delivering air cargo at the facilities. On the air-side, each door should be of sufficient height and width to accommodate large cargo handling equipment, including unitized cargo loading systems. Unused door positions should be closed with non-structural wall to facilitate subsequent installation of doors as desired. Doors must be designed to maintain maximum possible verical and lateral clearance in the open position. Vertical bumpers must be provided to protect jambs and tracks from damage. The type of doors to be used may be one of two

- manually or power-operated, counter-balanced overhead doors
- according type doors

The type of door to be used is dependent upon a number of local factors and should be the subject of consultation locally with the operators concerned. Where overhead doors are provided, consideration should be given to providing small personnel doors built into each overhead door in those cases where there

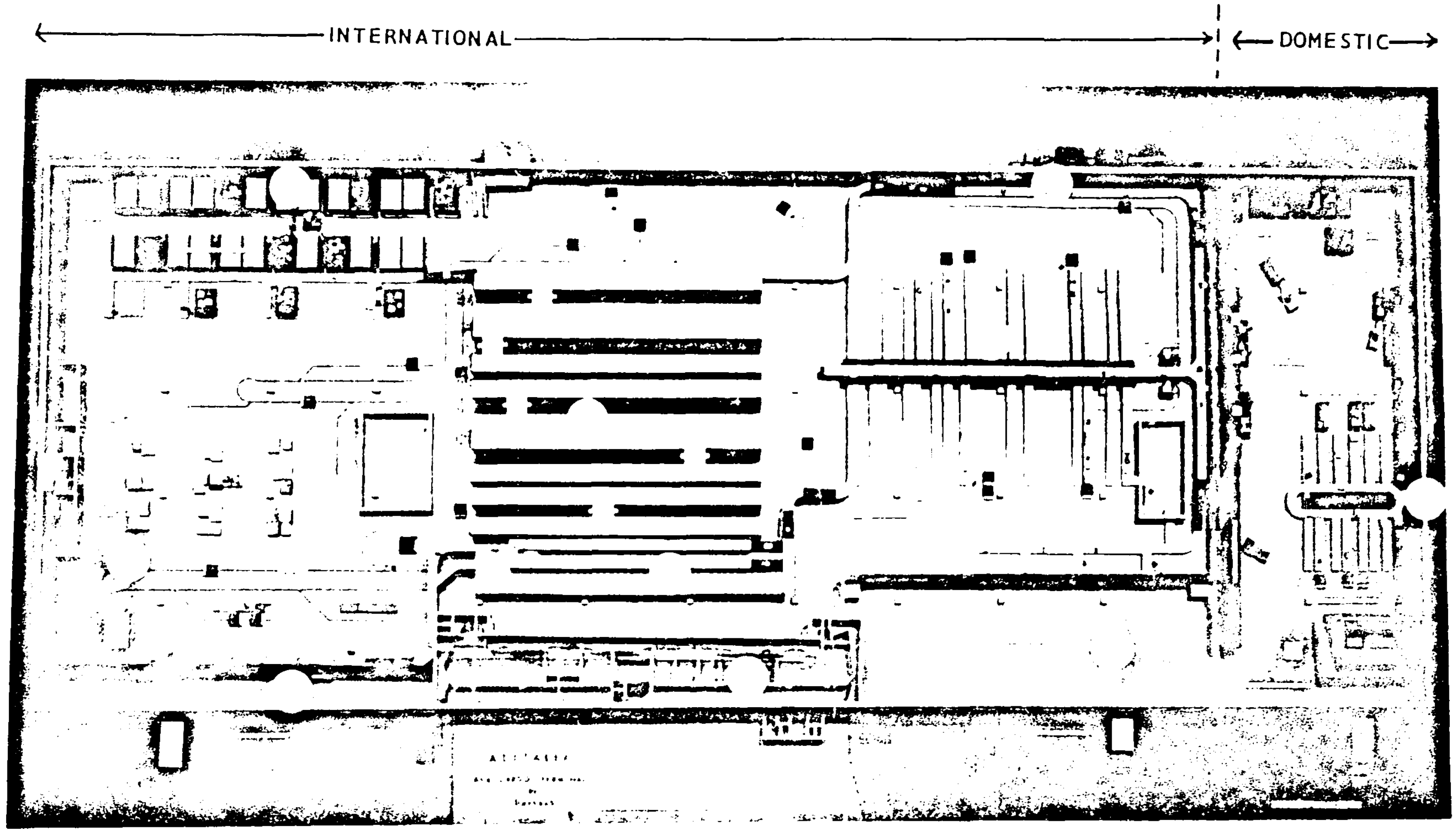
ALITALIA CARGO TERMINAL - FIUMICINO AIRPORT, ROME

← INTERNATIONAL → | ← DOMESTIC →



1. Export receiving
2. Import deliveries
3. Automatic sorter
4. Carousel sorter
5. Stackers
6. Order picker
7. Towline
8. Pallet handling system
9. Apron cart build-up area
10. Apron cart off-load conveyors
11. Special storage and customs area

ALITALIA CARGO TERMINAL – FIUMICINO AIRPORT, ROME



1. Export receiving
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3. Automatic sorter
4. Carousel sorter
5. Stackers
6. Order picker
7. Towline
8. Pallet handling system
9. Apron cart build-up area
10. Apron cart off-load deliveries
11. Special storage and customs area

is insufficient space to accommodate a personnel door otherwise. Consideration should be given to the possibility of covering door positions with "air curtains" or similar equipment, such as overhead blowers, in order to maintain temperature within the cargo terminal.

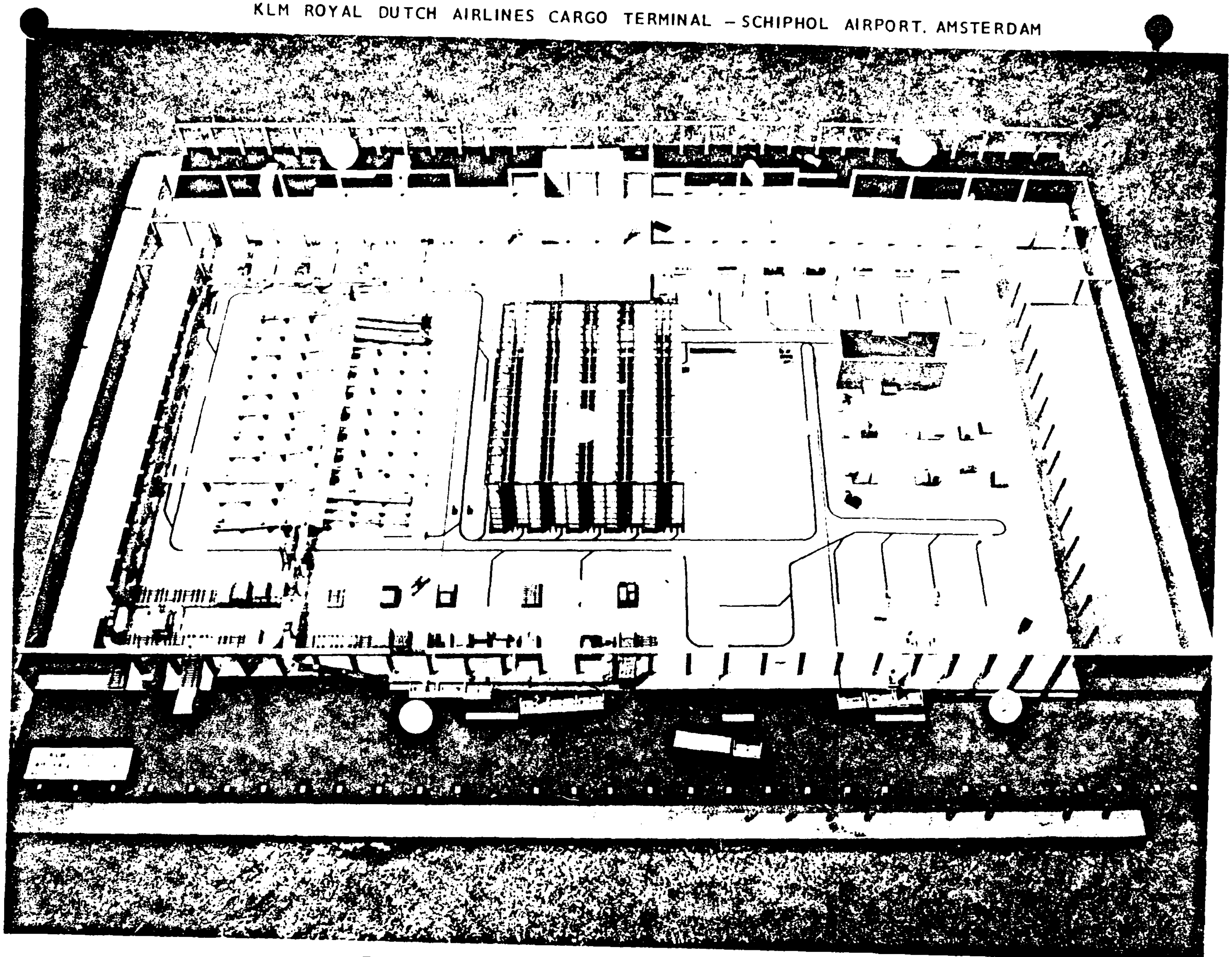
Clearance Height - The clearance height inside the cargo terminal will be determined by the handling and storage systems or requirements of the users. The clearance height is the height which should be maintained below heaters, ducts, pipes, lighting fixtures, etc.

Floors - The relationship between the ground fllor level of the cargo terminal and the pavement level for trucks on the land-side should be obtained by topographical conditions or by grading, but in no case by the use of wells. There may also be provision for built-up ramps or lift devices, such as 'levelators', to facilitate the accommodation of low-bed vehicles. On the air-side of the building the level of the floor should be determined in consultation with the operators in the light of local circumstances, taking into consideration at least the following points:

- the method of movement of air cargo between cargo terminal and the aircraft
- the movement of air cargo between carriers' areas (interline traffic)
- the growing use of unitized load systems, requiring the minimum of handling operations and changes of level. In particular cases where a difference of level is requested for use of special equipment, a straight-in access to the cargo terminal should be maintained for carts and trucks, by way of a ramp whose slope should not exceed 5 per cent. In general, there shall be no platform installed between the cargo terminal doors and the edge of the dock. However, where sufficient doors are not available, platforms may be necessary to facilitate loading and unloading of trucks.

Each floor should be of such a type that is is capable of supporting regularly the maximum weights of cargo foreseen in the cargo terminal and shall take into account the highly concentrated wheel loads associated with mechanical

KLM ROYAL DUTCH AIRLINES CARGO TERMINAL – SCHIPHOL AIRPORT, AMSTERDAM



1. Export receiving
2. Import deliveries
3. From arriving aircraft
4. To departing aircraft
5. Sorter
6. Automatic storage (stacker)
7. Pallet build-up area
8. Oversize and overweight storage

operations. The floors should be level and free of any raised projection, e.g. door tracks should be recessed. Floors should be a smooth trowelled finish with an application of a surface hardener. Where necessary, floor drains should be provided to facilitate washdown and drainage. Users must determine the requirements for slab depressions to accommodate scales, materials handling systems, etc. It may be desirable to enclose such depressions with knock-out panels. The expansion joints in the floors should run diagonally and not parallel to the flow of traffic

Illumination - The level of illumination in all working areas must be adequate for reading necessary documents and marks and labels on packages, and there should be lighting externally at each doorway and along the docks. For daytime working the fullest use should be made of natural light. Adequate illumination is also essential for the adjacent apron and roadways

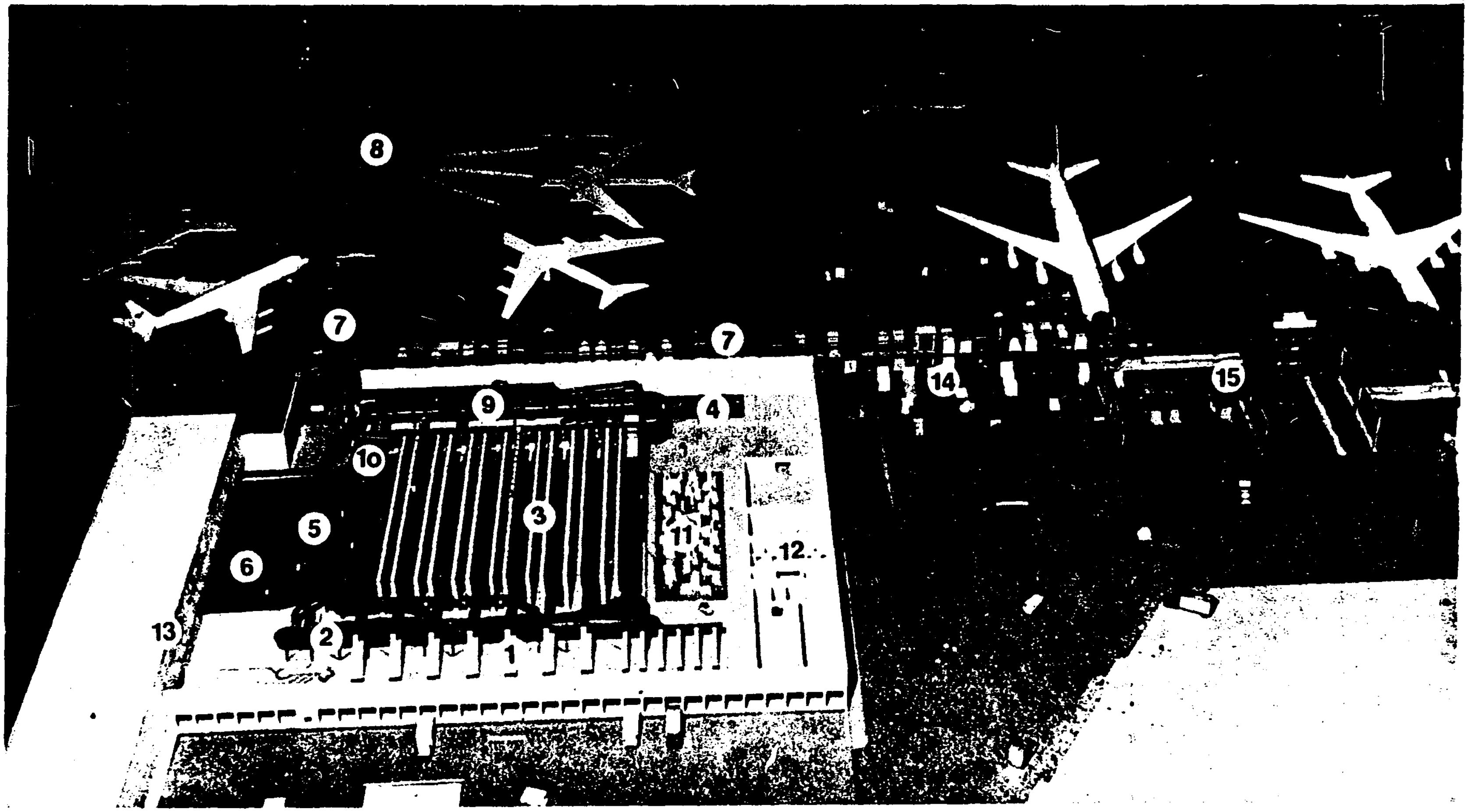
Access - Steel ladders should be installed between doors or bays to provide easy access from truck apron level to terminal floor level, and they should not project beyond the face of the door bumpers. Personnel and customer entrances should be provided with steps which should be of prefabricated steel type in order to facilitate a move incase it is desirable to relocate them

General - Adequate office, lavatory rest-room, canteen, clothing/locker room and wash-room facilities should be readily available. The type and extent of this accommodation should conform to the general airport standard

The cargo terminal should be constructed with the minimum number of internal supports which, to the extent possible, should not interfere with the internal movements of vehicles

Space on the land- and air-sides should be adequate to allow for the loading, unloading, manoeuvring and parking of vehicles and the lifting of equipment and should take into consideration the longest vehicle which is likely to be used

LUFTHANSA CARGO TERMINAL - FRANKFURT AIRPORT



1. Export receiving / import deliveries
2. Export sorter
3. Import stackers and gravity export freighter three-level accumulation piers (between stacker rows)
4. Pallet build-up on lower level; pallet break-down on upper level
5. Passenger aircraft sorter
6. Gravity passenger aircraft accumulation piers
7. Pallet and freighter-belly feed conveyors and two-level pallet storage
8. Loading fingers with pallet pre-staging positions
9. Primary sorter for arriving cargo
10. Order picker
11. Heavy goods area
12. Facilities for special cargo
13. Offices, Customs and appraisers area
14. Boeing 747 container acceptance and discharge
15. Craning facilities for Boeing 747 containers

A bulk weighing facility (weighbridge) should be provided, if necessary

The cargo terminal should be of economical construction and should be fireproof.

The building must comply with local fire regulations

Guide lines should be provided for truck manoeuvring; such lines shall start at each door edge, continuing down the face of the dock to the pavement, and extend on the pavement away from the building to a length equal to the largest truck normally servicing the facility. These guide lines should correspond with the width of the doors

Docks should have rubber track bumpers installed along the face so as to absorb the shock of a truck bumping the dock when backing into position. There should be a minimum of two 36 in. (90 centimeters) bumper per door.

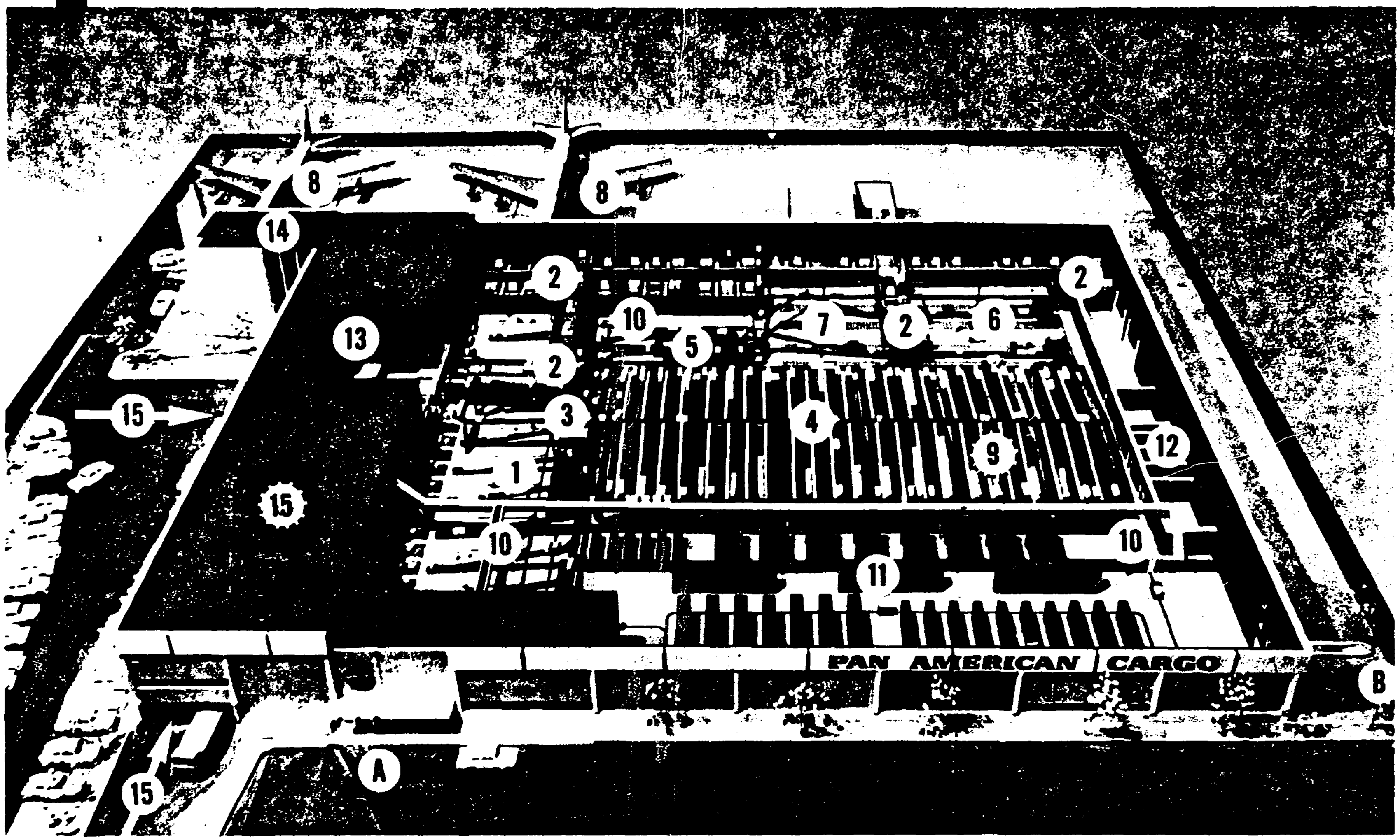
Space requirements

There are two principal factors which will govern the actual space required in the cargo terminal and the layout of this space. One is the rate of flow, which will depend upon the handling system employed and the cargo carrying capability of passenger and all-cargo aircraft, including frequency of services. The other relates to the future storage requirements in the cargo terminal which is a feature depending heavily upon the procedures used by airlines in preparing goods for shipment and delivery, and the implementation of new procedures as the volume of air cargo increases.

The planning of space requirements in cargo terminals is a complex matter which calls for careful study. For example, although rapid and continuous movement of air cargo is a desirable objective, certain interim waiting periods may be imposed during the flow process. Such interruptions must be clearly foreseen and appropriate holding space provided as necessary.

As a guide to basic space requirements in cargo terminals, the following points should be taken into consideration:

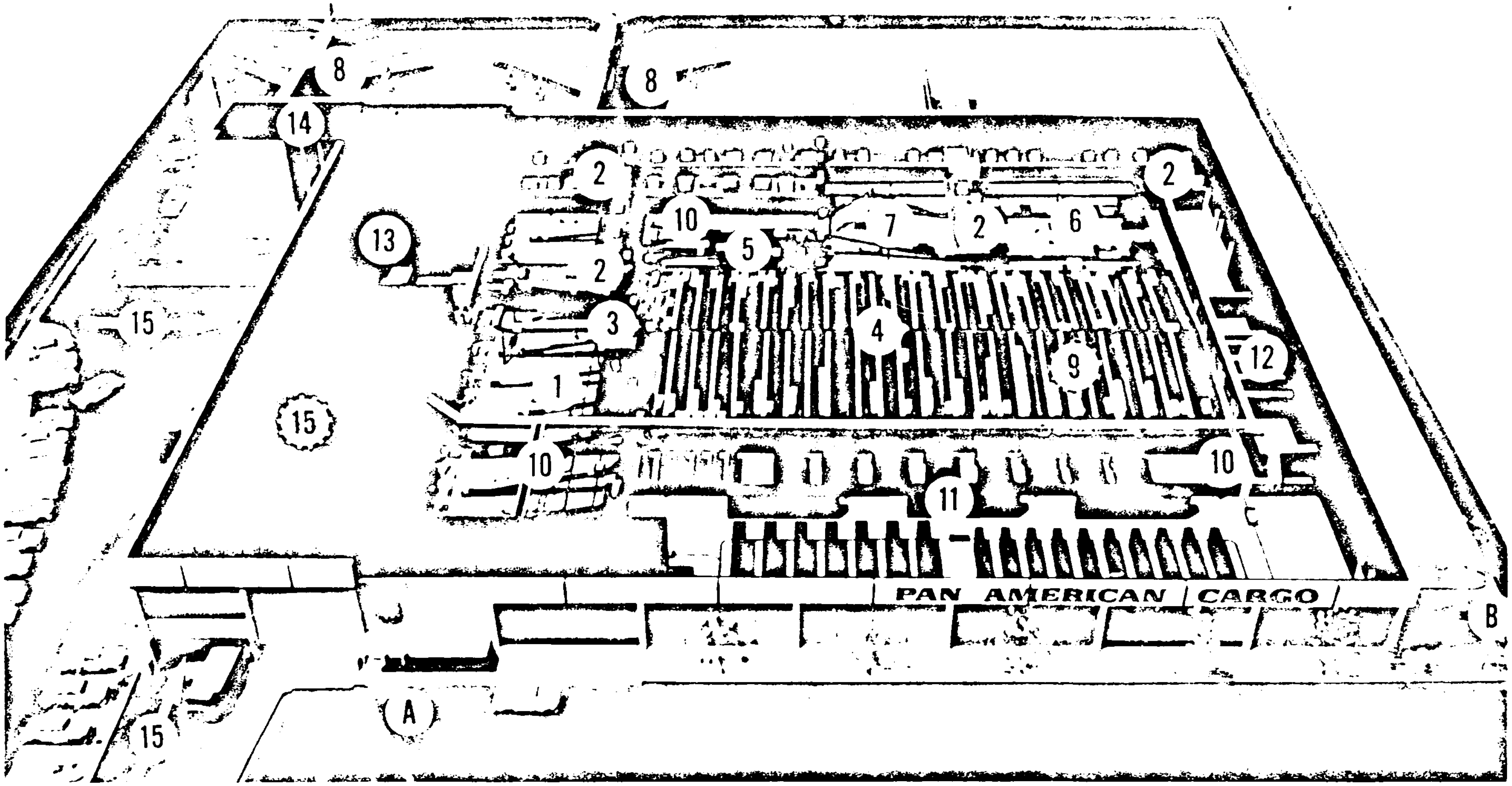
PAN AMERICAN WORLD AIRWAYS CARGO TERMINAL – J.F. KENNEDY INTERNATIONAL AIRPORT, NEW YORK



1. Receiving conveyors
2. Roller conveyors (elevation 11 ft.)
3. Sorting station (elevation 13 f t.)
4. Gravity flow storage racks
5. Checking station
6. Roller conveyors (floor level) – pallet make-up for export
7. Roller conveyors (floor level) – pallet break-down after arrival
8. Loading fingers
9. Export holding towlines (floor level)
10. Part of towline network
11. PAA company supply storage area
12. Compressor room, electrical switchgear, shops, animal room, refrigerated room
13. Offices, training area, aircraft simulators, cafeteria (two levels)
14. Customs and appraisers area
15. Covered trucking concourse

A. Employees' entrance
B. Supply receiving

PAN AMERICAN WORLD AIRWAYS CARGO TERMINAL – J.F. KENNEDY INTERNATIONAL AIRPORT, NEW YORK



1. [illegible]
2. Roller conveyors (elevation [illegible] ft.)
3. Sorting station (elevation [illegible] ft.)
4. Gravity flow storage racks
5. Checking station
6. Roller conveyors (floor level) – pallet make-up for export
7. Roller conveyors (floor level) – pallet break-down after arrival
8. Loading fingers
9. Export holding towlines (floor level)
10. Part of towline network
11. PAA company supply storage area
12. Compressor room, electrical switchgear, shops, animal room, refrigerated room
13. Offices, training area, aircraft simulators, cafeteria (two levels)
14. Customs and appraisers area
15. Covered trucking concourse

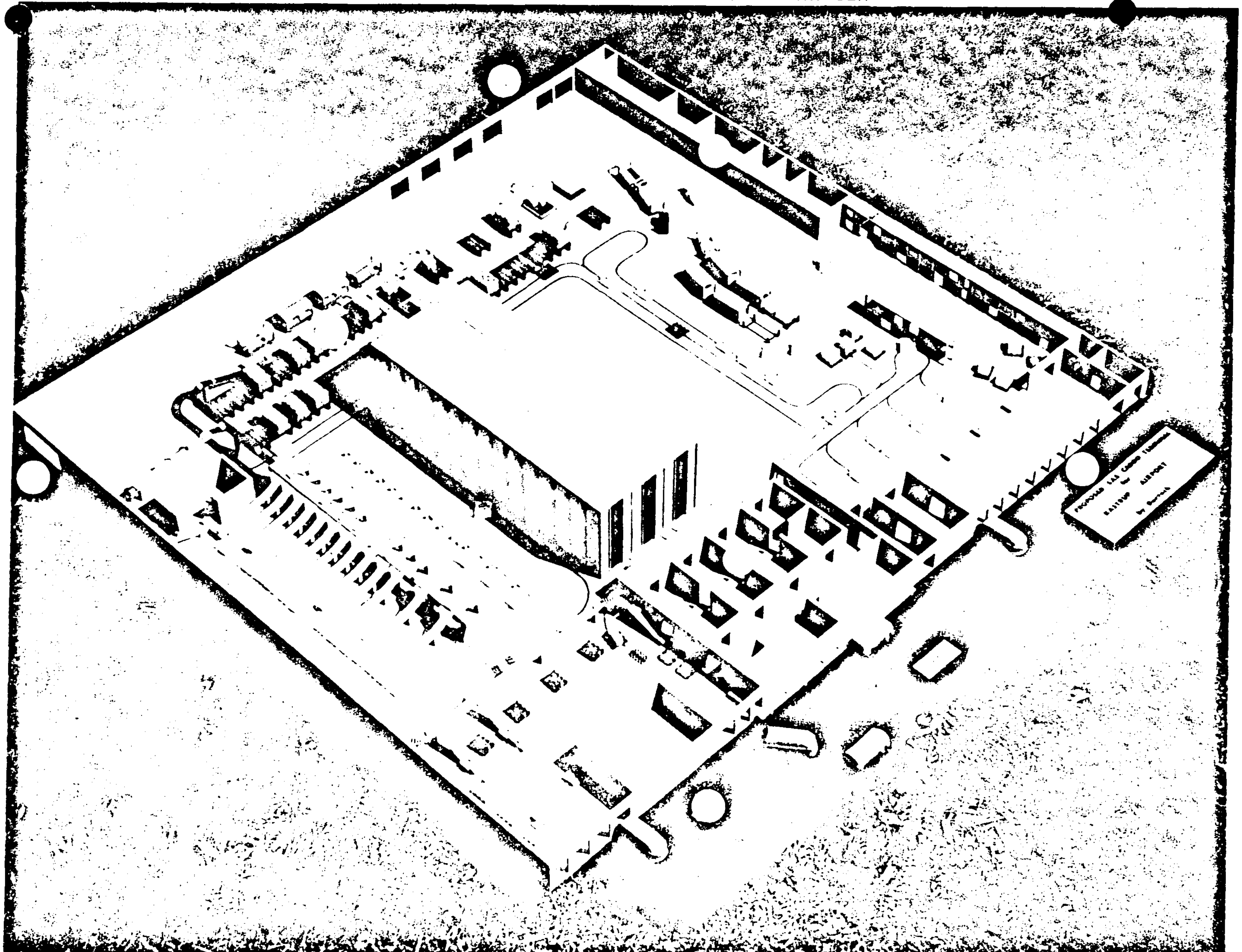
A. Employees' entrance
B. Supply receiving

- the area allocated to the segregation of inward consignments should be so situated that it is as close as possible, and certainly readily accessible, to the assembly area for outward consignments. This will facilitate the movement of transfer consignments.
- adequate space for presentation, opening and examination of air cargo for Customs
- adequate space, near to the final delivery area, for repacking of air cargo after Customs examination
- adequate warehousing areas, both free and bonded, inclusive of areas for preparation of load prior to shipment or dis-assembly of load from incoming aircraft and including the handling of pallets or unitized loads
- separation of outgoing consignments by destination in clearly and adequately marked areas
- space for cool storage of vaccines, perishables and foodstuffs but additionally, where an airline so require, deep-freeze or other refrigeration methods
- strongrooms for valuables and bullion
- storage space for human remains
- parking and storage space for loading vehicles and other equipment
- public reception counters
- accommodation for animals and livestock
- provision for offices for Control authorities as necessary, and adequate space for presentation, opening and examination of consignments by Customs.

Loading Docks

At certain high volume airports there may merit in considering the installation of loading docks on the apron to bridge the gap between cargo terminals and parked aircraft. While such docks may reduce the flexibility of possible aircraft parking configurations on the apron, they can (at least for certain all-cargo aircraft) foster much more rapid loading and unloading of air cargo at the aircraft

SCANDINAVIAN AIRLINES SYSTEM CARGO TERMINAL, COPENHAGEN



1. Export receiving
2. Import deliveries
3. From arriving aircraft
4. To departing aircraft
5. Sorter
6. Stacker
7. Pallet area
8. Heavy and bulky goods
9. Special goods stowage, i.e. radioactives, human remains, live animals, etc.
10. Agents' offices, etc.

itself, since the goods can be moved directly from the cargo terminal into the aircraft without need for transferring it across the apron on mobile equipment. This offers the most advantages with respect to the use of containers or pallets.

Cargo Apron

To ensure efficient cargo handling, the cargo apron must be treated as a continuation of the cargo terminal itself. At all times, it should be possible for aircraft to be loaded or unloaded on the apron directly outside the cargo terminal. In addition, sufficient reserve space should be provided in the long-range plans so as to permit expansion of the apron in line with intended expansions of the cargo terminals.

In determining the layout of the cargo apron, due consideration should be given to provide adequate space for parking mobile servicing and handling equipment.

The apron should be of sufficient width to permit free taxying of aircraft around and outside aircraft parked at the cargo terminal. There should be no cross circulation of aircraft and vehicular traffic on the same level, In addition, provision should be made to permit controlled truck access to the apron for direct loading or unloading of aircraft.

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