

TERMINAL FACILITIES FOR THE GENERAL EDWARD L. LOGAN INTERNATIONAL AIRPORT,
EAST BOSTON, MASSACHUSETTS

Submitted in partial fulfillment of the requirements for the degree of
Bachelor of Architecture

January 7, 1963

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Dear Sir:

In partial fulfillment of the requirements for the degree of Bachelor of Architecture, I submit the following thesis entitled "Terminal Facilities for the General Edward L. Logan International Airport, East Boston, Massachusetts."

Yours,

Robert F. Duff, Jr.

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Abstract

One of the newest and most challenging problems that the twentieth century presents to the architect is the design of airport terminal facilities. Not only must new airports be built, but existing airports with their already fixed transportation access and runway systems must be redesigned to meet the changing needs of commercial aviation. This thesis project investigates this latter problem with the redesign of the now outmoded terminal facilities at the General Edward L. Logan International Airport in East Boston, Massachusetts, to meet the air traffic demand of 1972. In this investigation the influence of air transport industry upon airport design will be analyzed, as will be also the nature of Boston's air traffic and aviation facilities. The operation of the terminal area and particularly the air passenger terminal will also be studied in order to achieve a design having optimal efficiency, convenience, and flexibility. The bases of the architectural expression for an air terminal will also be re-examined.

I. The Air Transport Industry and Airport Design

A. Growth of the air transport industry

The growth of the United States commercial air transport industry began in the early 1920's when the Post Office Department contracted with private operators to establish regular air mail routes. With the coming of larger and safer aircraft during the 1930's, regular air passenger service was developed and grew throughout the decade. The Civil Aeronautics Act of 1938, providing Federal supervision over both aircraft safety and the economic aspects of aviation, gave the air transport industry greater economic stability and increased public acceptance of air travel. Although the industry's growth rate suffered during the Second World War, commercial air travel continued to increase. The developments in military aviation during this period later revolutionized post-war air travel; not only were better aircraft, skilled personnel, and safer air traffic controls made available to the industry, but also a public acceptance, and even public necessity, for air travel was created. The war also caused the Federal sponsorship of airport construction. In the years since the war, the air transport industry has grown tremendously, and is expected to continue to grow as air travel becomes more popular. This growth may be seen in the following table: I.

Year	Revenue Passengers (000)	Revenue Passenger-miles (000)	Scheduled Aircraft
1937	887	411,545	
1940	2,523	1,052,156	
1945	6,576	3,362,455	
1948	13,168	5,980,993	5,910
1950	17,345	8,002,825	7,954
1955	38,025	19,819,221	19,741
1959	54,768	29,269,033	29,158
1965	76,900 84,800	41,100,000 53,000,000	
1970	102,000 113,000	53,100,000 58,500,000	
1975	130,000 153,000	66,700,000 75,000,000	

This phenomenal growth presents many problems whose solutions have greatly affected the nature of air transportation. In order to coordinate this growth the Federal government now regulates every aspect of the industry; the airlines have adopted new operating procedures, new equipment, and new promotional techniques; new aircraft have to be introduced to carry larger passenger loads, faster, safer, and cheaper. The growth of air travel and its effects upon airline operations and aircraft design

have created serious and, as yet, unsolved problems in airport terminal facilities. Many airports built directly after the war are already inadequate because the growth of air travel was underestimated and the secondary effects of this growth were not considered in their design.

Detailed and, hopefully, accurate estimates of future air travel growth for each city have been prepared by the Federal Aviation Agency. From these the primary growth effects of more passengers and cargo can be predicted in airport design. However, while the possible expansion of facilities to meet this growth can be easily designed into the airport, the requirements of the airport to meet the new needs of the airlines and of future aircraft are more complex and often involve fundamental changes in existing facilities.

B. Airline operations and airport design

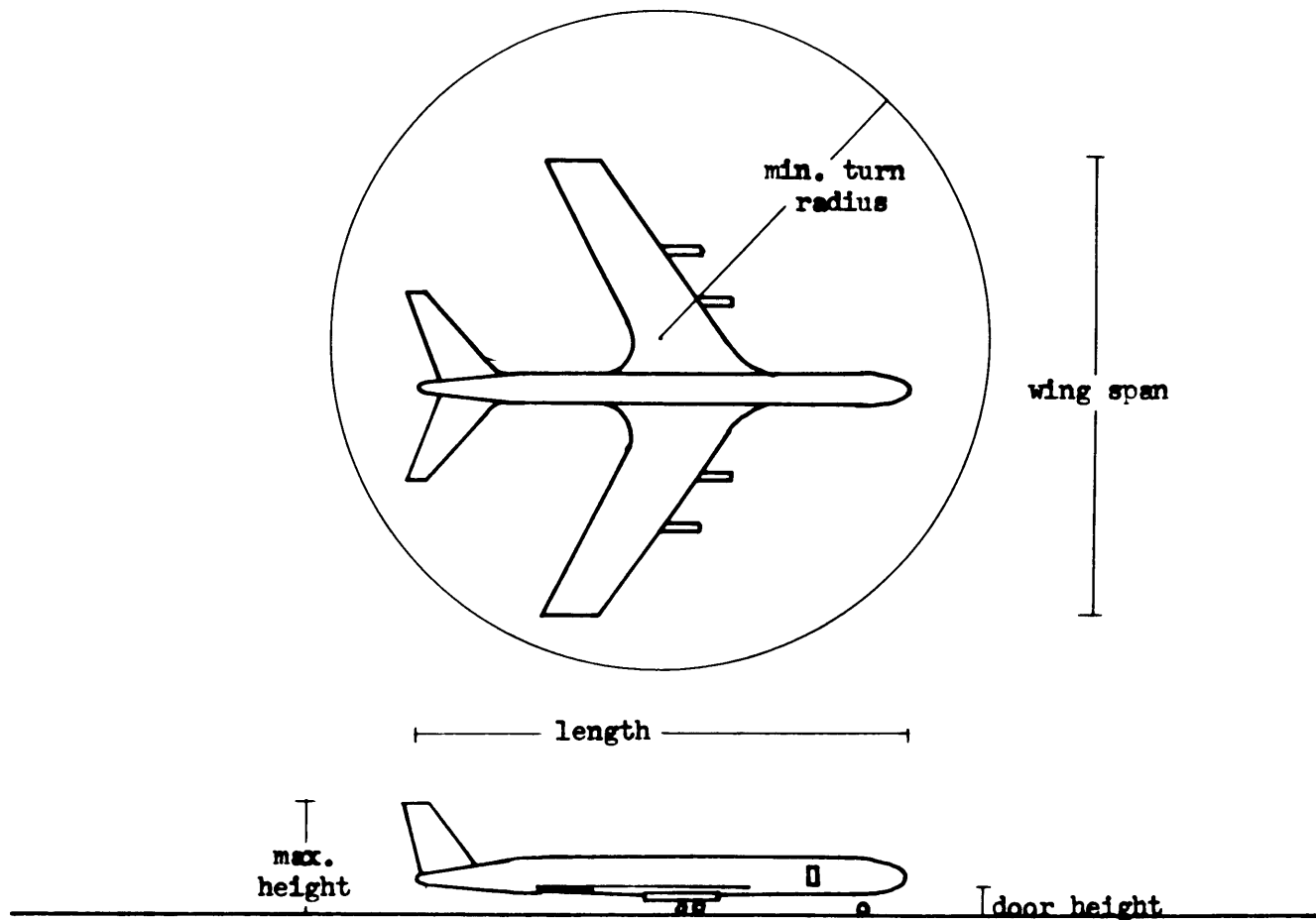
Although the growth of air travel is assured, there is fierce competition among the airlines to obtain this added traffic. This competition is increased by the unique economic problem of the industry: the airlines developed huge deficits when they bought the needed jet aircraft, and now in order to wipe out this deficit and show a profit, they must keep the jets in the air filled with paying passengers. To do this a greater market of passengers must be reached and different promotional techniques used to do so. No longer can the airlines rely upon the glamor of flying and gimmicks such as flight bags to attract customers; now they must provide service and convenience at low fares. This means service, convenience, and economy at the airport terminal. Quicker ticketing and baggage service, shorter and protected walking distances, pleasant waiting and dining facilities, and convenient parking and access to the terminal are necessary. To provide cheaper

fares, the airlines must cut operating cost by more efficient use of personnel and by utilizing as many common facilities among the airlines as possible. Since the growth of each individual airline is unsteady and unpredictable, the airlines need to centralize their facilities and to have flexibility within this centralized area. Concentration, flexibility, and common facilities are possible due to standardization among the airlines, caused by the rigid regulations of the government and by the use of almost identical equipment by airlines, particularly aircraft.

C. Commercial aircraft and airport design

The aircraft is the most important part of air travel and must dictate the design of the airport terminal facilities. Fortunately the basic development in commercial aircraft design can be rather accurately forecast, since civilian aircraft follows the design of military aircraft by several years.

The basic aircraft designs now used are expected to continue in use for the next ten to twenty years. Propeller aircraft will be replaced by jet aircraft, while new types of engines will be developed, possibly even using atomic power. However, the factors affecting airport terminal design such as size, shape, and ground maneuverability^{3.} are not expected to change greatly; this is due to Federal regulations limiting runway requirements and to the development of more powerful engines, allowing smaller aircraft to carry larger loads. The "design aircraft" used by Eero Saarinen in designing the Dulles International Airport seems to be a valid criterion of future aircraft size. (figure 1)



aircraft	wing span	length	max. height	door height		min. turn radius	runway length
				front	rear		
Boeing 707-320B	142'-5"	152'-11"	38'-8"	10'-2"	10'-4"	109'	10,000'
Boeing 707-120B	130'-10'	144'-6"	38'-3"	10'-7"	10'-7"	101'	8,250'
Douglas DC-8	142'-4"	150'-6"	42'-4"	10'-6"	12'-1"	89'-6"	9,600'
Douglas DC-7 (prop)	117'-6"	110'	29'-3"			72'	6,050'
Lockheed Electra (turo-prop)	99'	104'-7"	32'-9"	8'-1"	8'-5"	65'	5,400'
Caravelle VI	112'-6"	105'	28'-7"	7'	7'	90'	6,100'
Viscount 802 (turo-prop)	93'-8"	81'-10"	26'-9"			70'	5,300'
Comet 4B	108'	118'	29'-6"	8'-9"	8'-9"	85'	6,600'
Saارين design	160'	160'	40'			92'-6"	

figure 1: AIRCRAFT SIZE CRITERIA 4.

Some factors of new and future aircraft do influence the terminal design. Since the capacity of future aircraft will increase, the processing and circulation within the terminal must be able to handle larger groups of people and baggage. Positive protection must now be provided for passengers from the noise, fumes, and blast of aircraft at all times. Shorter aircraft servicing times of 20 to 30 minutes require quicker transfer of people and cargo between the aircraft and the terminal.

The development of commercial super-sonic transport aircraft and of vertical-and-steep-take-off (v/sto) aircraft is expected to have little effect upon terminal design. Although aircraft such as helicopters will increase in use, they will end up carrying a very small percentage of passengers.^{5.} This is due to their limited capacity, speed, and range and to their very high operating cost. Their use at an airport will be limited to a conventional heliport near the terminal but out of the way of fixed-wing aircraft.

Proposal designs for super-sonic aircraft indicate that while having a different shape and cruder maneuverability they will be no larger than conventional aircraft.^{6.} The use of super-sonic aircraft will probably be limited to airports distant from cities, due to their noise.

Although current standards of design can be assumed to be adequate in the future, there should still exist the flexibility within the terminal to provide for any drastic change in aircraft design.

II. Commercial Aviation in the Boston Area

A. Air traffic of Boston

In 1961, the Boston area ranked ninth in the nation in commercial air traffic, and in view of the area's low population growth, it is doubtful if the area's relative rank will increase.^{7.} Although not as large as New York or Washington, Boston is and will remain a major aviation center. A map of current flights to and from Boston shows that most of the direct traffic is within the northeastern part of the country, and that most western flights pass through New York City, and that Boston is the center of New England local air traffic. (figures 2 and 3) Boston is an "end-of-the line" terminal in that almost all flights begin and end here; consequently there are few transfers and through passengers, and aircraft will have longer waiting times.

In 1961 the number of passengers using Boston's Logan Airport was 3,000,000.^{8.} This figure is expected to increase by about 7% a year,^{9.} until by 1972 there will be 6,500,000 passengers per year. Of these about 12% will be international passengers to and from Europe, Canada^{10.} and South America. Air cargo traffic in 1961 was 40,000 tons, and future air cargo is expected to increase rapidly although no exact figures are available. Executive aviation is also expected to increase rapidly although again no exact figures are available.

B. Aviation facilities in the Boston area

Commercial aviation facilities in the Boston area include the General Edward L. Logan International Airport and the Bedford Airport (Hanscom Field). Presently Logan Airport contains all commercial aviation facilities in the area, executive aviation facilities, and National

Figure 2: DIRECT AIR TRAFFIC FROM BOSTON



POPULATION KEY

- Over 100,000
- 50,000 to 100,000
- 25,000 to 50,000
- 10,000 to 25,000
- Under 10,000

UNITED STATES

Scale of Miles
0 100 200 300
MAP NO. 732

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Scale of Miles



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POPULATION KEY

- Over 100,000
- 50,000 to 100,000
- 20,000 to 50,000
- 10,000 to 20,000

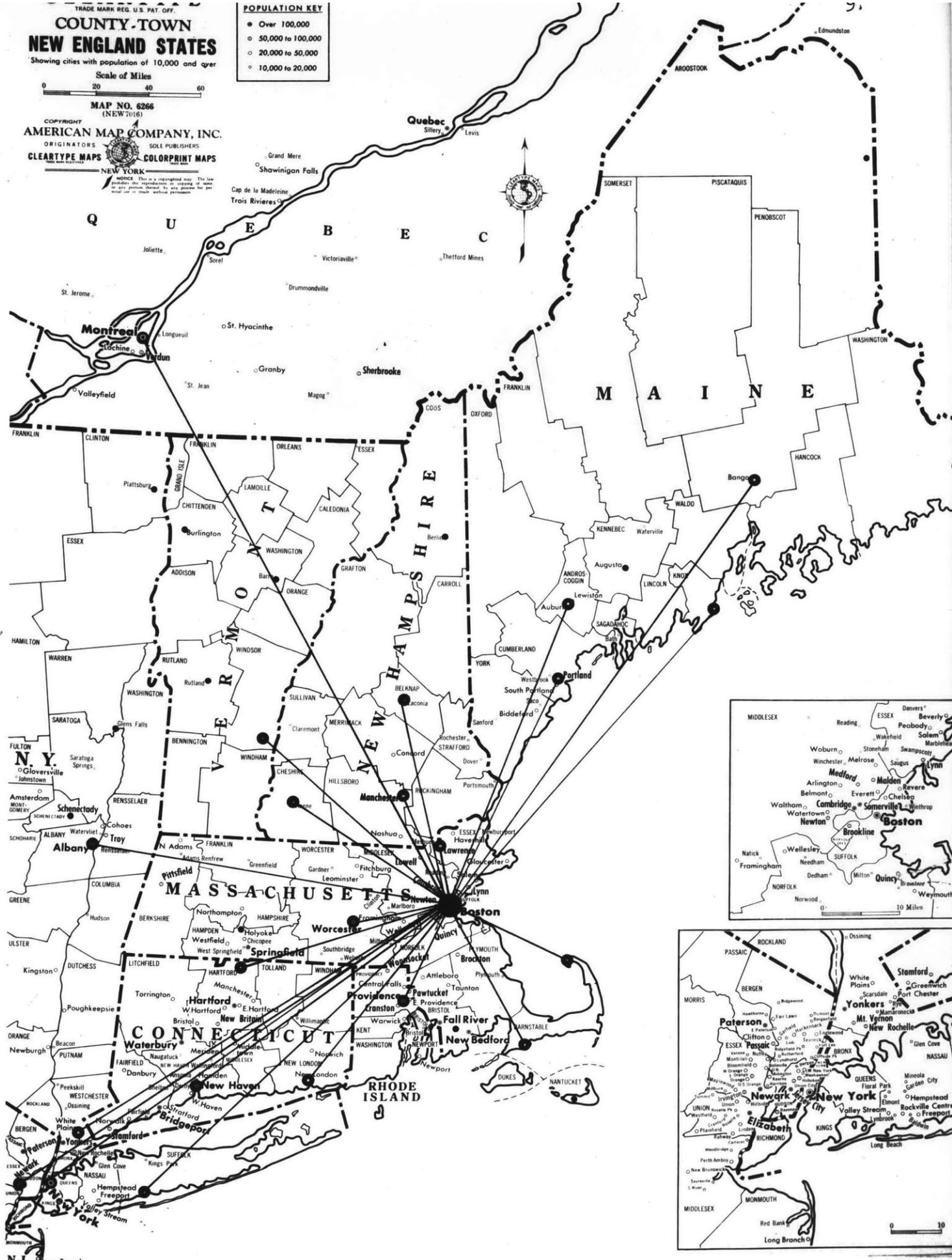


figure 3: DIRECT AIR TRAFFIC FROM BOSTON

Guard facilities, while Bedford has been little developed for commercial aviation. However, in the future it is considered desirable for Logan Airport to contain only passenger air traffic, a limited amount of air cargo traffic, and some executive aviation, while Bedford Airport will be used for additional air cargo and general aviation and for the

11.
National Guard. Also in the future a new passenger airport may have to be constructed if passenger traffic grows past the ultimate capacity of Logan's runway system; this will happen when the number of annual passengers passes 10,000,000.
12.
Despite its limited expansion, Logan Airport is ideal as a passenger terminal, since it is located near the center of the Boston Metropolitan area and near downtown Boston and is well related to the existing urban transportation system.

(figure 4)

C. Logan Airport

Logan Airport was established in 1922 upon filled land in Boston Harbor. In 1941 it was taken over by the Massachusetts Port Authority who now own it. The Port Authority, beginning in 1944, designed and rebuilt the whole airport into its present form; construction of the triangular runway system, linear terminal building, and highway access interchange was completed in 1949. Later the various airlines built maintenance hangers within the terminal area. Unfortunately, this terminal area at Logan Airport has become outmoded by the recent developments in air transportation mentioned above. The linear single story passenger terminal is inconvenient, inefficient, and uneconomical for airlines, concessions, and passengers, alike. Passenger circulation is crowded and confusing with no protection for the passengers when boarding the aircraft and with no pleasant waiting or dining areas.



figure 4:
BOSTON HIGHWAY
SYSTEM

Land-vehicle traffic has a confusing road system, congested loading and unloading points and poor parking arrangements. Circulation of aircraft is also confusing and provides no separation of large and small aircraft. Because of the inadequateness of the terminal facilities at Logan Airport, their total redesign seems an interesting and worthwhile project.

In redesigning the terminal facilities the present runway system and land access should be retained. At present the runway system consist of four runways, and in the future land can be filled to expand the system into its final form of three pairs of parallel runways.

(figure 5) This final runway system will have a capacity of 70-90 operations per hour, an operation being either a landing or a taking off.^{13.}

Land access to the terminal area is by an elaborate interchange from the McClellan Highway, which leads to the North Shore and via Sumner Tunnel to downtown Boston and the Storrow and Fitzgerald Expressways. Several minor streets provide access from East Boston. A rapid transit line runs along the west boundary of the site with a station located at the highway interchange. The map shows the boundaries of the terminal area. Only to the south is limited expansion possible by filling out to the wharf line. The location of buildings upon the site must conform to the established clear zones for the runways.

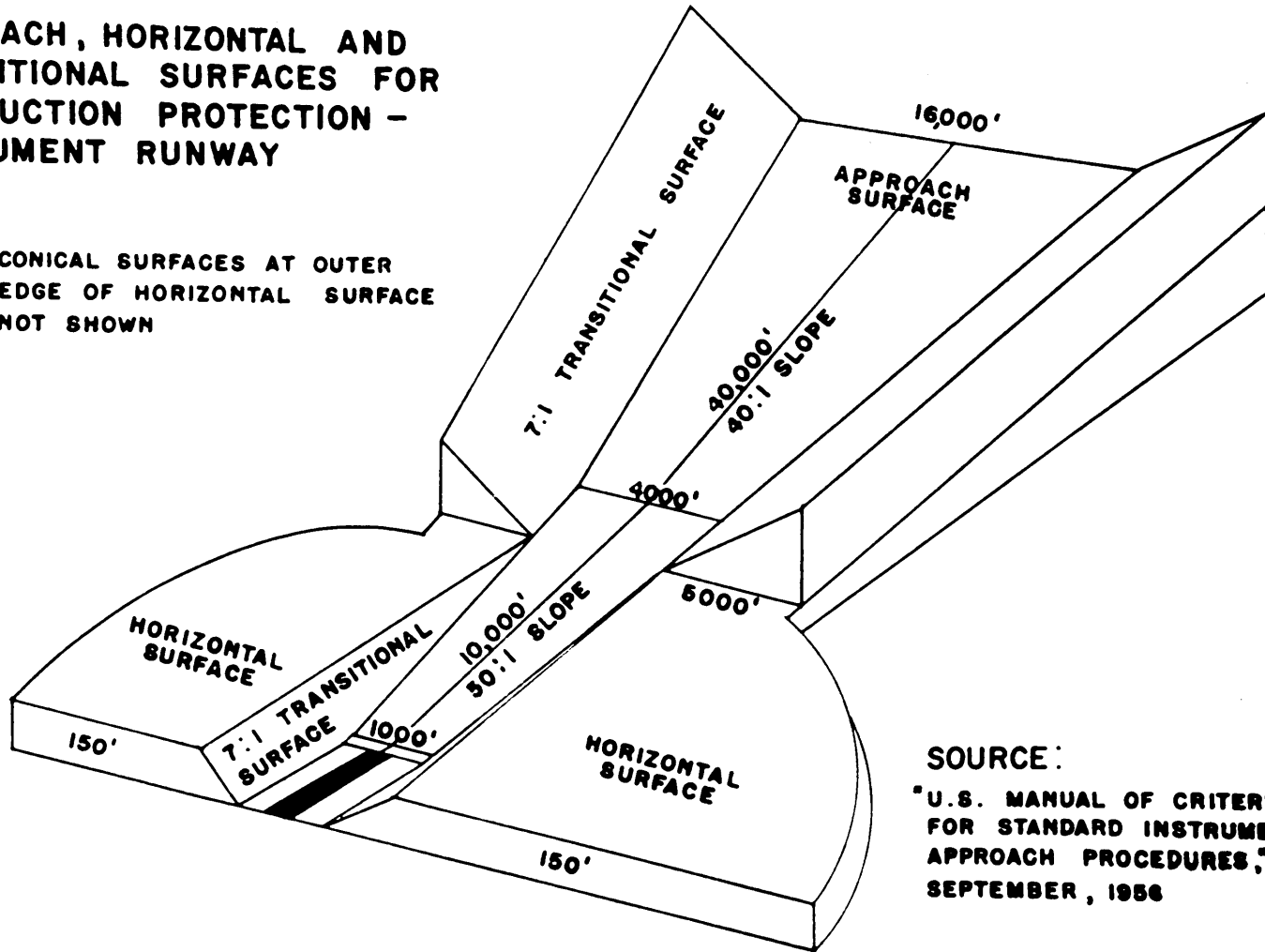
(figure 6)



Figure 6: RUNWAY CLEAR ZONES II.

APPROACH, HORIZONTAL AND TRANSITIONAL SURFACES FOR OBSTRUCTION PROTECTION - INSTRUMENT RUNWAY

NOTE: CONICAL SURFACES AT OUTER EDGE OF HORIZONTAL SURFACE NOT SHOWN



SOURCE:
"U.S. MANUAL OF CRITERIA FOR STANDARD INSTRUMENT APPROACH PROCEDURES,"
SEPTEMBER, 1956

III. The Airport Terminal Area

The terminal area of an airport is the interchange point of people and goods between land and air vehicles and also provides servicing facilities for the air vehicles. The terminal area is subdivided into several functions each of which has its own design criteria and circulation characteristics.

A. Terminal areas

1. Air passenger terminal - This is the most important function at the airport, handling the interchange of passengers, of mail, and of some cargo. It will be considered in detail in the next section.
2. Air cargo terminal - This function handles cargo carried by non-passenger aircraft. The cargo arrives by truck and is unloaded in a small warehouse where it is processed and prepared for flight; the cargo is then placed upon rolling pallets which are lifted into the aircraft by fork-lift truck, pushed into position within the plane, and tied down. It must also be possible for a truck to unload directly into the aircraft. The warehouse is generally a long building with continuous truck platforms on one side and aircraft access on the other. Although new equipment is being developed to speed the loading and unloading process, the basic section of the building will probably not change. (figure 7)
3. Executive aviation area - This function stores and services non-commercial aircraft, especially the executive aircraft owned by corporations and businesses. In addition to shops and service hangers, buildings include lounge areas, some concessions, and administration and flight information offices. This area is used by small aircraft and should be removed from the traffic of the larger commercial aircraft.

4. Airlines maintenance area - This area contains parking, hangers, and shops for airline aircraft. The basic hanger design now used consists of a central core of offices, shops, and services with the hanger roofs cantilevered on both sides. Sufficient paved area should be provided for both aircraft parking and aircraft circulation. (figure 8)

5. Miscellaneous areas - This includes crash and emergency equipment, fuel storage, and radar installations.

B. Circulation within the terminal area

Circulation within the terminal area of both land and air vehicles is of utmost importance. The basic principle of this circulation is the separation of different traffic. Large aircraft must be separated from small aircraft; public traffic must be separated from cargo, service, and employee traffic. (figure 9)

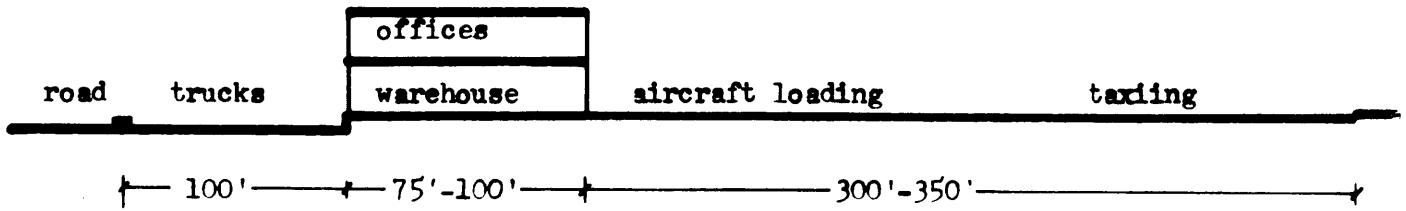


figure 7: AIR CARGO FACILITIES

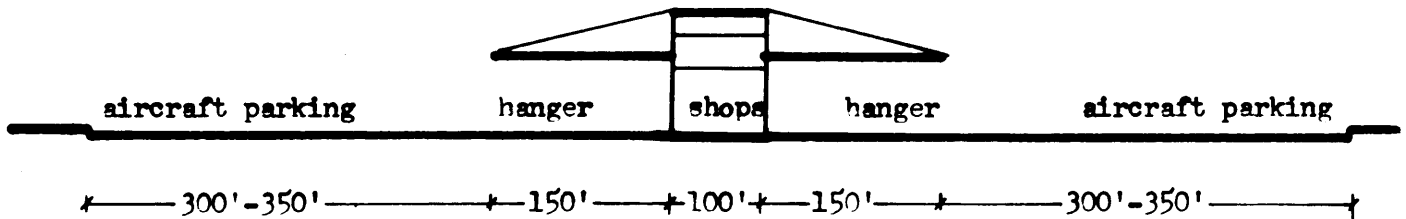


figure 8: AIRLINE MAINTENANCE FACILITIES

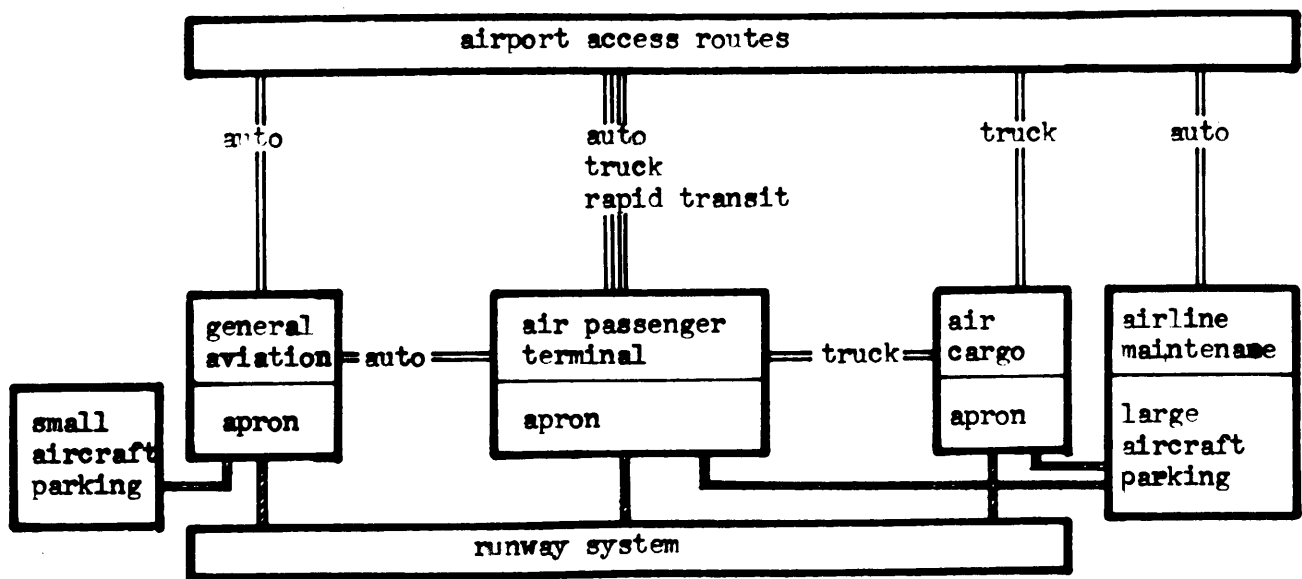


figure 9: INTER-TERMINAL CIRCULATION

IV. Air Passenger Terminal Area

The primary function of the air passenger terminal is the transfer and processing of people and their luggage between land and air vehicles. Secondary functions are passenger conveniences and concessions, mail and air express interchange, and facilities for airlines, airport management, and Federal government. The various aspects of the terminal design will be considered in the order that they affect enplaning passengers.

A. Concentration of terminal facilities

1. Single centralized terminal and building

This is the predominant type due to its flexibility in operation, its economy through consolidation of facilities, its ease of transfer between aircraft, and its simple access. It has problems of air and land traffic around it. However, if these problems can be solved, this is the best terminal type.

2. Several unit terminals

This is best used at airports with very high air traffic volumes where passenger walking distances and vehicle congestion are major problems. Each unit may contain an individual airline or a group of similar airlines. This terminal type has the disadvantage of being inflexible in operation, uneconomical in both initial and operating cost, and confusing to enplaning passenger access.

B. Land vehicle circulation

The following are the land vehicles using the air passenger terminal classified by vehicle type and vehicle user:

Automobile	Private	Passenger Visiting public Employee
	Public	Taxi, bus, etc. Rental automobile
Trucks	Service Mail and cargo	

Rapid Transit System

Each of these eight vehicles has unique traffic characteristics, the major ones being:

- 1) Access route into and from the terminal.
- 2) Interchange points of goods and people to and from the vehicle.
- 3) Parking characteristic such as parking system, parking time, and distance to terminal.

The basic principle for each of these points is that vehicles should be grouped together when they have the same characteristics, but must be segregated when their characteristics differ. The diagram shows the access, interchange, and parking properties of each vehicle and the relationships between them. (figure 10)

Because the greatest congestion occurs at the interchange points of the enplaning and deplaning ramps, these loading ramps should be separated either horizontally or vertically and should have long road fronts and extra wide roadways.

It is now necessary to consider the use of parking garages, particularly at centralized terminals. These allow shorter protected walking distances with vertical segregation of parking.

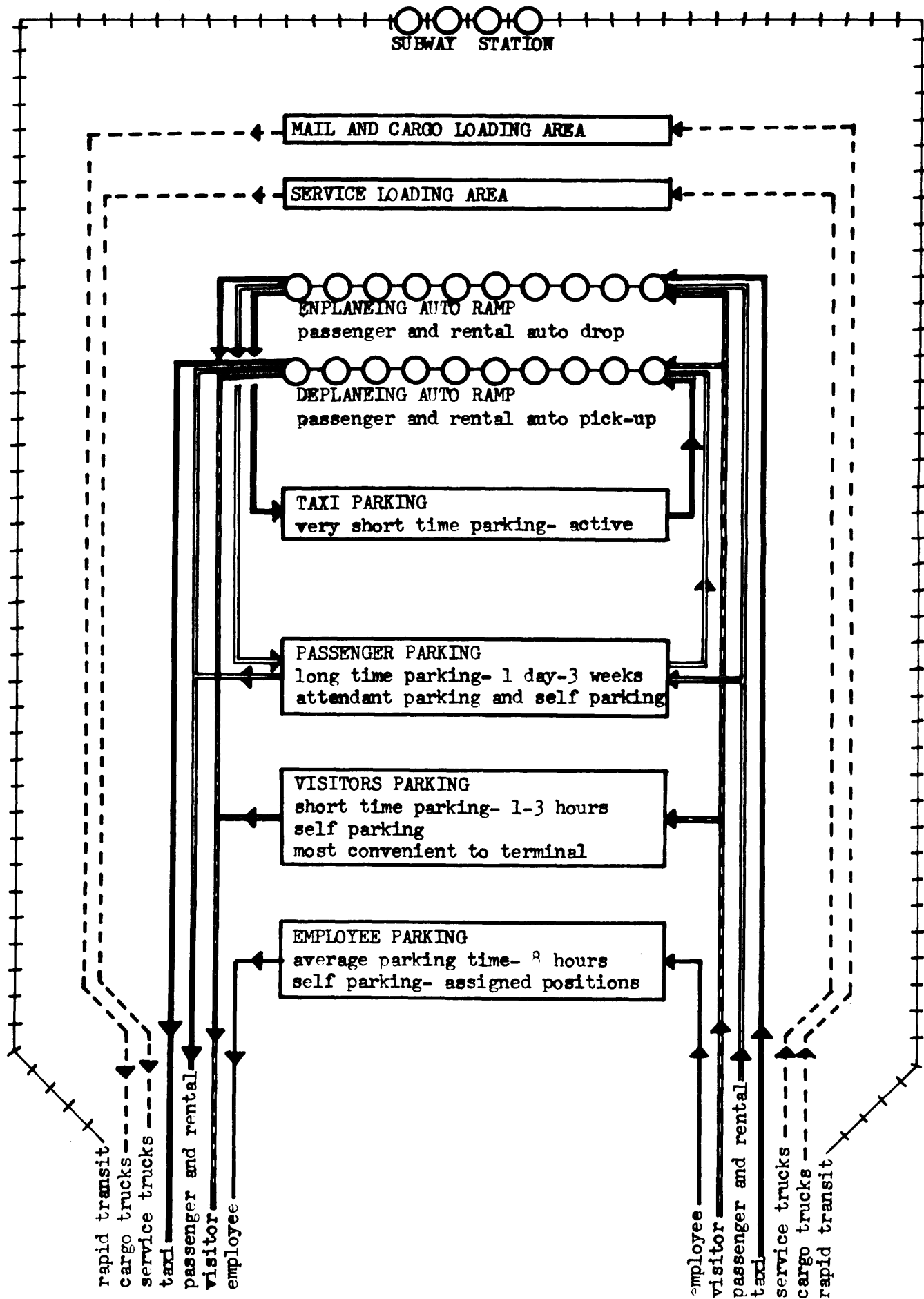


Figure 10: PASSENGER TERMINAL LAND VEHICLE CIRCULATION

Although helicopters might be considered "land" vehicles due to their short range, they will be considered later.

C. Passenger and baggage circulation

The basic principle of passenger circulation is that it be as short, convenient, and safe as possible. The maximum walking distance within the terminal for enplaning or deplaning passengers should be no more than 1000 feet, while the distance the passenger must carry his luggage should be at a minimum. There should be no cross circulation and few vertical level changes. As much as possible, passengers should be separated from non-passengers, and enplaning passengers separated from deplaning passengers.

1. Flow diagrams for shuttle, regular domestic, and international traffic are shown below (figure 11) and descriptions of each area follow:

- a. Ticket lobby - This is the major entry of the terminal and contains the ticketing and baggage checking counters. There are now two types of counters used by the airlines: 1) the conventional counter along the wall with adjacent offices, which is best when both ticketing and baggage checking occur at the terminal, and 2) the free-standing "supermarket" counter which only does baggage checking, while ticket selling is done at downtown ticket offices.
- b. Baggage claim area - This contains seats for short waiting periods (5 minutes) and apparatus for the passenger's claiming of his baggage. The preferable system is the self-claim one where the luggage is fed by machines or attendants onto long racks and is there picked up by the deplaning passenger who presents his claim check as he leaves the area.

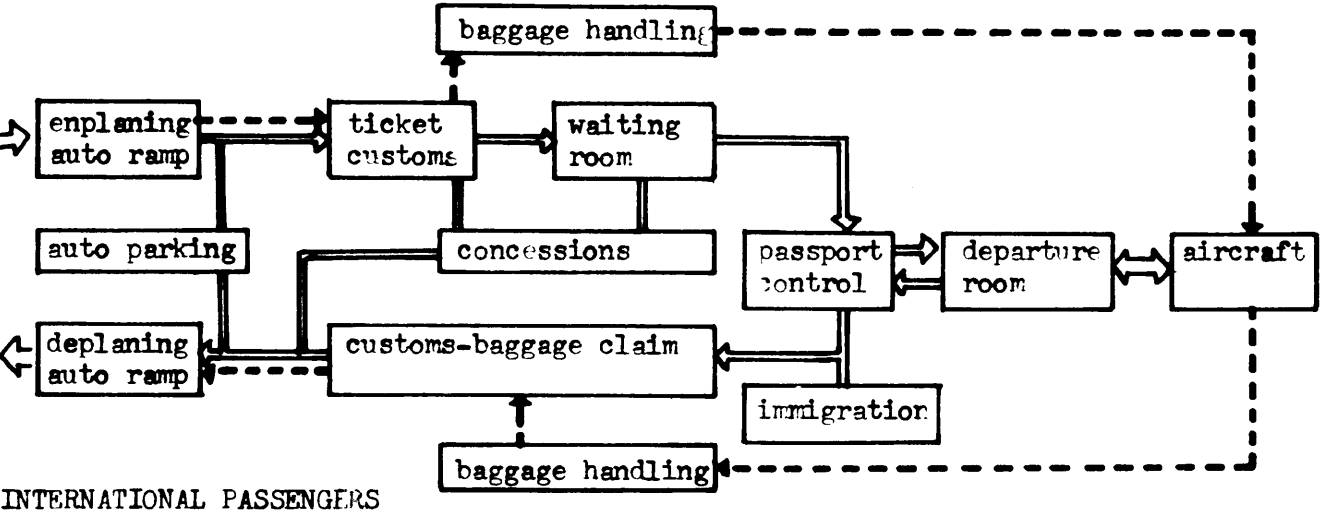
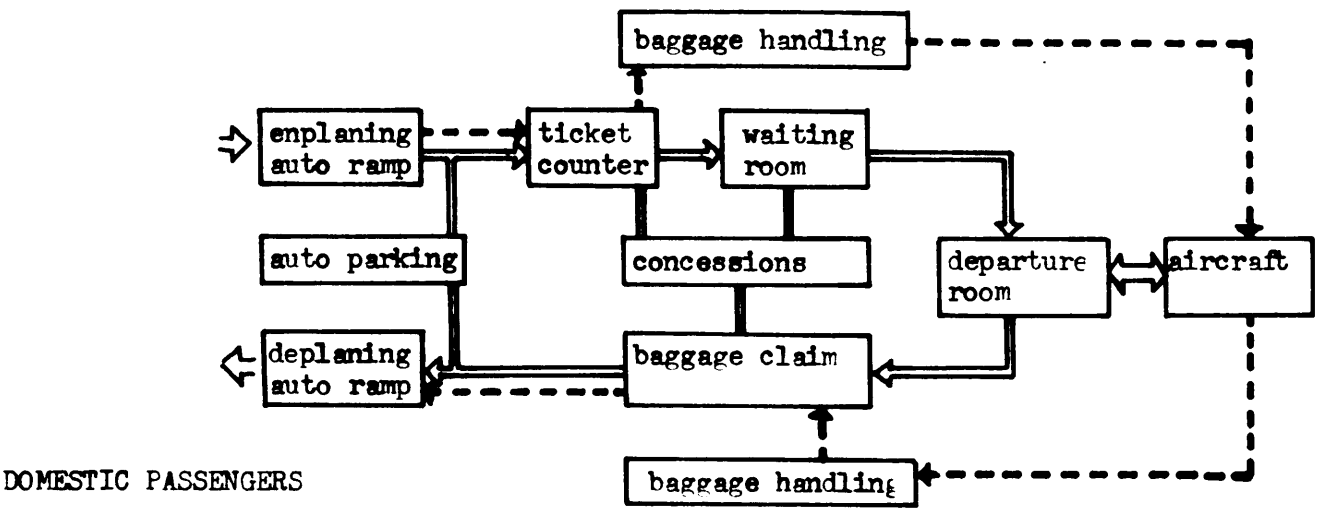
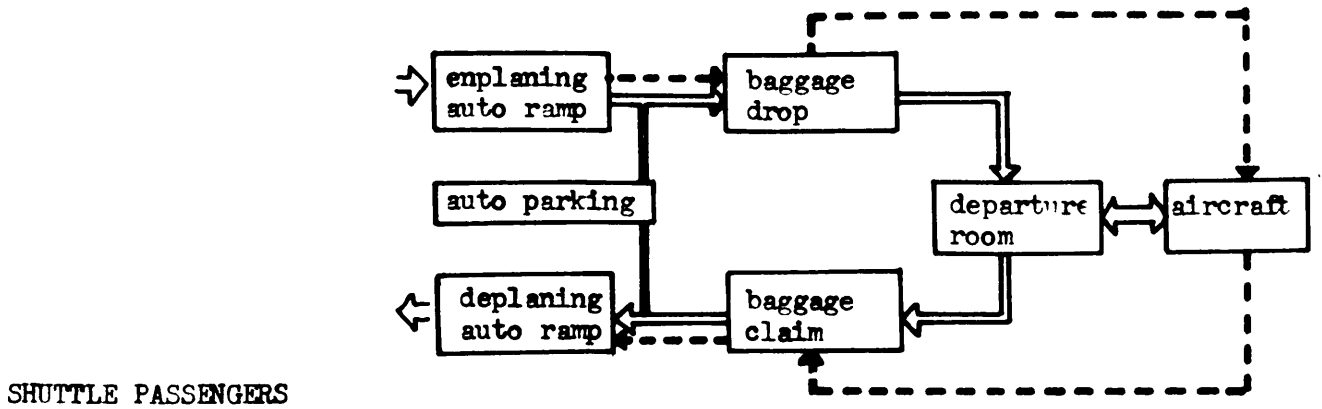


figure 11: AIR PASSENGER FLOW DIAGRAMS

passenger flow \Rightarrow
 baggage flow $- - - \Rightarrow$

- c. Waiting area - The function of the waiting area is to provide pleasant seating for enplaning passengers. It should be directly related to ticket lobby, restrooms, concessions, and gate positions. It should not be used as a circulation space, although adjacent to the enplaning passenger flow and out of the way of deplaning passenger flow. If aircraft noise can be controlled, the waiting area should have a view of the apron. In order to facilitate quicker loading and separate enplaning from deplaning passengers, most airports now supplement the main waiting room by departure rooms of about 150 seats at each gate position.
- d. Dining and refreshment areas - A variety of eating areas ranging from fine restaurants to coffee shops and sandwich counters should be provided along with cocktail lounges, bars and soda fountains. Although the location of each eating place depends upon its nature, all should be convenient to passengers but not directly in the flow of circulation. If at all possible a central kitchen should be used for these facilities, and this kitchen should be related to the flight kitchen area.
- e. Conveniences and services - Rest rooms and telephones should be convenient throughout the terminal. Other necessities are information booths, traveler's aid, police, first aid, and a nursery. A chapel may also be provided.
- f. Concessions - A distinction should be made between concessions used by enplaning and by deplaning passengers. Insurance and news stands should be near enplaning flow, automobile rental and storage lockers near the deplaning flow, and Western Union

near both. Because concessions range from game rooms to flower and clothing stores, concession space must be as flexible and generalized as possible. A small hotel for passengers and flight crews is now a necessity at the terminal.

g. Customs, passport and immigration control - Customs for enplaning passengers is within the ticket lobby near the international airlines' ticket counters, while deplaning customs is at the exit of a special enclosed baggage claim area. Passport control is at the gate position. Immigration facilities consist of several rooms for waiting, processing, and medical examination. Normally all these functions are related to a definite group of gate positions generally used by the international flights.

h. Observation area - This area consists of an unenclosed, but perhaps roofed, deck close to and above the aircraft positions. This deck should be easily accessible to both passengers and non-passengers.

2. The speed of passenger circulation depends upon baggage circulation. Baggage is conveyed from the ticket counter to the apron level where it is sorted and conveyed to the aircraft. Recently preloaded containers or pods have been used, these are filled with luggage within the terminal and the whole container loaded into the plane by a special truck. This also speeds deplaning baggage flow since each piece of luggage must only be handled once. Moving belt systems have been used at several airports but as yet they are not as efficient as the pods. Baggage circulation also includes the sorting and handling of airmail and air express carried by passenger aircraft.

3. In order to achieve maximum efficiency in the passenger and baggage

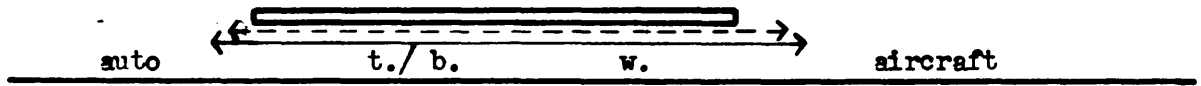
circulation, several levels are often required, with higher passenger volume requiring more levels. (figure 12)

- a. Single level - This is practical only at small terminals where the ticket counter and the baggage claim counter can be on opposite sides of the waiting room.
- b. One and a half levels - This again can only be used at smaller terminals since enplaning and deplaning automobile traffic are at the same level.
- c. Two levels - This works well at large terminals except that baggage circulation is awkward and baggage handling area is limited.
- d. Three levels - This becomes necessary at very large, concentrated terminals. It allows maximum separation of enplaning and deplaning passengers and baggage. A variation of this is used by I.M. Pei for the Multi-airline Terminal at Idlewild, having enplaning and deplaning automobile ramps at the same level but separated horizontally.^{15.}

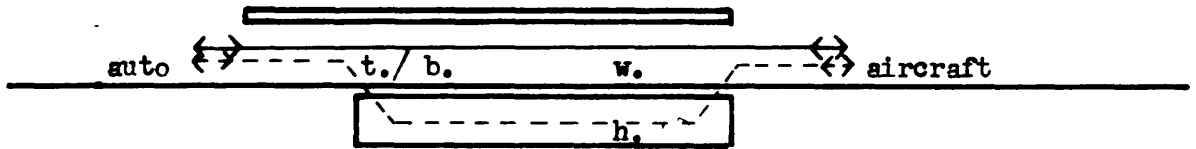
D. Terminal to plane interchange

I. Methods of boarding (figure 13)

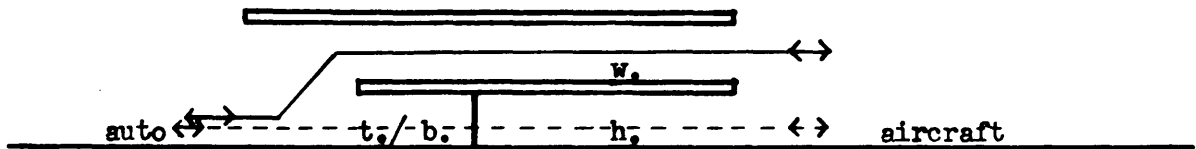
- a. Walking across the open apron - This is the oldest and least satisfactory method since it is inconvenient, uncomfortable, dangerous, and confusing to the passenger.
- b. Moveable gangway - These enclosed telescopic or swinging bridges provide protected, uninterrupted flow from the second level of the terminal and allow efficient use of airline personnel. However, this system is expensive (\$60,000 per gangway), limits flexibility of the apron, and requires relatively accurate



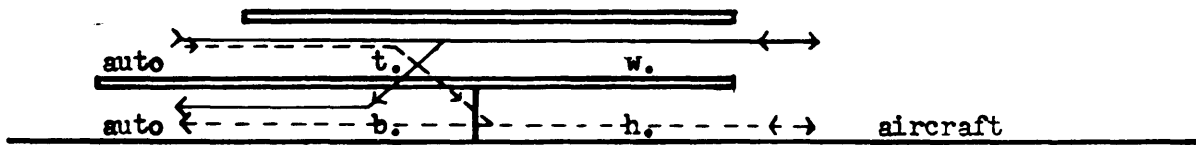
SINGLE LEVEL



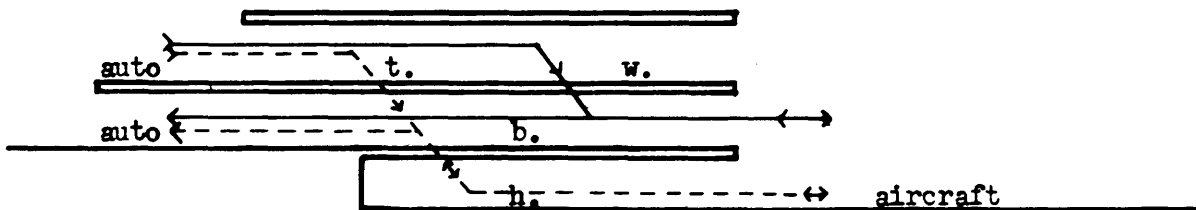
ONE AND A HALF LEVELS



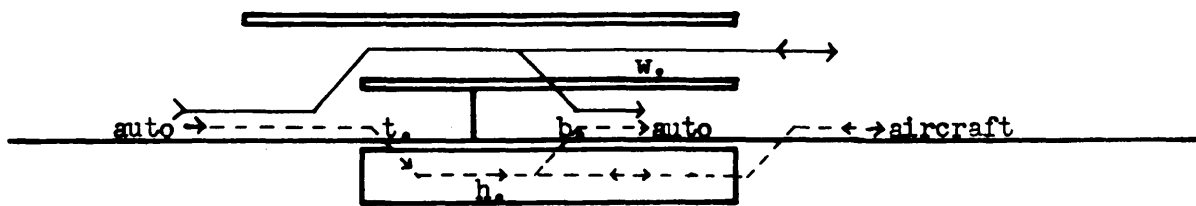
ONE AND A HALF LEVELS



TWO LEVEL



THREE LEVEL



THREE LEVEL: Multi-airline Terminal, Idlewild Airport - J.M. Pei, arch.

- t. - ticket counter
- w. - waiting room
- b. - baggage claim
- h. - baggage handling

figure 12: TRAFFIC SEPARATION BY LEVELS

16.

positioning of the aircraft.

- c. Mobile lounge - These are motorized departure rooms which carry loads of passengers to distant aircraft. These machines have great flexibility and considerably shorten walking distances. However, they are very expensive (\$230,000 per lounge), create congestion of passenger flow, increase apron traffic, and have the possibility of mechanical breakdown. ^{17.} These are still in the experimental stage, although the new Dulles Airport has been designed around their use. Although the Federal Aviation Agency is strongly supporting the use of mobile lounges, airline and airport officials are still very reluctant to use them until their feasibility has been demonstrated at Dulles Airport.

2. Arrangement of positions at the terminal (figure 14)

- a. Open apron systems with access to aircraft directly from the air side of the terminal building.
- 1) Positions directly adjacent to terminal - Since this allows very few positions it can only be used at very small airports.
 - 2) Positions removed from terminal - This requires the mobile lounge boarding system, but allows many positions and shortens walking distances. This arrangement can be carried to the extreme of having no terminal building at the airport and loading the mobile lounges at a downtown terminal building. ^{18.}
- b. Positions around finger structures extending from the main terminal building.
- 1) Regular fingers - These enclosed fingers are of light construction and may be moved if absolutely necessary. Any number of fingers may be used as long as aircraft can maneuver

easily among them. Walking distances within the finger should be less than 700 feet. Most fingers now used are two levels, with passenger access, departure rooms and the possibility of moving gangways at the upper level, and baggage access and maintenance at the lower level.

- 2) Satellites - These are basically finger schemes with sub-terminal buildings, around which the aircraft park, at the end of the finger. A popular variation of this is to replace the finger structure by a tunnel under the apron, thus increasing aircraft maneuverability, but also creating several level changes, difficulty in baggage access, and considerable inflexibility.

E. Apron circulation

The essence of apron circulation is the movement, parking and servicing of aircraft at the gate positions.

At large airports servicing jet aircraft, gate positions consist of 200 foot diameter circles 200 feet on center. This area allows the largest aircraft to taxi in, turn around, and taxi out under its own power without interfering with adjacent aircraft. Smaller circles may be used by smaller aircraft. The number of such gate positions depends on the typical peak hour passenger volume, the average passenger load, and the average occupancy time for the aircraft. A maximum of gate positions depends upon the runway system capacity and the occupancy time.

$$\text{Max. no. of positions} = \frac{(\text{runway operations/hr}) (\text{av. occupancy time})}{120}$$

There are three basic configurations of the aircraft with relation to the terminal building: (figure 15)

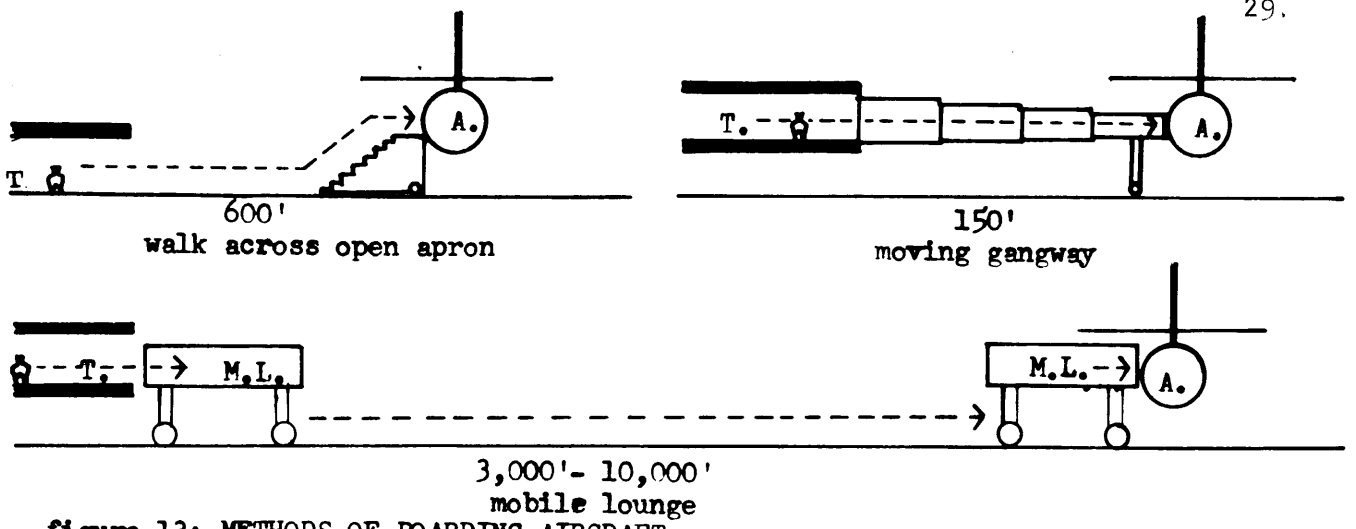


figure 13: METHODS OF BOARDING AIRCRAFT

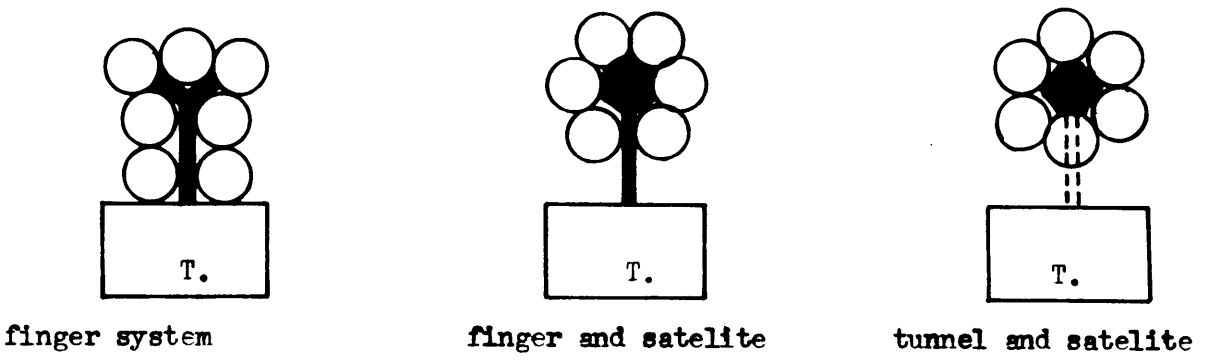
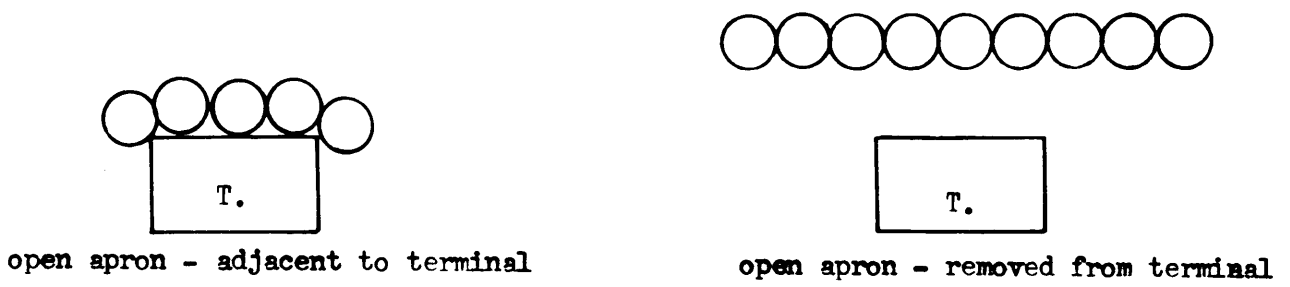


figure 14: ARRANGEMENTS OF POSITIONS AROUND TERMINAL

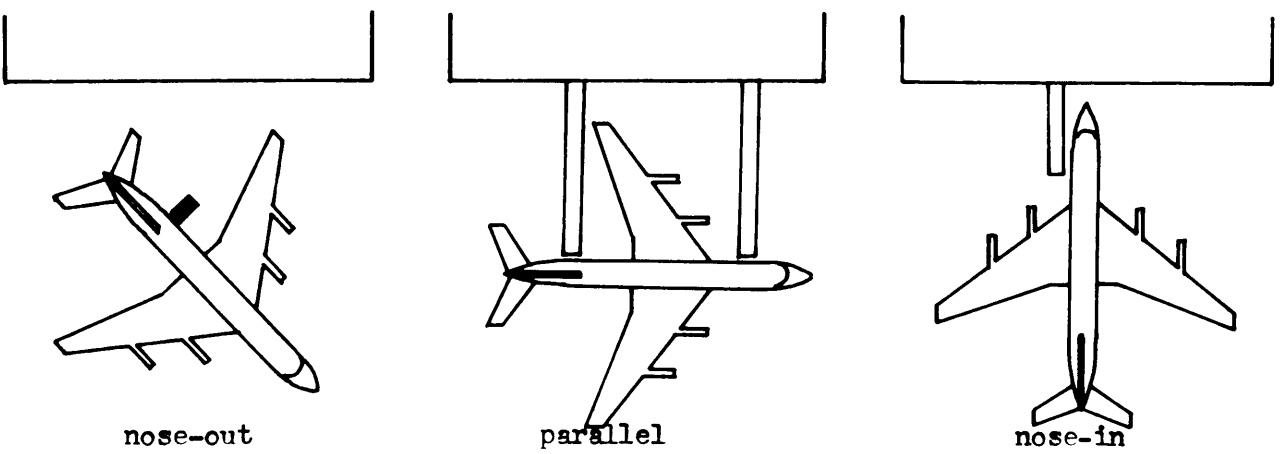


figure 15: AIRCRAFT PARKING

- a. Nose out - This configuration is used with the open apron boarding method and is the least satisfactory. Blast and noise are directed against the building when the engines are started and when they are speeded up to start the aircraft moving.
- b. Parallel - This is adaptable to moving gangways and allows both doors of the aircraft to be utilized. This configuration requires rather accurate maneuvering of the aircraft, and although not directed at the building, the blast of the engines is directed towards adjacent aircraft.
- c. Nose in - This configuration requires the use of towing trucks to tow the aircraft from the position. However it allows a shorter gangway and removes the aircraft from near the building before it begins its engines.

The present trend is to centralize aircraft services into fixed service pits at each position, instead of having several trucks each provide fuel, electricity, water, and compressed air. Although this limits flexibility to an extent, it also minimizes the number of vehicles upon the apron.

F. Airline operations area

1. Ticket counter and adjacent offices - This area is within the ticket lobby and has access to the baggage handling area for the conveying of luggage.
2. Baggage handling, airmail, and air express - This is at apron level with access for goods to the aircraft, to trucks, to the baggage claim area, and to the ticket counter.
3. Operation Control - This area includes the preparation of flight documents, weight and balance computations, weather briefing,

and general coordination for each airline's aircraft. This area should be on the aircraft access level and close to the positions normally used by the particular airline. There should also be direct access to the apron. Flight crew lounge, locker, and rest areas must also be provided within this area.

4. Aircraft servicing and maintenance - This opens directly upon the apron and contains maintenance offices and storage for apron equipment.

G. Other areas within the terminal

1. Airport management offices - This is standard office space for accounting, operations, and public relations of the airport. Some of this should be located near the passenger functions.
2. Governmental functions - This includes F.A.A. offices, weather bureau, and communication facilities located within or near the control tower; customs, passport, and immigration are located within the terminal; and Post Office facilities located upon the apron level near the baggage handling area.
3. Control tower
4. Flight kitchen - This prepares the food used in flight and should be both at apron level and closely related to the kitchen areas used by restaurants.

H. Helicopter facilities

A heliport is now essential at every large airport. It should be located near the fixed-wing terminal building, but there should be maximum separation between the helicopter operations and fixed wing operations. A wide corridor of air space should lead to the heliport without crossing the regular take-off and landing paths.

The diagram below shows the landing requirements of a typical heliport for high volume passenger service. (figure 16)

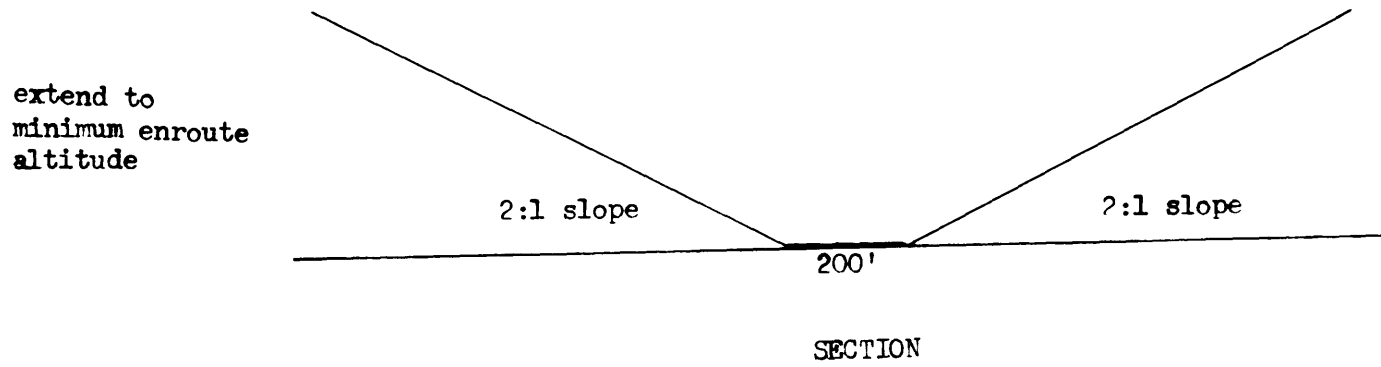
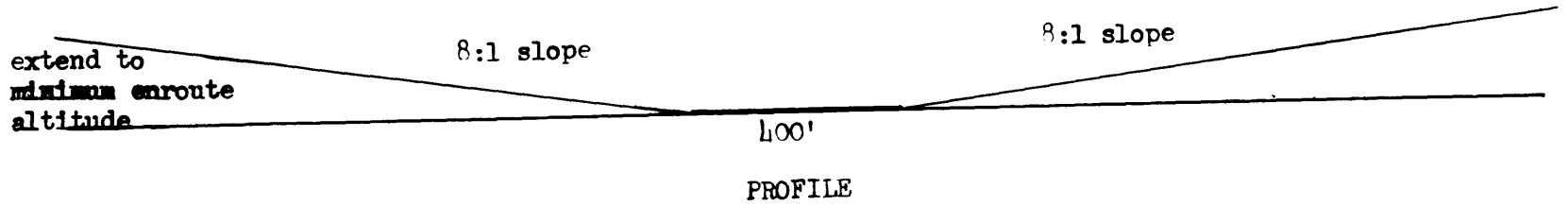
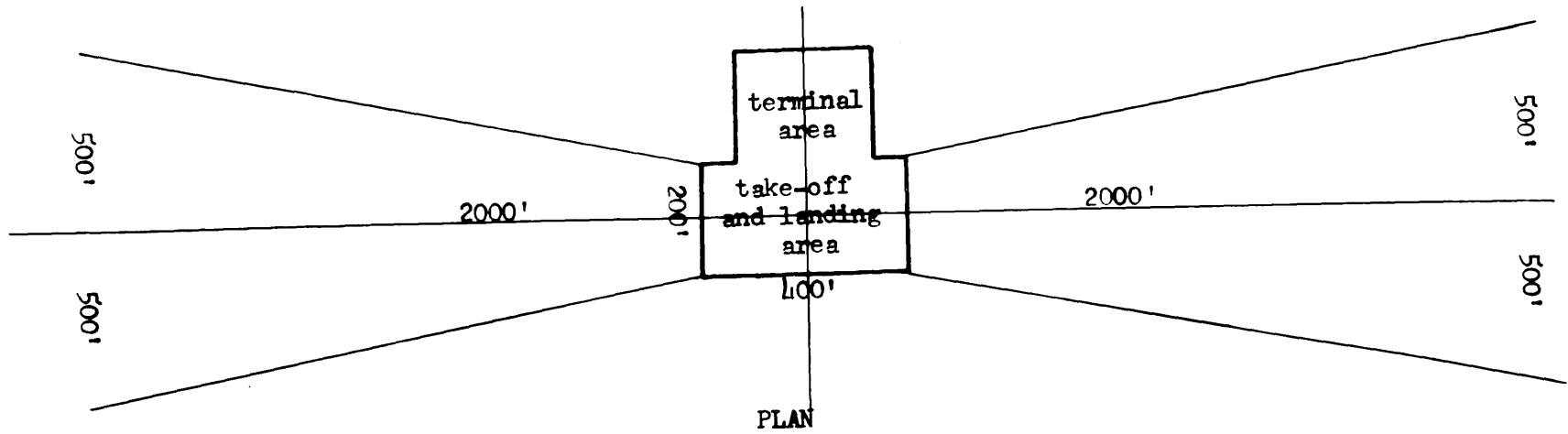
Passenger flow within the heliport is similar to fix-wing operation except not as formal. The heliport terminal should include a small ticket, baggage check, and baggage claim counter, waiting area, conveniences, and operational area.

The heliport may be upon the flat roof of a building if the roof structure is suitably reinforced.

1. Expansion and flexibility

The growing and variable nature of the commercial aviation industry make expandability and flexibility of paramount importance in air passenger terminal design. The structure should be capable of accepting additions with a minimum of demolition and interference with service. In general a building with a rectangular and modular configuration rather than odd-shaped one is easier to add to. Expansion should be possible so that all the areas and positions can be expanded at once. Flexibility can be achieved by using non-bearing partitions and by concentrating fixed facilities such as vertical circulation into core areas.

Figure 16: HELIOPORT DESIGN CRITERIA 20.



V. Architectural Expression of the Air Terminal

Although there is still a wonder and excitement about air travel and its influence upon contemporary life, attempts to express this wonder should not interfere with the efficiency, convenience, or flexibility of the air terminal; nor should they supersede expression of the realities of the air terminal such as land vehicle and aircraft circulation and the passenger interchange between them, since this wonder will certainly decrease as air travel becomes more accepted. Similarly, analogies between the air terminal and earlier building types should not negate the particular characteristics of the air terminal. In short, the primary expression of the air terminal should arise from the location, operations, and requirements of the air terminal itself.

A. Order based upon circulation

The primary characteristics of an airport terminal area are circulation and interchange. The circulation systems both within and served by the terminal should be the basis of the terminal's architectural expression. A definite order throughout the terminal based upon the land vehicle, aircraft, and pedestrian traffic patterns is essential not only for the obvious functional reasons, but also for unifying the whole area and for establishing a definite hierarchy of importance within the terminal area. The order and expression of the air passenger terminal should include both aircraft circulation and the circulation and parking of automobiles. The use of parking garages makes this point particularly important and provides a means of better expressing the dual circulation aspect of the airport as the interchange between land and air vehicles. Since the airport is generally seen from the air, the order of circulation must be evident in a corresponding over-all

geometric order of the whole site.

B. Architectural scale

At and around the air passenger terminal there exist many scales: the nearby urban scale, the scale of aircraft movement, the high speed automobile scale, the large public pedestrian scale of the terminal building, and finally the almost intimate scale of the aircraft's interior. However, the most dramatic and visually dominant scale is that of the flat and uninterrupted plane of the runways and aprons, surrounded by the hemisphere of the sky. (figure 17) All the scales at the terminal might be unified to an extent by relating them to this largest "sky" scale. The continual awareness of this dominant scale is a unifying element consonant functionally and symbolically with the nature of the air terminal. There should also be a hierarchy of scales within the passenger terminal beginning with the automobile scale and ending in the aircraft interior scale; this hierarchy should correspond to the circulation hierarchy of the terminal and should be evident in a hierarchy of structure and spaces.

C. Spatial quality

The airport terminal is a major gateway to the city it serves. However, it differs greatly from the older type of gateway, the railroad station; whereas the railroad station achieves its impact as a large space or "great room" connecting the space of the railway carriage to the urban space surrounding the station, the air passenger terminal gains its effect as a free-standing mass surrounded by completely open space. As such a mass the terminal signals not so much the entry into the city, which has already been dramatically displayed to the passenger from the air, as the transition from one

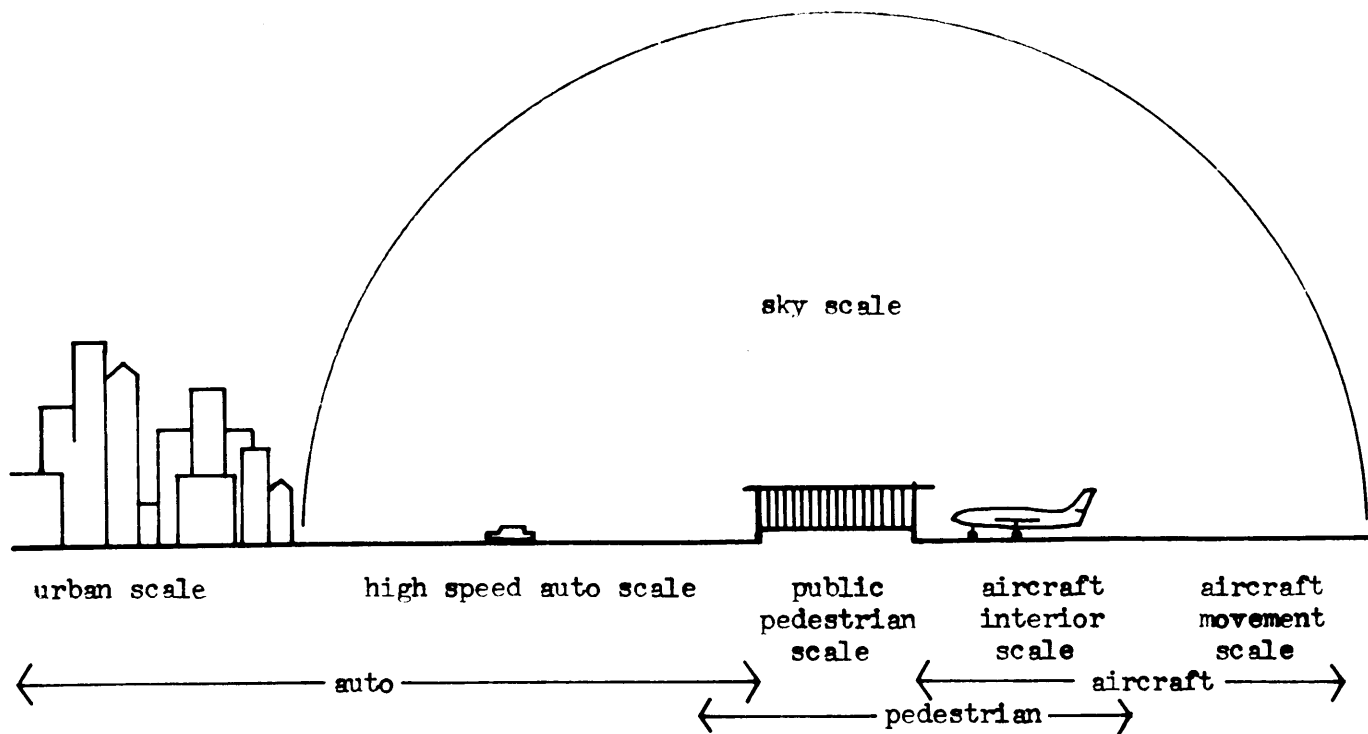
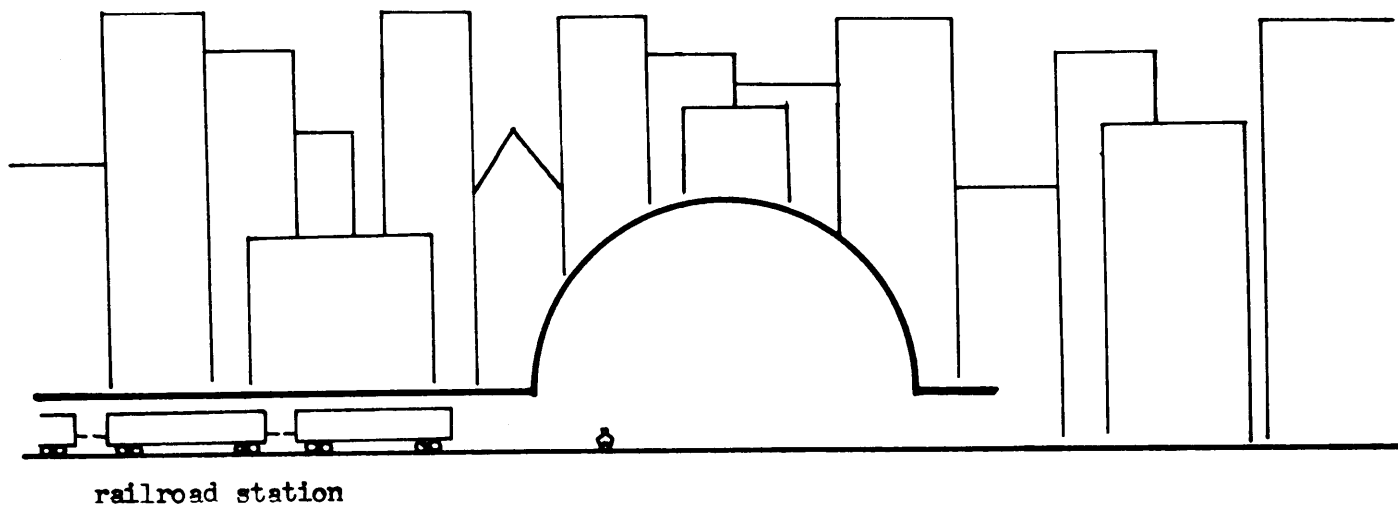


figure 17: ARCHITECTUAL SCALES AT THE AIRPORT



air passenger terminal

figure 18: DIFFERENCE BETWEEN RAILROAD STATION AND AIR PASSENGER TERMINAL

circulation system to another. Even within the terminal building itself the concept of a "great room" is questionable; since unlike the railroad station the air terminal allows and even demands the opening up of its rooms to the open space around it, thereby largely destroying any sense of definite spatial enclosure. (figure 18) Instead of a room, the terminal is an island, in that its location, definition, and expression come primarily from the mass relationships of the building's floor levels to one another and to the dominant surrounding apron level. Similarly, the structure of the terminal may be designed not so much to define and articulate space as to provide an orderly system of solid points of reference to which the passenger can continually relate himself. While the whole terminal is visually open to the surrounding area, the platforms and structure should be used, as masses, to definitely define the boundaries between the land-vehicle, the pedestrian, and the aircraft areas. Although the dominant expression of the air terminal is of "massive" platforms and structure, spatial composition is still important, particularly at the points of pedestrian to automobile and pedestrian to aircraft interchange.

D. Static character

The function of the air passenger terminal as the interchange node between various dynamic circulation systems seems to demand a nodal and static expression for the terminal building. The existence of the building as a free-standing mass also recommends a static expression. A further and perhaps the most important point supporting a static character for the passenger terminal is the need for a calm and restful environment for passengers, the majority of whom still have an uneasiness about air travel and its potential for well .

publicized disaster. This static quality should be inherent within the planning, circulation, and structure of the terminal. Although this static quality eliminates much of the "flight" and "jet age" symbolism inherent in recent designs such as Saarinen's T.W.A. and Dulles air terminals; the need of a more static expression is now being appreciated by airport designers. Examples of this change in thought are the new Athens Airport by Saarinen, the Memphis Airport by Mann and Harrover, and the Multi-Airline Terminal at Idlewild by I.M. Pei.

Appendix A:Program of building areas

Redesign of terminal facilities at General Edward L. Logan International Airport, East Boston, Massachusetts, for year of 1972

I. Air Passenger Terminal Area

21.

6,500,000 passengers per year

15% international passengers

22.

2400 typical peak hour passengers

23.

A. Buildings

sq. ft.

I. Passenger terminal facilities

ticket lobby

25,000

counter length

650 ft.

baggage claim lobby

20,000

counter length

650 ft.

waiting area

45,000

seats

1200

observation deck

concessions (news, shops, bank, etc.)

12,000

services (information, police, first aid)

4,000

conveniences (telephones, lockers, etc.)

3,000

restrooms - men

6,000

urinals and closets each

40

restrooms - women

5,000

closets

40

nursery

2,000

chapel

1,000

restaurant area

20,000

seats

1200

coffee shops and bars

15,000

kitchen area

35,000

airline operations (ticketing, baggage, flight)

90,000

customs and immigration

5,000

mail and cargo

10,000

airport maintenance and utility

10,000

308,000

circulation 25%

77,000

385,000

2. Terminal hotel		
lobby		1,000
administration and services		4,000
rooms (100 rooms at 250 sq.ft.)		25,000
circulation 20%		6,000
		<hr/>
		36,000
3. Airport, airline, and government offices		100,000
4. Flight kitchen		25,000
5. Control tower		
6. Subway station		
24.		
B. Aircraft positions	30	
C. Automobile parking		
public	5000	
employee	2000	
rental	300	
D. Helicopter landing area		
II. General Aviation Area		
25.		
70 fix-based aircraft		
A. Buildings: hangers, shops, passenger facilities		100,000
B. Aircraft positions	70	
C. Automobile parking	150	
D. Helicopter landing area		
III. Air Cargo Area		
150,000 tons per year		
26.		
A. Buildings - receiving, storage		250,000
B. Aircraft positions	15	
C. Automobile parking	400	
D. Helicopter landing area		

IV. Airline Maintenance Area

27.

A. Buildings: hangers, shops

1,000,000

B. Aircraft parking

10

C. Automobile parking

1000

Appendix B:

Noise Control within the air passenger terminal

One of the major problems at the air passenger terminal is the control of jet aircraft noise. This noise depends upon aircraft orientation, engine operation and noise frequency. (figure 19) Recently "fan-jet" engines have been developed with less noise, and it is expected that the noise level of future engines will be even further reduced.

The frequency at which the noise level is most important is at the 1200 - 2400 cycles per second range, since the human ear is most sensitive to these frequencies. The maximum noise levels in this range for various terminal areas follows:

Baggage handling	70 - 80 db
Baggage claim, kitchen, toilets	60 - 70 db
Lobby, concessions, dining	50 - 55 db
Ticket counter, offices	40 - 50 db
Nursery, conference rooms	35 - 40 db

The noise reduction between the apron and the terminal function depends upon distance and the building materials in between. Most air passenger terminals are now air-conditioned so there always exist a wall between the noise and the terminal interior. The affect of various wall materials upon noise transmission is illustrated. (figure 20) Proper acoustical design within each area will further reduce the affect of this jet noise.

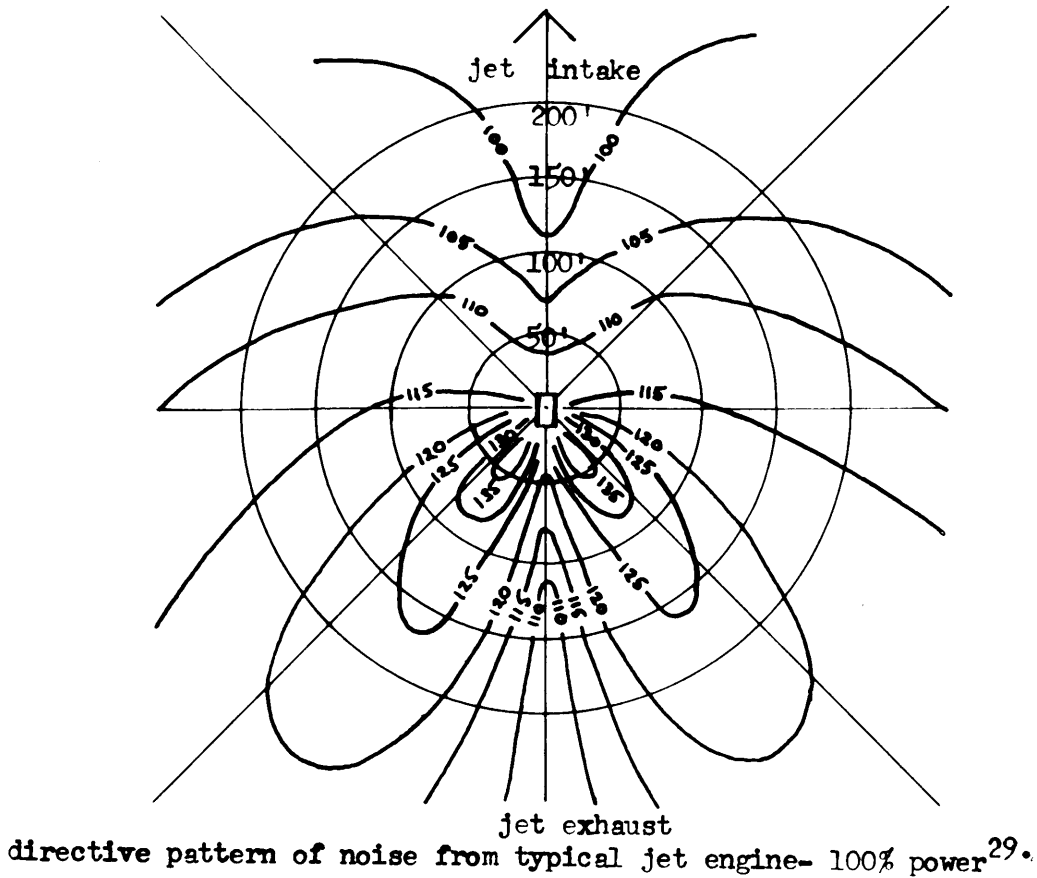
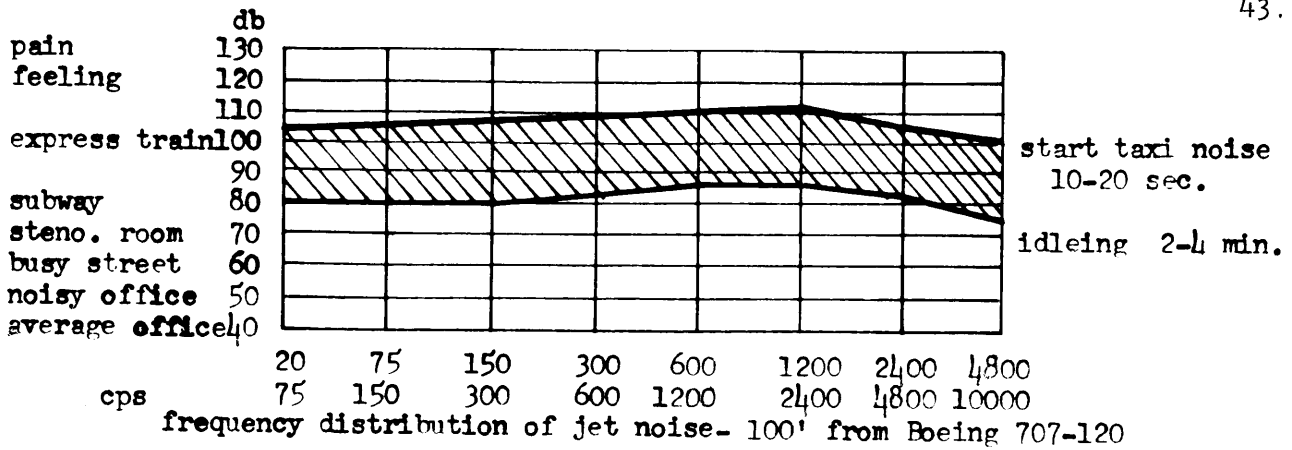


figure 19: NOISE CHARACTERISTICS OF JET ENGINES

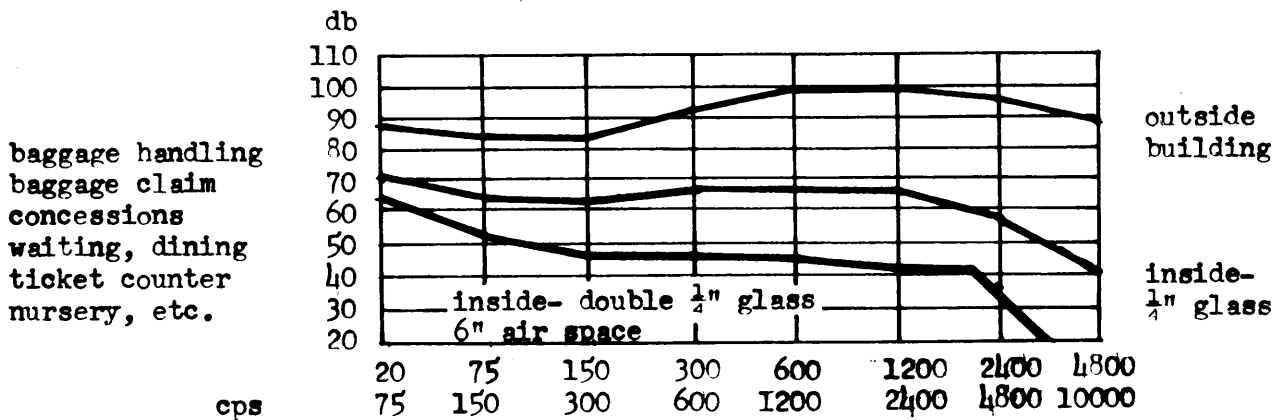


figure 20: JET NOISE AS AFFECTED BY WALLS - jet engines at idle, 100' from building³⁰.

Appendix C:

Parking structures at the air terminal

The air passenger terminal is the interchange point between land and air vehicles, and as such, must include provisions for both types of vehicles. One of these provisions is automobile parking for passengers, casual visitors, and employees. Almost always this parking is treated only as a necessary evil to be de-emphasized and hidden by landscaping. This negative attitude seems inconsistent with the functional and expressive importance of parking to the terminal. This appendix will investigate how parking can become a positive element in terminal design by the use of parking structures.

A. Need for parking structures

Since it is now necessary to provide $1\frac{1}{2}$ to 2 parking stalls for each typical peak hour passenger, ^{31.} the parking area at a large air terminal can become enormous. On the other hand, the walking distance to the terminal entrance should be less than 1000 feet, should be protected from the weather, and should be free from road crossings. All three of these are impossible with flat parking, whereas they can be solved to a very large extent by using parking structures.

B. Parking structure design

I. Mechanical or ramp parking structure

Of the two, ramp structures are the best for use at the air terminal since they are more economical in operation and provide quicker service. The major advantage of mechanical structures of occupying less land area is not significant at the airport.

2. Parking systems

a. Attendant parking - This is highly recommended for passenger parking, since the passenger can leave and pick up his automobile at the terminal entrance thus considerably shortening the distance he must carry his luggage. Also, since these automobiles will generally be stored for longer periods of time, they can be parked more densely and less accessibly by experienced attendants. An extra fee can be charged for attendant parking service.

b. Self-parking - This is the best for visitor and employee parking, since it is more economical and quicker. This system presents the problem of how and when the driver pays the parking fee; there are three possibilities:

- 1) no fee - Although this is simplest, it is not popular with the airport nor particularly with the airlines who would ultimately pay the parking fee
- 2) parking meter at each stall - This is very uneconomical, since not only must the meters be patrolled but they also present a maintenance problem
- 3) pick up ticket upon entering and pay on leaving - This is the best system, but has the disadvantages of limiting the number of access points to and from the parking and causing congestion at the few exit points.

3. Ramp systems (figure 21)

a. Vehicle circulation - Aside from the actual dimensions of the parking area (figure 22), the most important point of vehicle circulation is that it should be as simple and unambiguous as possible. To achieve this three things seem to be essential:

- 1) parking be segregated by length of parking time
- 2) a hierarchy of major routes through the parking level from which lesser routes extend to the actual parking stalls
- 3) use of only one way routes.

b. Pedestrian circulation - Although equally as important as vehicle circulation, this aspect of parking is generally ignored. One reason for this is the extremely flexible maneuverability of pedestrians; yet despite this flexibility, this circulation must be designed for maximum simplicity, clarity, and safety. The logical system is to provide walkways between the rows of automobiles, have these walkways connect to central pedestrian islands with a minimum of vehicle route crossings, and then have these central pedestrian islands connect through vertical circulation to the terminal entrance without crossing any major vehicle routes. (figure 23)

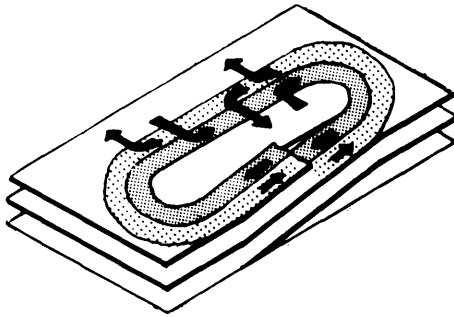
C. Relation between parking structure and terminal (figure 24)

I. Vertical separation

a. Parking under terminal - This system has the advantages

TYPES OF RAMP SYSTEMS

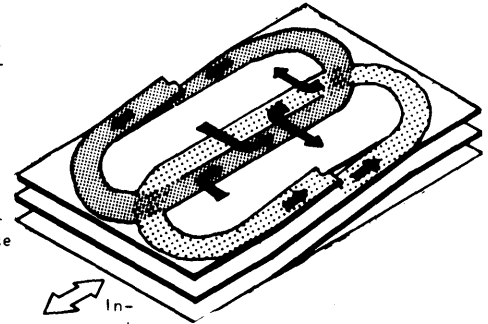
PARKING GARAGES



TWO-WAY STRAIGHT RAMP

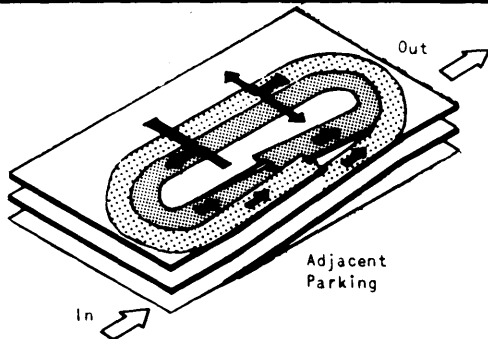
May be used in relatively narrow buildings, takes little area, is simple to construct.

2-way travel is hazardous and delaying. Best for use in only 2-3 story building.



PARALLEL STRAIGHT RAMP

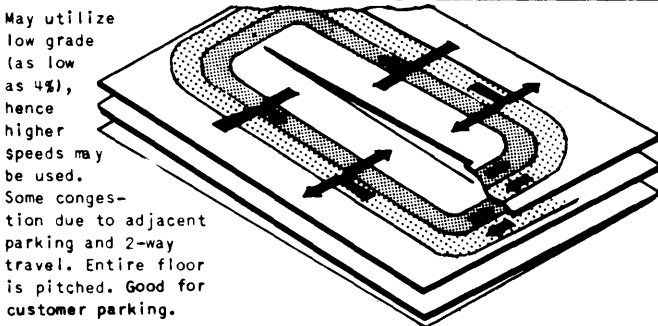
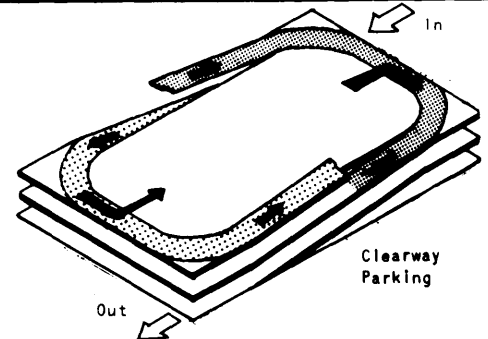
Takes small area, is simple to construct. Hazards and delays less than with 2-way straight ramp. Traffic crosses opposite lanes. Suited for buildings with entrance and exit on same street.



Conflicting movements somewhat less than in parallel straight ramp. Best suited for buildings with entrance and exit on separate streets.

Data on this page is from "The Traffic Design of Parking Garages" by Edmund R. Ricker, pub. by the Eno Foundation.

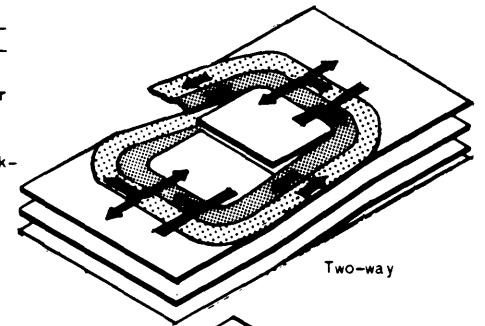
OPPOSED STRAIGHT RAMP



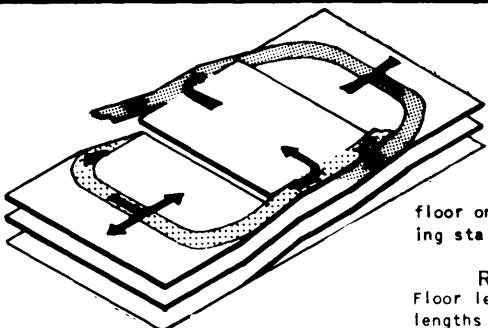
CONTINUOUS RAMP (SPIRALWAY)

May utilize low grade (as low as 4%), hence higher speeds may be used. Some congestion due to adjacent parking and 2-way travel. Entire floor is pitched. Good for customer parking.

Construction relatively simple. Efficient in terms of floor space per car stall. Up and down movement, parking and unparking, cause some conflict. Best suited for small, high cost site where maximum use of space must be made.



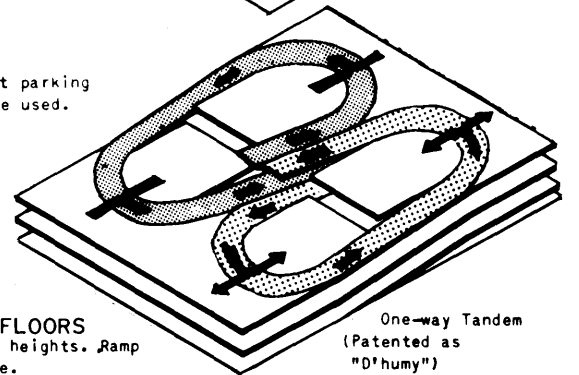
Two-way



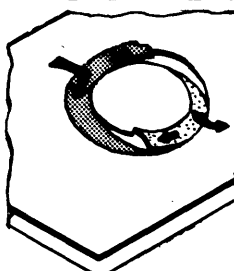
50% less turns required, travel time reduced. End sections have access only to up or down ramp and cars must travel extra 1/2 floor on entering, leaving stall floor level.

RAMP FOR STAGGERED FLOORS
Floor levels at intervals of 1/2 floor heights. Ramp lengths shorter. Takes least frontage.

Attendant parking should be used.



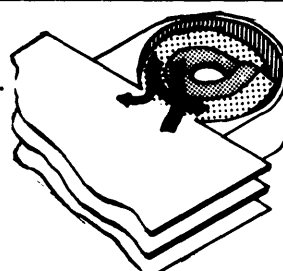
One-way Tandem
(Patented as "D'humy")



SEMI-CIRCULAR RAMP

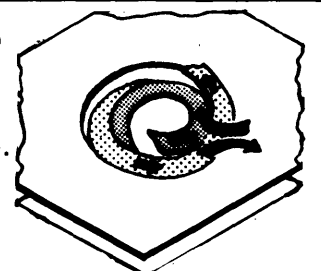
Few conflicts leaving or entering floors; shortest floor-to-floor travel paths. Area required larger than for straight ramp but less than for circular ramp. Two ramps may be separated and placed in corners of building.

Approaching drivers have clear view of storage floors. Entrance of ramps wasted and large ramp area required. Ramp suited for location at end or side of site.



PARALLEL CIRCULAR RAMP

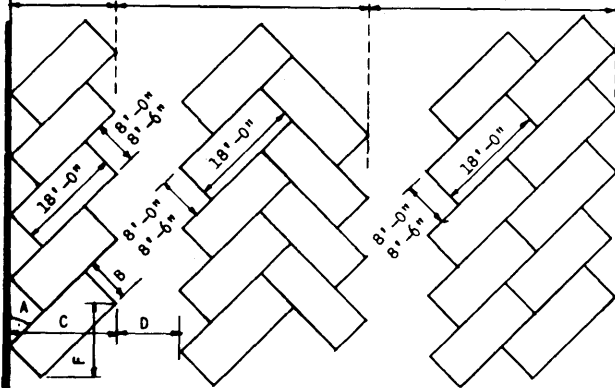
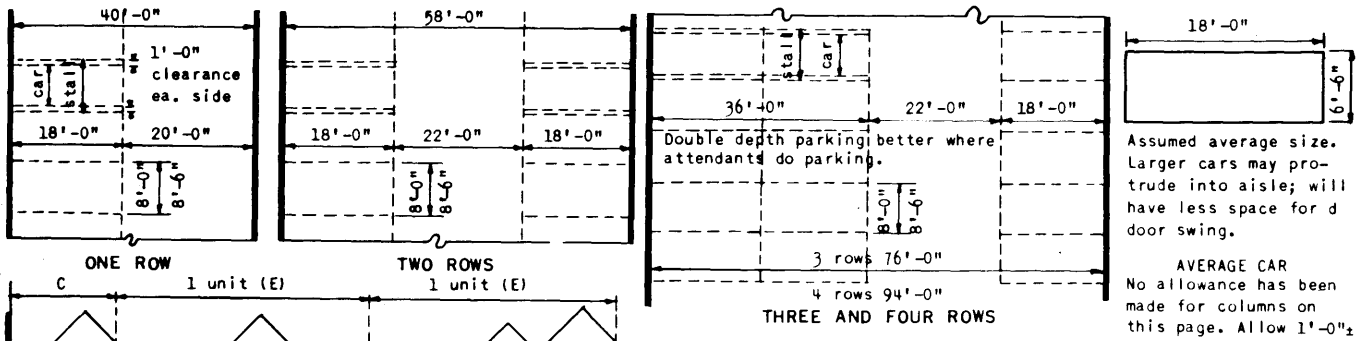
Drivers on up and down ramps do not see each other until they reach floor. Center area is wasted.



OPPOSED CIRCULAR RAMP

PARKING GARAGES

STALL AND AISLE DIMENSIONS FOR GARAGE AND LOT PARKING

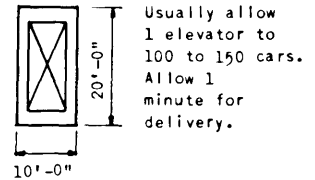
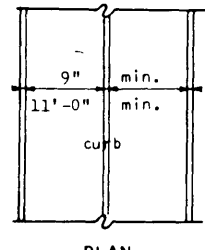
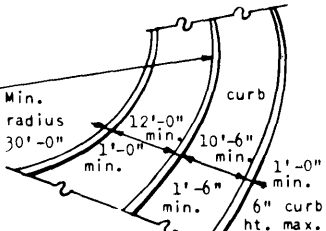
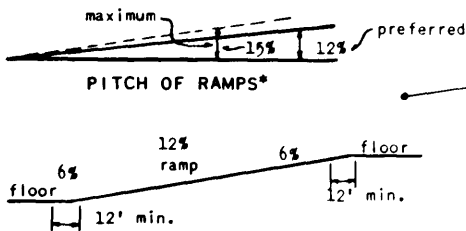


E = Unit Parking Depth (clear span construction). Angle-parking not feasible indoors; should be used only where space does not permit an integral number of 90° unit Parking Depths.

RECOMMENDED STALL & AISLE DIMENSIONS							
A	Direction of parking	B	C	D	E	No. of stalls in length X	Area per car sq. ft.
90°	back-in	8'-0"	18'-0"	22'-0"	58'-0"	$\frac{X}{8}$	232
60°	back-in	8'-0"	18'-10"	17'-4"	55'-0"	$\frac{X-11}{9.25}$	254
45°	drive-in	8'-0"	17'-2"	12'-8"	47'-0"	$\frac{X-17}{11.3}$	266
90°	back-in	8'-6"	18'-0"	22'-0"	58'-0"	$\frac{X}{8.5}$	247
60°	back-in	8'-6"	18'-10"	18'-4"	56'-0"	$\frac{X-11}{9.8}$	270
45°	drive-in	8'-6"	17'-2"	12'-8"	47'-0"	$\frac{X-17}{12}$	282

ANGLE-PARKING*

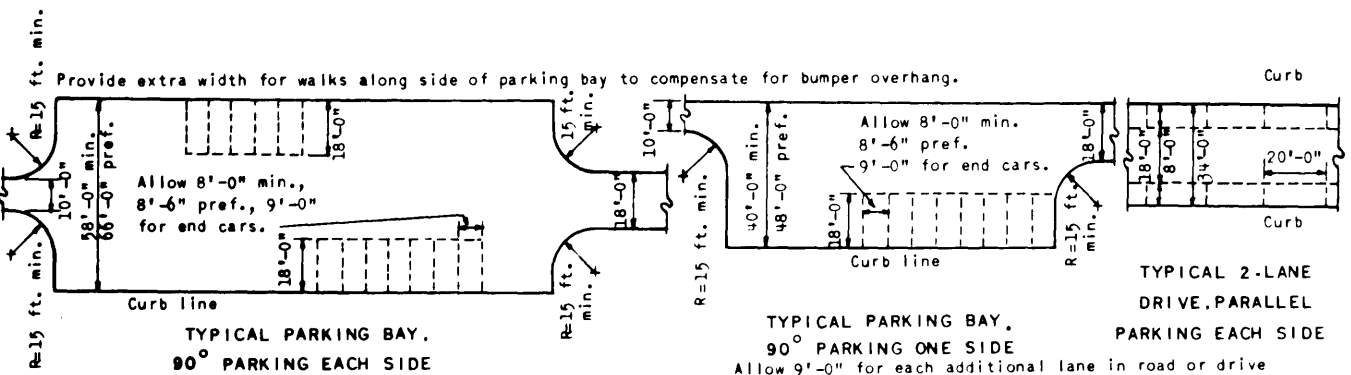
Use 8'-0" for attendant parking; 8'-6" for customer parking.



BLENDING RAMP & FLOOR GRADES* CURVED RAMP* STRAIGHT RAMP* ELEVATOR SHAFT

DATA FOR COMMERCIAL GARAGES

*Data from "The Traffic Design of Parking Garages" by E. R. Ricker, published by the Eno Foundation. When clear span (see "E" in table above) is not available, use 25'-6" between column faces. Clear ceiling height 7'-6". Floor-to-floor height 8'-6" to 10'-0". Super elevation of curved ramps 0.1 to 0.15 foot per foot.



OFF-STREET PARKING

Data supplied by Ralph Eberlin, C.E.

figure 22: PARKING DIMENSIONS 33.

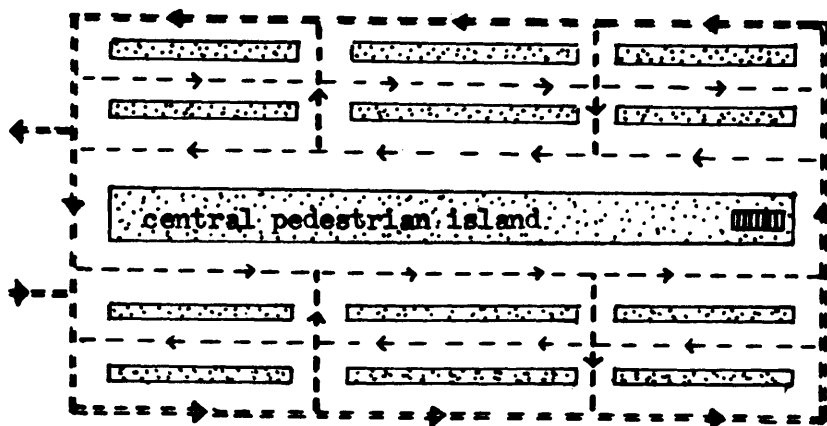
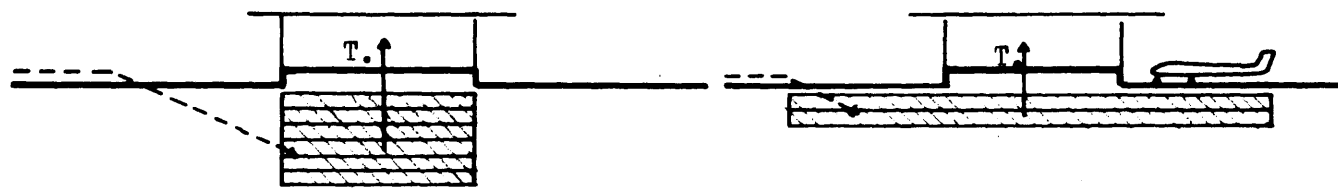
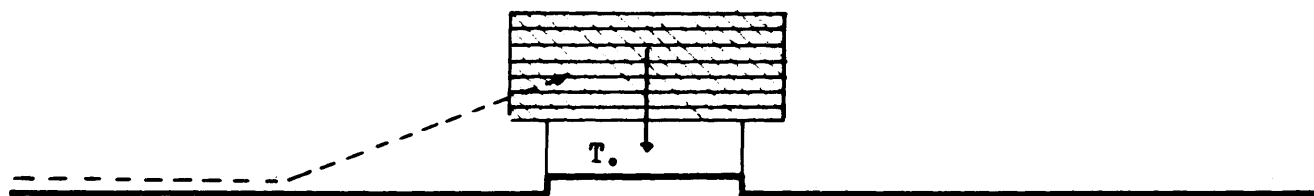


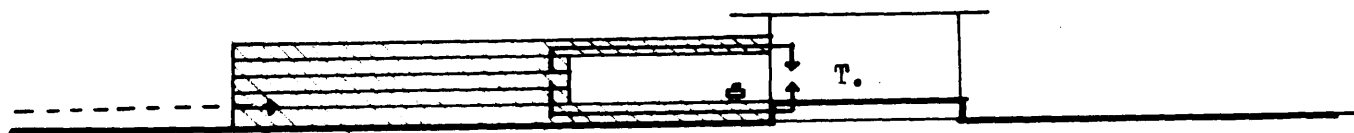
figure 23: VEHICULAR AND PEDESTRIAN CIRCULATION



parking under terminal



parking over terminal



parking beside terminal

figure 24: RELATION BETWEEN PARKING AND TERMINAL

vehicle - - - - ->
 pedestrian ———>

of good vehicle and pedestrian circulation. It does not interfere with the flexibility of the terminal, and the structure of the terminal and of the parking can easily correspond. However, this system has some problems. If the parking is only under the terminal, too many floors of parking will be needed, and if the parking extends under the apron, structural problems arise of carrying the dynamic loadings of the large aircraft. Underground parking also presents problems of ventilation and of expansion. By hiding the parking underground the expression of the terminal as an interchange is weakened considerably. A project using this type of parking relationship is ^{34.} Sergio Bernardes' Brasilia Airport.

b. Parking over terminal - This system has the advantages of good pedestrian circulation, easy ventilation, and a very clear and strong statement of the terminal as interchange. However, due to the height limitations at the airport (figure 6) and to the area of the terminal, this type provides only a limited amount of parking. There are also difficult problems in corresponding the short span structure of the terminal underneath and in vehicular access to the parking levels. The new Toronto Airport by John Parkins uses this system in a slightly modified ^{35.} form.

2. Horizontal separation

This system has the advantages of separating the vehicular traffic completely from the terminal, of allowing the optimal structure system to be used for each function, generally does not have ventilation problems, allows almost complete flexibility and expansion for each function, and provides an expression of land vehicles' importance to the terminal. The major disadvantage is pedestrian circulation between parking and the terminal: since the loading and unloading ramps must be between the two, it is necessary to bridge over or go under these ramps, thus causing excessive vertical circulation. Although the parking structure aids the expression of the terminal, there is also the problem that the parking will dwarf the terminal building itself; this is particularly true when approaching the terminal by automobile. This system seems to be in all the most feasible for large airports, despite these problems.

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7. Massachusetts Port Authority air traffic data
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17. Ibid, page 78
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19. R. Horonjeff: op. cit.; page 256
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Average occupancy time 45 minutes
Runway capacity 80 operations/hour
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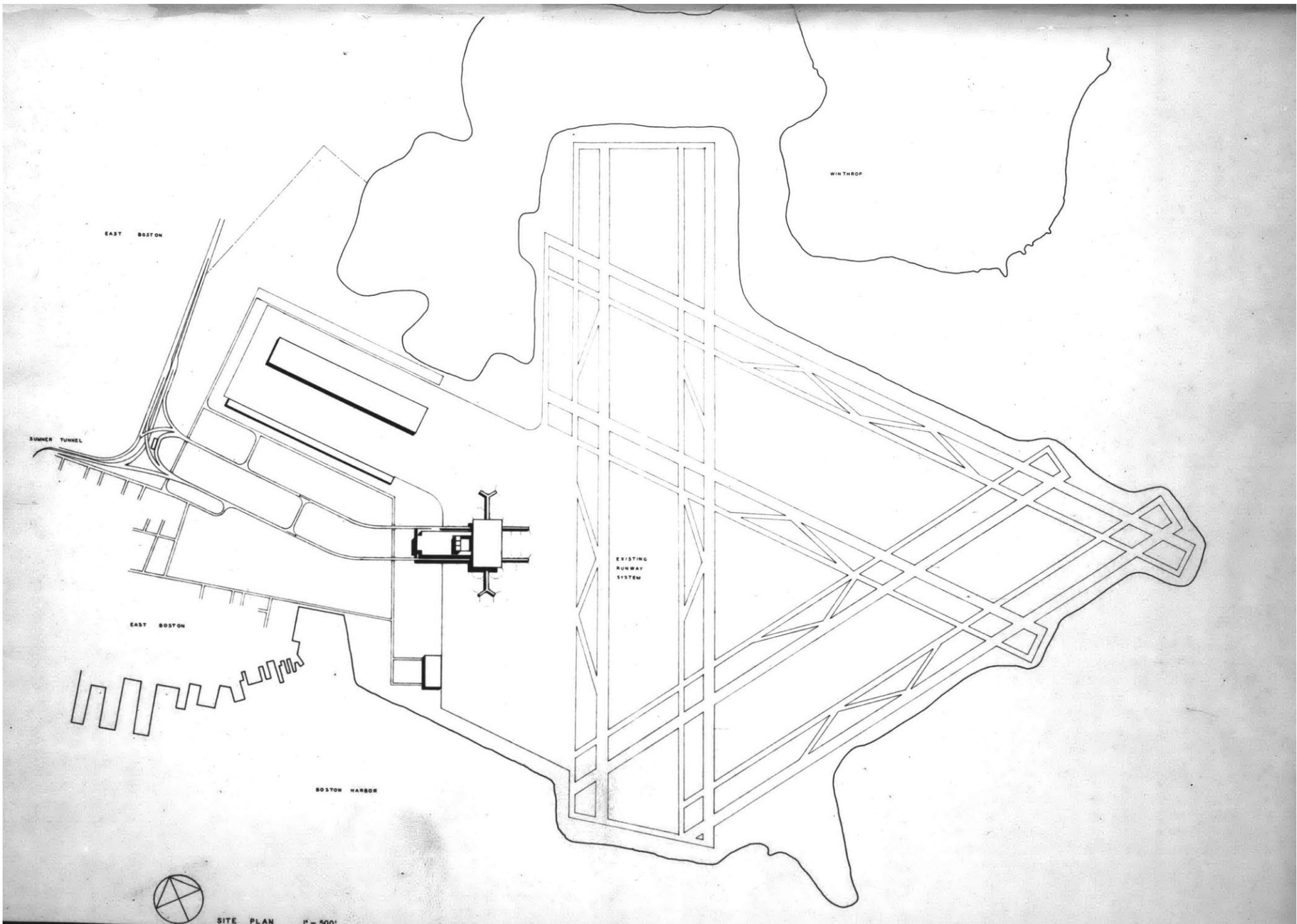
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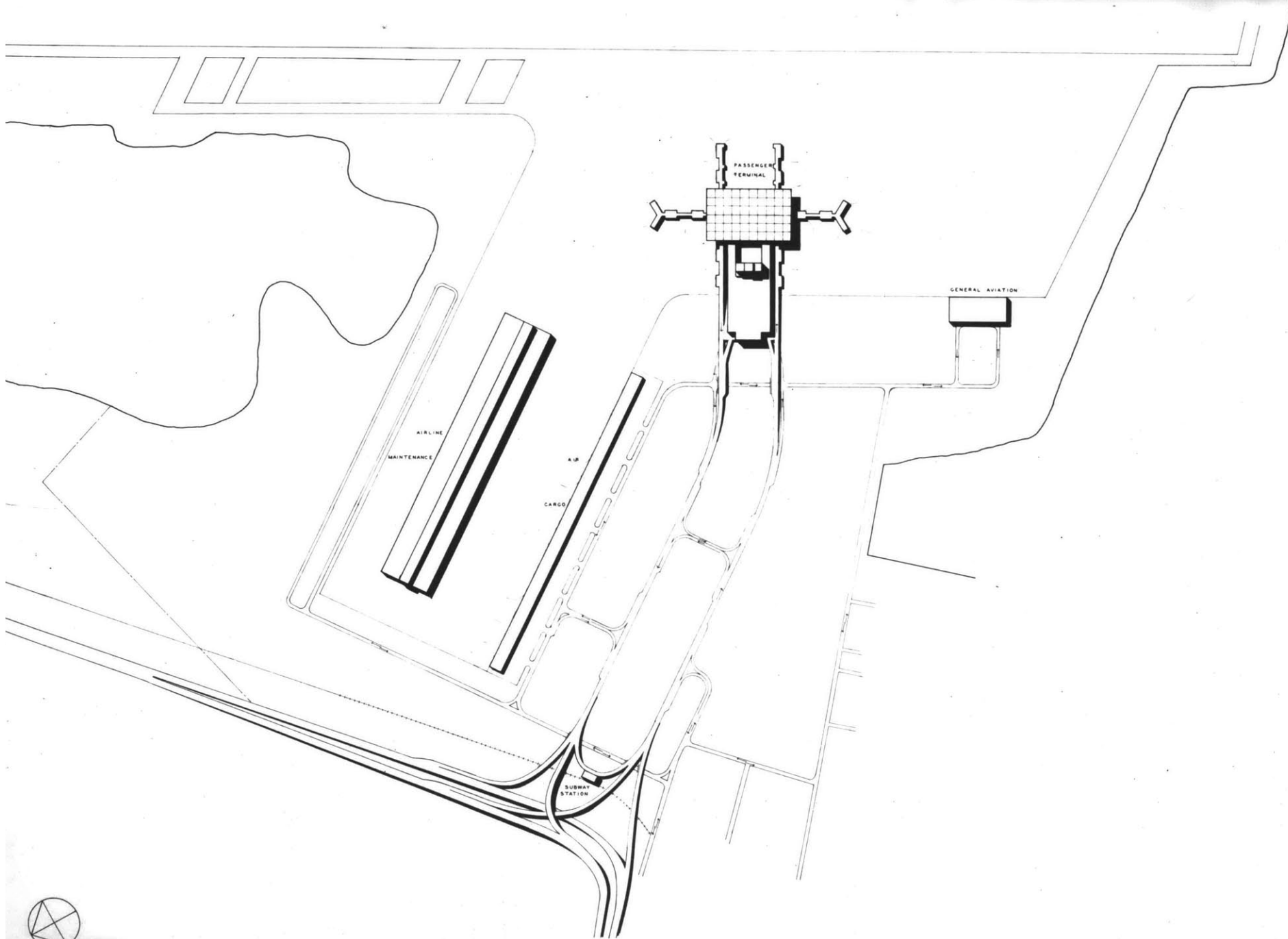
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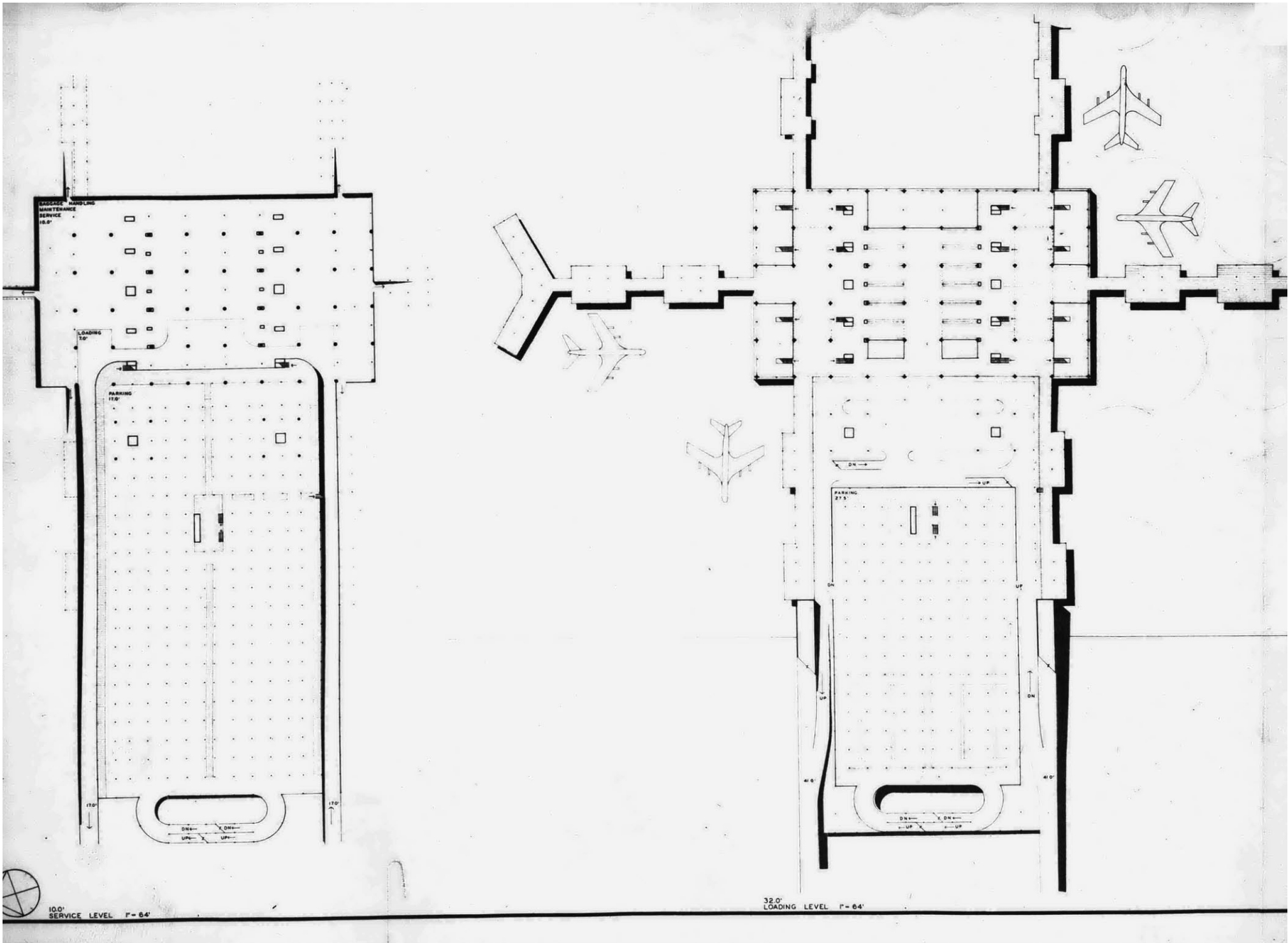
TERMINAL FACILITIES — LOGAN INTERNATIONAL



TERMINAL FACILITIES 1" = 300'

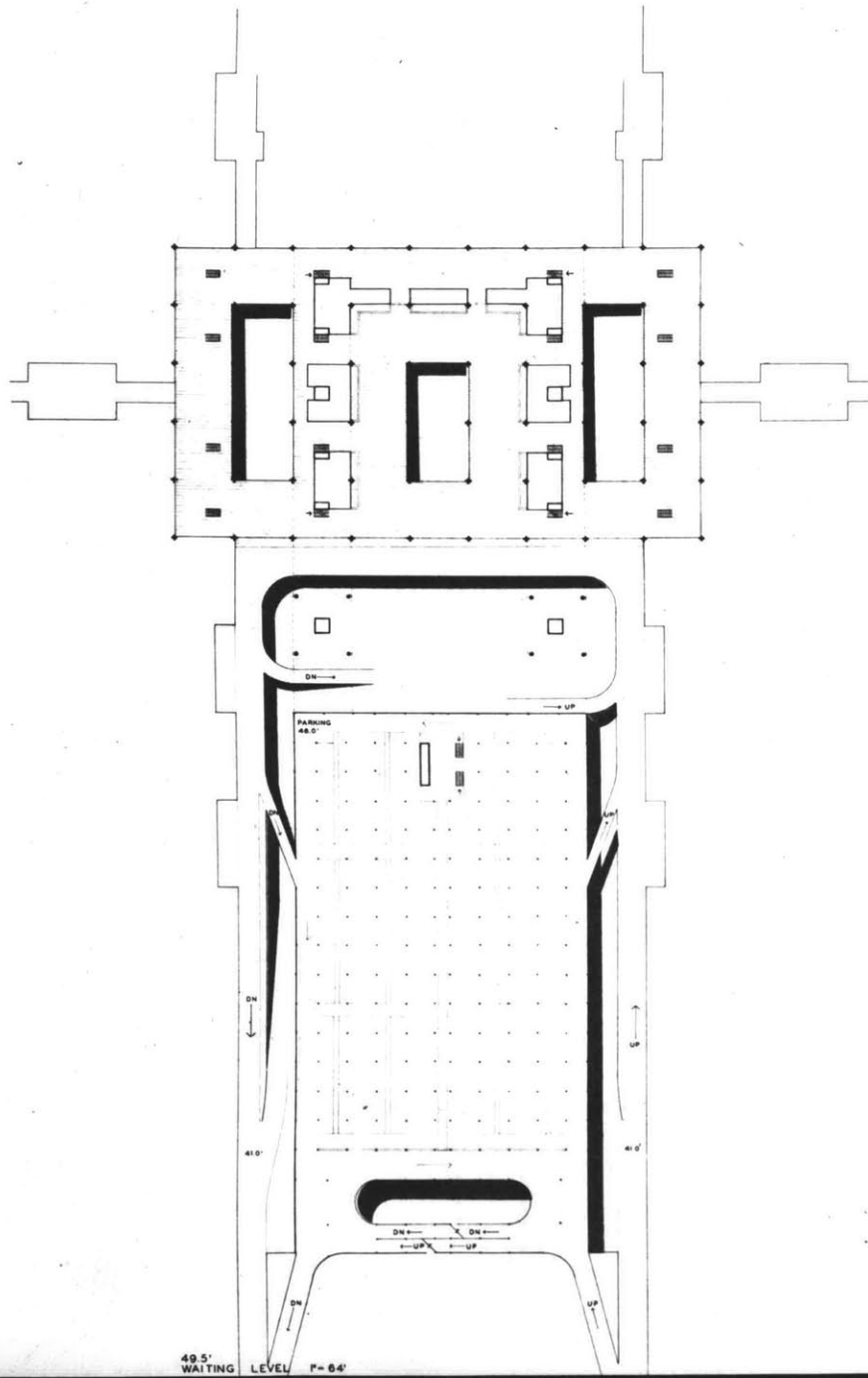
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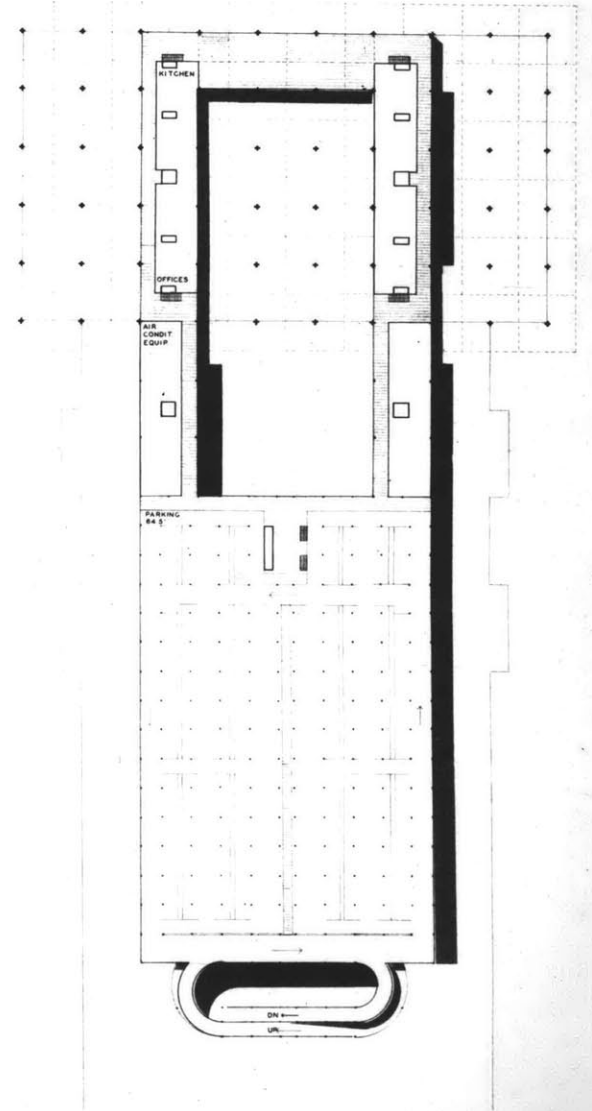


10.0' SERVICE LEVEL F-64

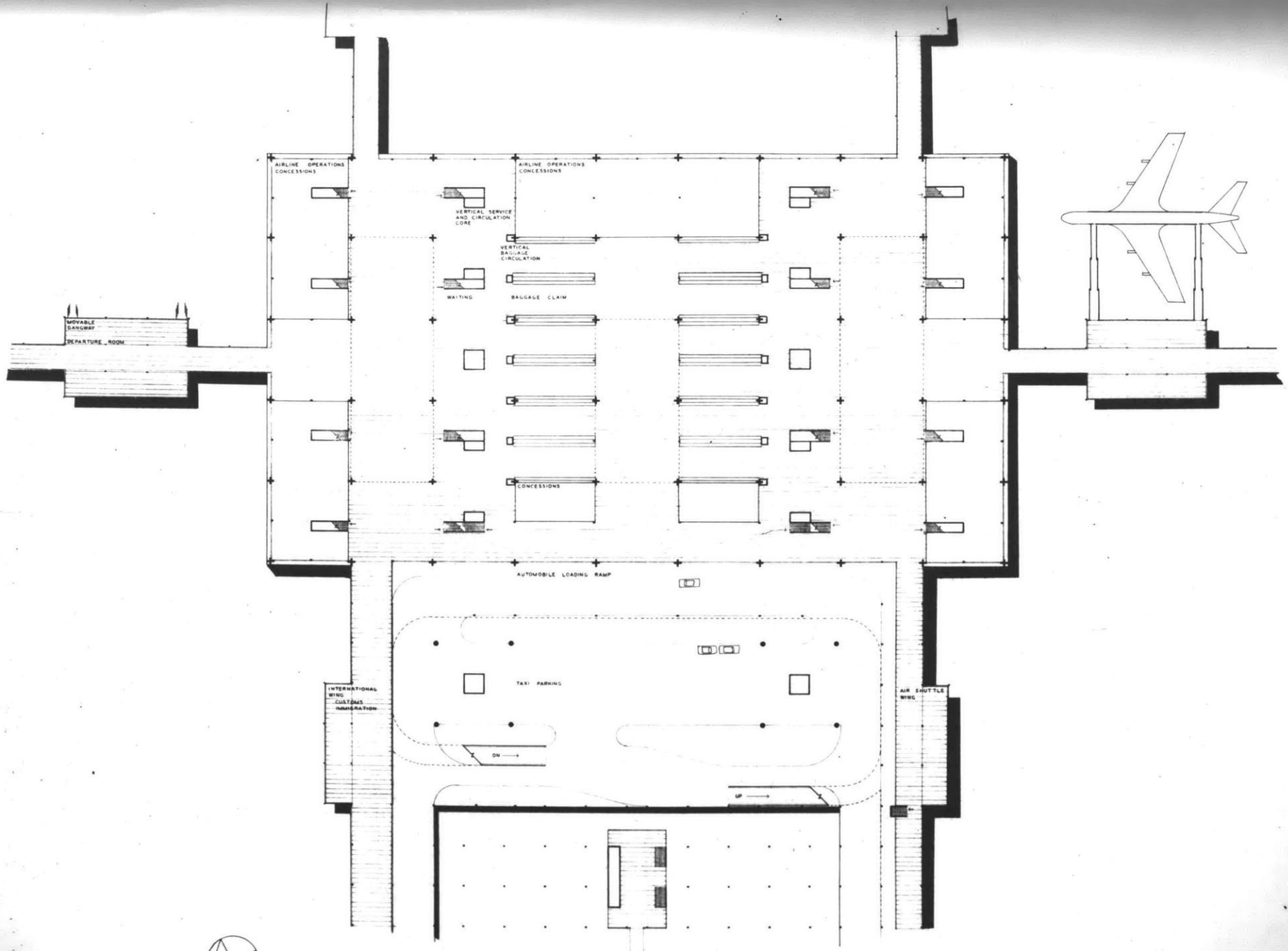
32.0' LOADING LEVEL F-64



49.5' WAITING LEVEL F-64



66.0' DINING LEVEL I'-64'



AIRLINE OPERATIONS
CONCESSIONS

AIRLINE OPERATIONS
CONCESSIONS

VERTICAL SERVICE
AND CIRCULATION
CORE

VERTICAL
BAGGAGE
CIRCULATION

WAITING

BAGGAGE CLAIM

CONCESSIONS

MOVABLE
GANWAY
DEPARTURE ROOM



AUTOMOBILE LOADING RAMP

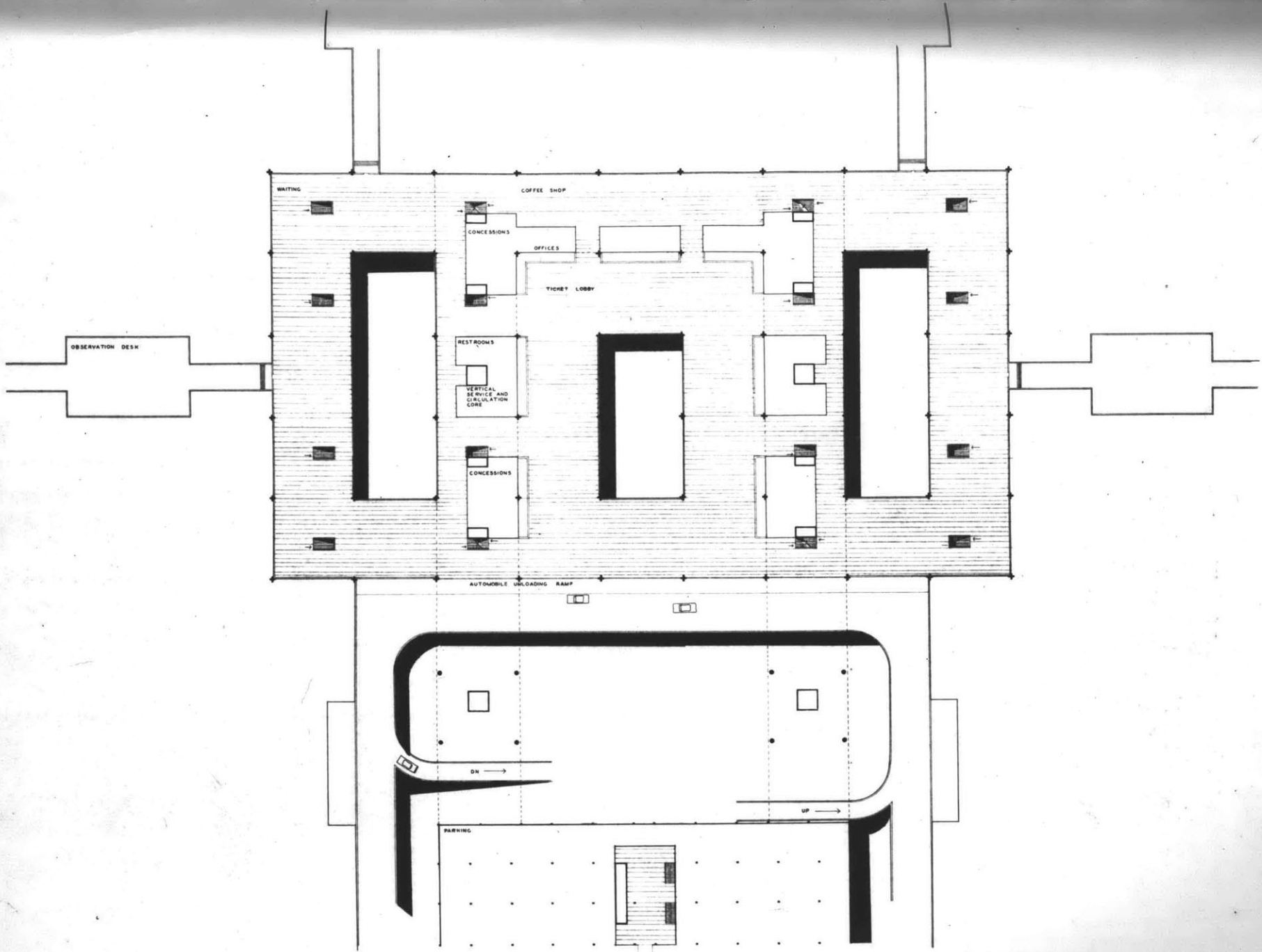
TAXI PARKING

INTERNATIONAL
WING
CUSTOMS
IMMIGRATION

AIR SHUTTLE
WING



32' 0"
LOADING LEVEL P = 32'

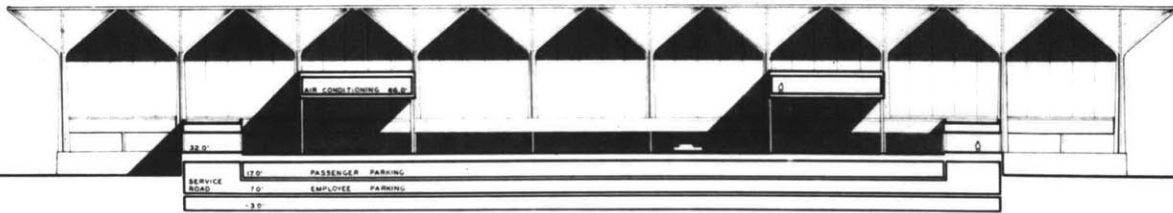


49.5'
WAITING LEVEL 1" = 32'

ELEVATION 1" = 32'

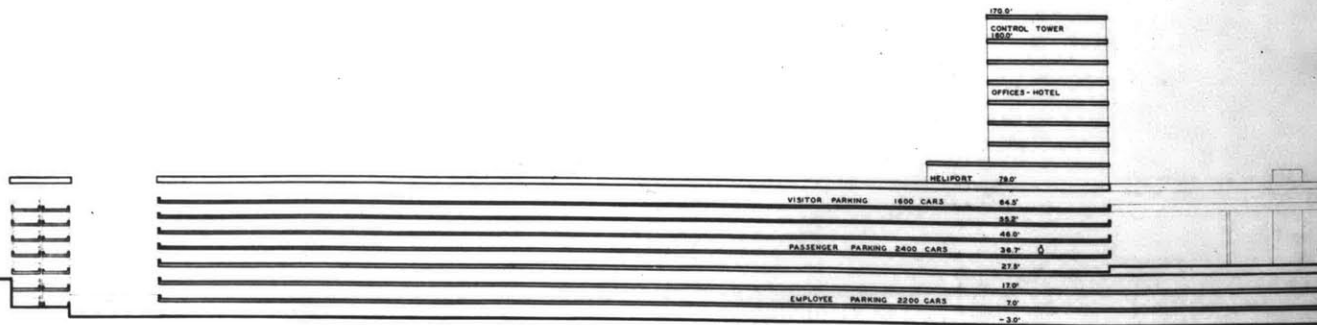


00'



17.0' PASSENGER PARKING
SERVICE 17.0' PASSENGER PARKING
ROADS 7.0' EMPLOYEE PARKING
-3.0'

25.0'



175.0'
CONTROL TOWER
160.0'
OFFICES - HOTEL
HELIPORT 78.0'
VISITOR PARKING 1600 CARS 64.5'
PASSENGER PARKING 2400 CARS 36.7'
EMPLOYEE PARKING 2200 CARS 7.0'
-3.0'

OUTH ELEVATION 1" = 32'

