

Rochester Institute of Technology

A Thesis submitted to the Faculty of
The College of Imaging Arts and Sciences
in candidacy for the degree of
Master of Fine Arts

Airport Design

by

Long-Wen Chen

1999

Approvals

Chief Advisor: Charles F. Lewis _____

Date 2-3-99

Associate Advisor: Nancy Chwiecko _____

Date 2-3-99

Associate Advisor: Doug Cleminshaw _____

Date 99 Feb 03

Chairperson: Charles F. Lewis _____

Date 2-3-99

I, Long-Wen Chen, would like to be contacted a request for production is made, I can be reached at the following address:

8F, No. 351, Chang Chun Road

Taipei, Taiwan

lxc0190@rit.edu

Signature _____

Date 2-3-99

CONTENTS

ACKNOWLEDGEMENTS	i
LIST OF TABLES	ii
LIST OF ILLUSTRATIONS	iii
LIST OF ABBREVIATIONS	vi
GLOSSARY	vii
PREFACE	ix
PROPOSAL	x

CHAPTER

I. INTRODUCTION	1
II. BACKGROUND INFORMATION	3
What is an Airport ?	3
Airport Land Planning	4
Airport Land Needs	4
Airport System Planning	4
A Data Base for Airport System Planning	5
Traffic Data	5
Demand Characteristics	5
Airport Data	5
Supply Data	7
Socioeconomic Data	7

Physical Elements of the Masterplan	7
Standards of Space Requirements	8
Elements to be Considered in Design of Air Freight Terminals	9
1. Market Demand Forecast	9
2. Forecast of Aircraft Fleet and Flight Activity	9
3. Main Capacity Constrained Elements of Design	10
4. Cargo Handling Concept Choice	10
5. Site Selection Factors	10
6. Architecture Decisions	10
7. Other Areas to be Included	10
8. General Design Considerations	12
Airport Master Planning	12
Airport Layout Basic Factors and Types	13
III. DESIGN DEVELOPMENT	19
Concept Development and Evaluation	19
IV. DESIGN EVOLUTION	22
A. The Original Concept	22
B. Concept Evolution	26
C. Final Concept	26
1. Apron Ceiling Structure	26
2. Vertical Separation	32
3. Central (Departure/Check-In) Building	32

4. Air Traffic Control Building (Navigation Tower)	35
5. Satellite (Arrival/Pick-Up) Building	39
Airport Prototype	42
V. DESIGN RESULTS	45
VI. CONCLUSION	62
BIBLIOGRAPHY	64

ACKNOWLEDGEMENTS

I would like to take this opportunity to thank my advisors, Charles F. Lewis, Douglas Cleminshaw and Nancy Chwiecko, who have always helped me and have given me ideas. Furthermore, during the developing periods before the thesis exhibition, Professor Craig McArt gave me many ideas for building a model and performing my work. I highly appreciate all the help they have given me. Their concerns about the many problems involved in acquiring land for new airports or for the expansion of existing ones have encouraged me to conduct this study as a means of presenting more explicitly the difficulties of airport planning in metropolitan areas.

The growing need for resource planning for air transport is reflected in the updated thinking in the latest publications in this area by the International Civil Aviation Organization (ICAO) and the Federal Aviation Administration (FAA), as well as some non-governmental organizations such as the International Air Transport Association (IATA), Airport Association Council International (AACI) and Institute of Air Transport (ITA).

Naturally, any errors of omission and/or commission are mine alone.

LONG-WEN CHEN

Rochester, NY
January 1999

LIST OF TABLES

TABLE	PAGE
2.1 Typical Peak Hour Passenger (TPHP) flow as a percentage of annual flows for different amount of passengers	8
2.2 Space required for domestic terminal space facility	8
2.3 Additional space required for international terminal space facility	9

LIST OF ILLUSTRATIONS

FIGURE	PAGE
Chapter II	
2.1 Flow chart of analysis for airport system planning	6
2.2 Passenger/ Baggage flow system	11
2.3 Airport System planning (1).....	13
2.4 Airport System planning (2)	14
Chapter IV	
4.1 Concept (1)	23
4.2 Concept (2) -Unit Terminal	24
4.3 Concept (3) -Linear Terminal	25
4.4 Concept (4) -Unit Terminal with Piers	27
4.5 Concept (5) -Terminal with Piers	28
4.6 Concept (6) -Terminal with Satellite	29
4.7 Concept (7) -Triangle Terminal Concept	30
4.8 Roof Plan	31
4.9 Typical vertical separation arrangements of passenger and baggage	33
4.10 Cargo Level Transmit Belts Arrangement	34
4.11 Central Terminal (Departure Building) 1F Floor Plan	36
4.12 Central Terminal (Departure Building) 2F Floor Plan	37

4.13 Model concept of Air Traffic Control Building	38
4.14 Satellite Terminal (Arrival Building) 1F Floor Plan	40
4.15 Satellite Terminal (Arrival Building) 2F Floor Plan	41
4.16 Perspective of 2F Satellite Terminal Concession Concourse/Lobby	43
4.17 Boarding device concept	44

Chapter V

5.1 Site plan	46
5.2 1F Arrangement	47
5.3 2F Arrangement.....	48
5.4 Section of Satellite terminal	49
5.5 Concept Model (1)	50
5.6 Concept Model (2)	51
5.7 Concept Model (3)	52
5.8 Concept Model (4)	53
5.9 Concept Model (5)	54
5.10 Concept Model (6)	55
5.11 Concept Model (7)	56
5.12 Concept Model (8)	57
5.13 Concept Model (9)	58

5.14 Concept Model (10)	59
5.15 Concept Model (11)	60
5.16 Concept Model (12)	61

Missing Page

GLOSSARY

Airport

An area of land (including buildings, runways and control towers) for the arrival or departure of aircraft

Airport Roads

Network of public and private roads providing access to airport buildings and areas

Airside

Area under government or airport control providing access to aircraft, and prohibited to non-traveling public

Apron

Paved area on airside where aircraft are parked

Arriving passenger

A passenger arriving at terminal by air

Baggage

The personal property of a passenger

Carousel

Rotating baggage-claim device

Concessions

Passenger amenities provided by retail, food services etc

Concourse

Open space or hall in passenger terminal, used for circulation or waiting

Departing passenger

A passenger departing from a terminal by air

Deplaning

To disembark from an airplane

Domestic flight

Flight within a single country not involving government control

Dwell time

Time that a passenger spends in a terminal

Enplaning

To board an airplane

Gate

Point of passenger access to aircraft

Gate lounge

Waiting area adjacent to gate

Inbound Baggage

Inward bound baggage collecting area

International Flight

A flight between two or more countries, and subject to government controls

Landside

Area of airport terminal to which non-traveling public has access.

Moving Passenger Conveyor

A transportation system for moving large numbers of people travelling distances too great on foot

Outbound Baggage

Outward bound baggage

Pier

A protruding extension to a terminal building giving access to aircraft gate

Satellite Building

Building surrounded by aircraft gate positions, normally separate from terminal building

Screening

Security checking by personal or electronic means of passengers, baggage, freight, and airport supplies

Terminal Building

A building between landside and airside where passenger and baggage processing takes place

Transit Lounge

Area set aside for passenger who has arrived by plane but is not terminating his travel there

Visitor

Non-passenger and non-employee using terminal building

PREFACE

“Airport and hospital design are the two most complicated design projects.” according to Charles F. Lewis, my chief advisor and Chairman of the Department of Industrial and Interior Design at Rochester Institute of Technology. When he told me that at first, I did not believe what he said. I just thought that there must be some way to improve the design of existing airports. Also, it was the first idea I had for my graduate thesis project. I started doing research and found that it was much more difficult and complicated than I had thought because of the many details, which not only an interior designer, but also an architect, needs to consider, as well as the professional knowledge required. It was also a big challenge for me as an interior designer to understand more about architecture. Seeking that challenge, I chose Airport Design as the subject for my thesis.

PROPOSAL

The purpose of this thesis is to improve the design of airport terminals to provide a more convenient environment for passengers and airport staff.

I intend to enhance the comfort, convenience, and experience of air travel and shorten the time required from arrival to check-in to boarding.

CHAPTER I

INTRODUCTION

A look at the early airports, aircraft factories, and airliners themselves, reveals that their design vocabulary reflected designers' efforts to encounter society's feelings of ambivalence and insecurity toward this new mode of transportation. This design proposes a new generation terminal which does not exist today.

The objectives of this thesis are to:

1. Create and design a totally new terminal which can be used on any kind of airport site in the future. Most current airports are designed and restricted to the area, location, and terrain of the airport land itself. Thus, to create and design a new terminal, free from any restriction listed above, is the priority of this study.
2. Design the terminal to be easily expanded in the future when necessary. An existing airport might alter its design and original structure as necessary in the future. The goal of this thesis study is to retain the existing terminal building.
3. Shorten the time and improve the process for passengers from check-in to boarding without undermining the airport, aircraft and airline security.
4. Create a more humanistic, more convenient and more thoughtful environment for passengers. Frequently, those passengers who are reboarding from large to small

aircraft, or from international to domestic flights, need to face unfavorable weather conditions because there is no enclosed access between aircraft and terminal. If the weather condition is unsatisfactory such as windy, raining, snowing, or hot, passengers have no choice but to bear it without any protection.

5. The most important part of this thesis study, airport design, is to create a new generation of airport terminal building. Passengers will experience the same humanistic, convenient, and thoughtful environment to access the aircraft, regardless of size or location.

CHAPTER II

BACKGROUND INFORMATION

WHAT IS AN AIRPORT?

Airports are large, complex and generally highly profitable industrial enterprises. They are part of a nation's essential transportation infrastructure, which, besides providing thousands of jobs at the airport itself, supports a much broader audience in social and economic terms. It has been estimated that for every job at the airport, an additional one is created in the region. As large industrial complexes, airports consist primarily of:

- runways and taxiing areas
- air traffic control buildings
- aircraft maintenance buildings
- passenger terminals and car parks
- freight warehouses

For the architect, the passenger terminal is the main airport building and an opportunity for architectural expression. Organizationally, the terminal building is the key element within the airport estate. It is, however, just part of an integrated system, which involves a complex interaction between airline companies, airport authorities and the traveler. The reputation of an airport is, however, determined by the quality of its terminal buildings, not just as architectural imagery but in terms of customer needs.

Well-designed terminal buildings enhance the reputation of the airline companies that use it, and the airport itself, and ensure that passengers enjoy a comfortable, stress-free start and end to their journey. ¹

AIRPORT LAND PLANNING

Airport Land Needs

During the next decade, substantial expenditures will be needed to acquire land for new airports and for the expansion of many existing ones. The acquisition of suitable, well located land for airports in or near metropolitan areas is going to become increasingly difficult and expensive during the next decade. Predicted rapid growth in urban population, increased automobile ownership, improved highways, and greater affluence mean that suburban areas will continue to spread out farther from central cities. Large scale developments such as new towns, extensive subdivisions, industrial districts, interstate highways, and parks will compete more intensively for sizable tracts of open land. These and other activities, such as commercial development, which are attracted by suburban residential expansion, will often encroach on existing airports making their expansion more difficult. ²

Indeed, rapidly increasing population in urban areas make it more difficult to find airport land. To design a new generation of airport is extremely important to overcome those difficulties and limitations of airport land in urban and adjoining areas.

Airport System Planning

Air travel is itself made up of a number of component systems:

- Airways
- Airports
- Airlines
- Aircraft
- General aviation
- People
 - * Air passenger
 - * Airline and airport employees
- Operation environment

“Airport system planning, however, frequently has to be carried out as part of the exercise of master planning at one or more airports within the system.”³

A Data Base For Airport System Planning

The following is a comprehensive data base recommended by A. Kanafani⁴:
Figure 2.1 indicates the method of predicting an individual airport’s share of total system traffic.

Traffic Data

- Route and city-pair specific data, including origin/destination flows
- Airport specific traffic data
- Traffic by other modes especially in short-haul situations

The traffic data should be obtained on an annual basis, as well as on a monthly and daily basis. The data should cover both passengers, cargo tonnages, and aircraft operations. For the calibration of demand forecasting models, it is necessary to obtain traffic data for at least seven years.

Demand Characteristics

- Origin destination demand
- Trip purpose distributions for passenger demand
- Commodity classifications for cargo demands
- General aviation activity demand

Airport Data

- Financial results, operation costs, and revenues
- Facility inventories
- Capacity
- Temporal traffic patterns, including hourly distributions
- General aviation-based aircraft and fixed-base operators

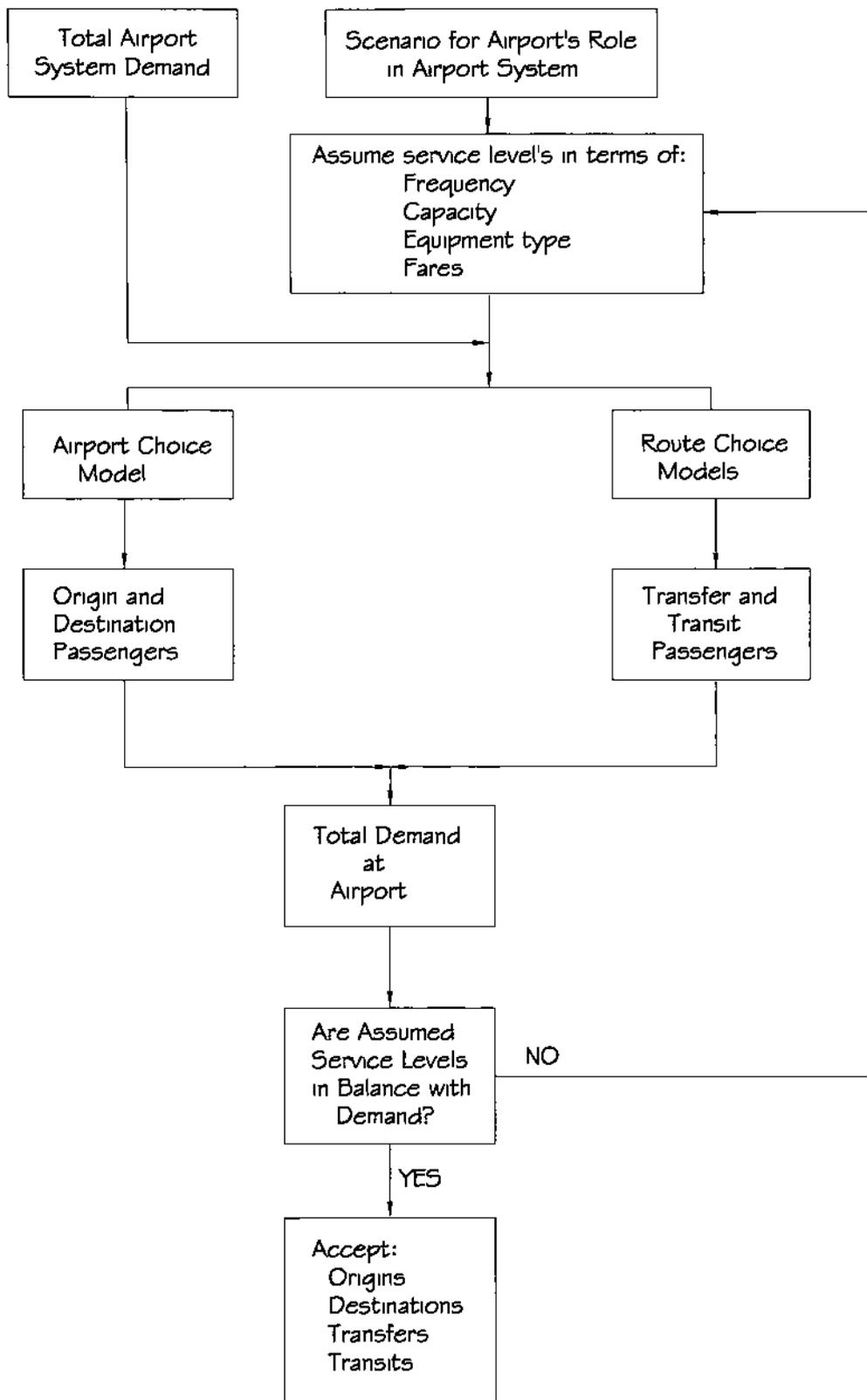


Figure 2.1 Flow chart of analysis for airport system planning

- Airlines served
- Access traffic conditions and facility inventories
- Safety records
- Weather conditions
- Traffic operating patterns, including delay characteristics

Supply Data

- City pair available capacity
- Schedules and fares for passengers and cargo
- Load factors prevailing
- Airline operating cost data

Socioeconomic Data

- Economic studies for regions and economic plans, if available
- Population and demographic characteristics and forecasts, if available
- Income characteristics and consumption patterns
- Foreign and tourism trade patterns
- Resource costs, including labor, fuel, and other inputs to aviation systems. Prevailing land use patterns, both locally and regionally⁵

Physical Elements Of The Masterplan

Masterplanning an airport is a team effort, but the architect or engineer is normally responsible for the physical disposition of the parts. It involves three principle elements:

1. Runways and taxiways
2. Hangers and service aprons
3. Terminals

and several secondary ones:

- Roads and car parks
- Security enclosure
- Air traffic control tower

- Airport railway station and light rail system
- Hotels, conference facilities etc.
- Freight warehouses⁶

Standards of Space Requirements

The FAA and other bodies have set down guidelines for relationships with TPHP (*Table 2.1*). IATA also published a set of space design standards based on the level of the service concept (*Table 2.2 & 2.3*)⁷.

Table 2.1

Total annual passengers	TPHP as a Percentage of Annual Flows
30 million and over	0.035
20,000,000 to 29,999,999	0.040
10,000,000 to 19,999,999	0.045
1,000,000 to 9,999,999	0.050
500,000 to 999,999	0.080
100,000 to 499,999	0.130
under 100,000	0.200

Table 2.2 SPACE REQUIREMENTS(Domestic)

Domestic Terminal Space Facility	Space Required per 100 TPHP	
	(1000 ft ²)	(100 m ²)
Ticket lobby	1.0	0.95
Airline operational	4.8	4.57
Baggage claim	1.0	0.95
Waiting rooms	1.8	1.70
Eating facilities	1.6	1.52
Kitchen and storage	1.6	1.52
Other concessions	0.5	0.48
Toilets	0.3	0.28
Circulation, mechanical, and maintenance, walls	11.6	11.05
Total	24.2	23.02

Table 2.3 SPACE REQUIREMENTS(International)

International Terminal Space Facility	Additional Space Required Per 100 TPHP	
	(1000ft ²)	(100m ²)
Public health	1.5	1.42
Immigration	1.0	0.95
Customs	3.3	3.14
Agriculture	0.2	0.19
Visitor waiting rooms	1.5	1.42
Total	7.5	7.12
Circulation, baggage, assembly, utilities, walls partitions	7.5	7.12
Total	15.0	14.24

(Source: FAA)

Elements To Be Considered In Design of Air Freight Terminals

1. Market Demand Forecast

- * Domestic/international volumes
- * Inbound/outbound transfer volumes
- * Cargo/mail
- * Bypass traffic (freight already containerized in flight-ready containers).
- * Nature and amount of terminal requiring special handling:
 - heavy/oversized freight.
 - perishables.
 - very great urgency material.
 - high value
 - dangerous goods
 - livestock.
- * Seasonal, daily, and hourly fluctuations of flows.

2. Forecast of Aircraft Fleet and Flight Activity

- Fleet mix.
- Type of operation: all-cargo, combination, belly loads only.
- Frequency of operations.
- Number of aircraft to be handled simultaneously on the apron.
- Air vehicle type: DC-8, DC-9, DC-10, MD-11, A300, A320, Boeing 777, 767, 757, 747, 737, 727, 707...etc.

3. Main Capacity Constrained Elements of Design

- Overall area.
- Build-up positions.
- Pallet and container storage area.
- Bins.
- Air side and land side doors.

4. Cargo Handling Concept Choice

- Low mechanization, high manpower.
- Low manpower, mobile lifting, and loading equipment.
- High mechanization with transfer vehicles(TVs) and elevating transfer vehicles(ETVs).

◆ *Passenger/ baggage flow system see Figure 2.2*

5. Site Selection Factors

- Dimensions of terminal, apron, and land side access area.
- Layout of road access and degree of separation of commercial freight vehicles from passenger terminal traffic.
- Proximity and ease of air side access to the passenger apron.
- Layout and capacity of air side service roads.
- Availability of utilities.

6. Architectural Decisions

- Main floor level.
- Land side and air side dock levels.
- Clear height (later installation of ETVs should be considered).
- Construction materials.
- Expandability for future traffic growth.
- Flexibility for changes of freight type and handling methods.
- Floor pits for self-leveling build up/breakdown areas.

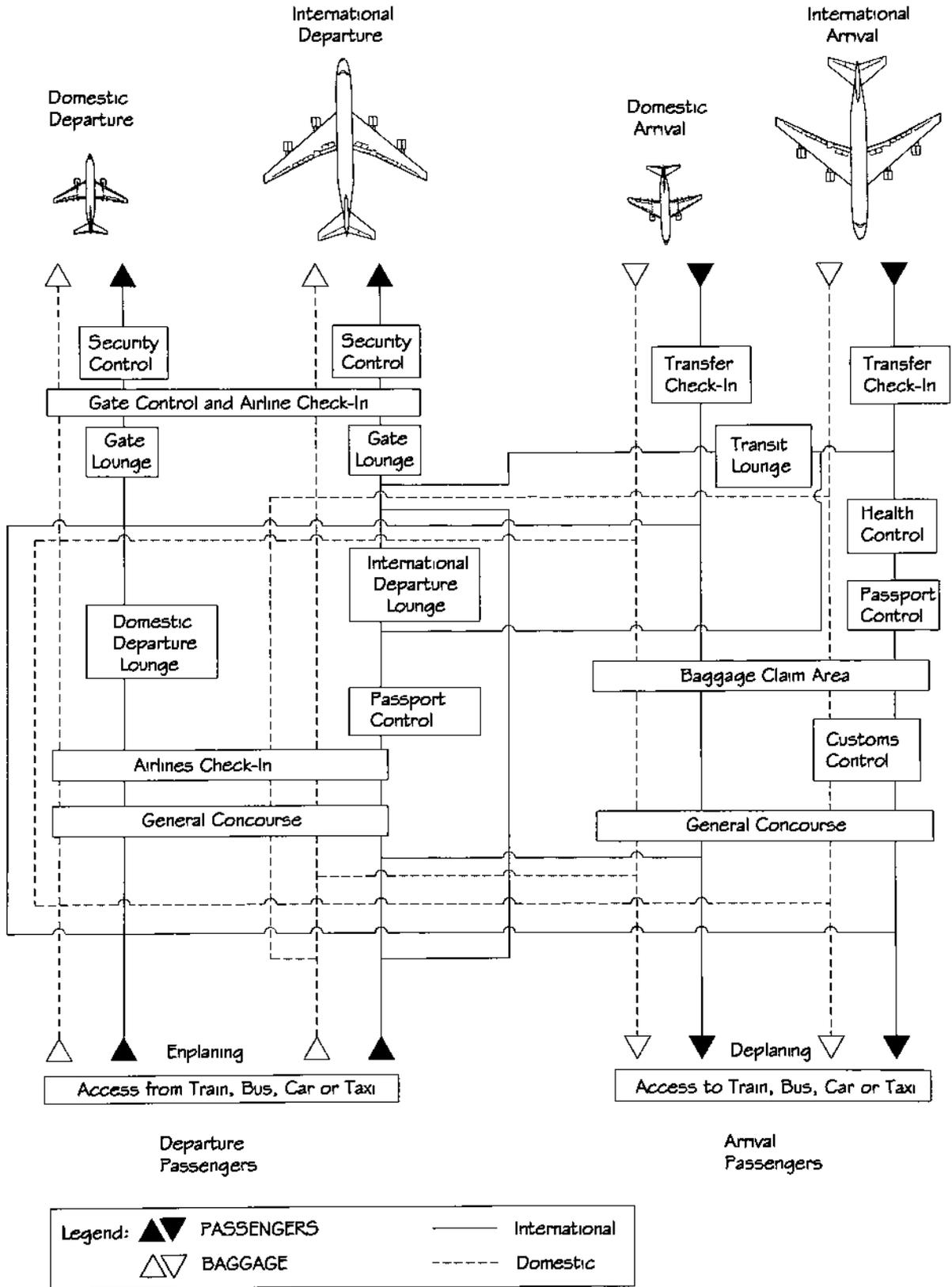


Figure 2.2 Passenger/ Baggage Flow System

7. Other Areas to be Included

In all cases, the dimensions of the space allotted, as well as of the doors, must be suitable for the function of the area.

Maintenance and Support Facilities: For the maintenance and repair of ULDs and their handling devices. Space will include facilities for washing and welding, compressor and vehicle hoist.

Customs: Inspection area, offices, toilets, secure storage area.

Livestock: Storage areas, cages, feeding, watering, and cleaning facilities. Environmental control.

Dangerous goods: Facilities dependent on nature of goods; secure storage.

Cold Room: Areas for high value and fragile cargo, human remains, and radioactive material.

8. General Design Considerations

Security: Ease of general access into the freight terminal area, location of space for security personnel, use of closed circuit TV.

Health and Safety: Design to observe local and national industrial health and safety laws that govern workers and working conditions. Noise levels, operating procedures predicted by design, and surface finishes.

Insurance: Sprinkler system, smoke detectors, fire rating of building materials.

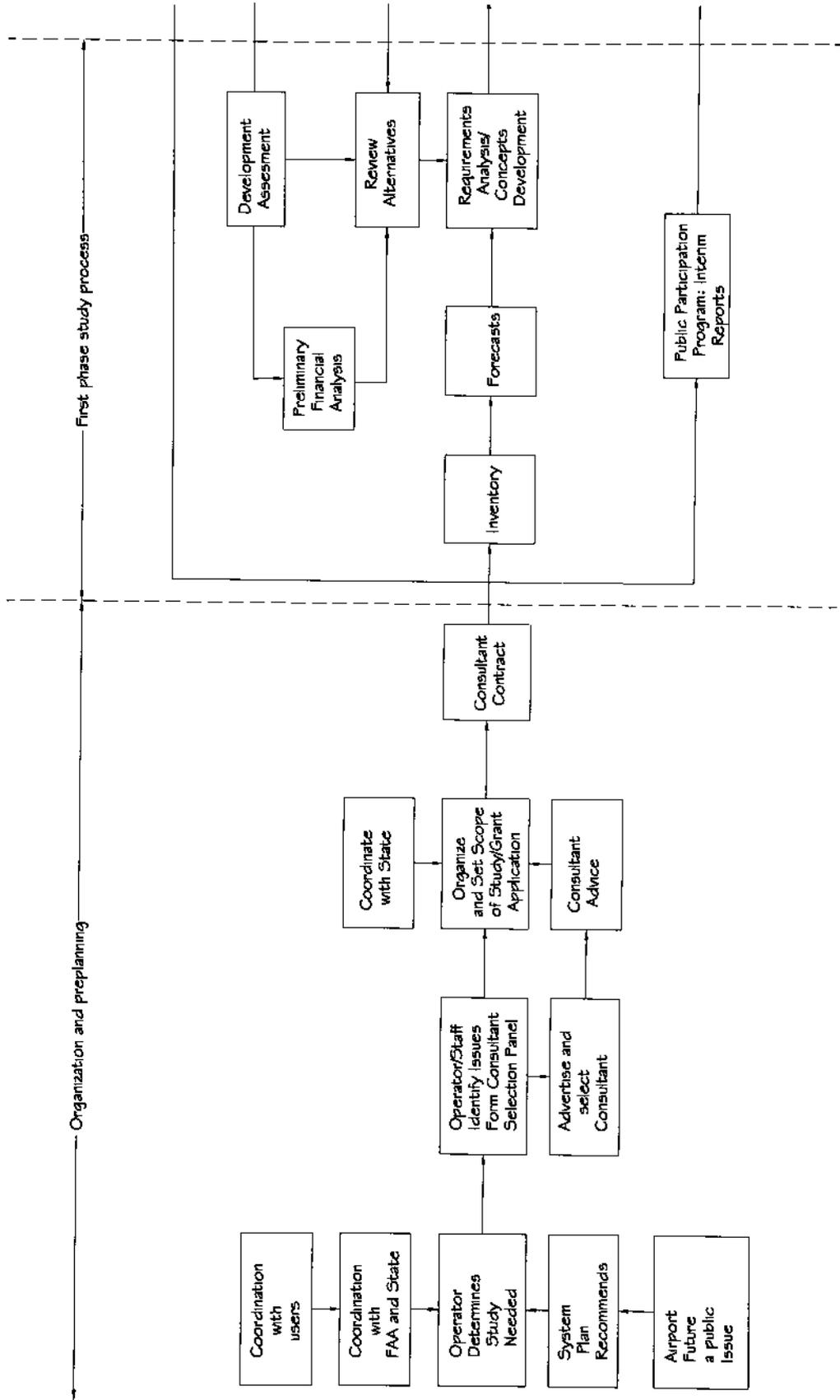
Suitability of Building Materials: Material used must reflect the handling methods within the terminal. Potential damage should be minimized and its repair should be easy.⁸

Airport Master Planning

The FAA specifies a number of elements which are generally to be included in any master planning exercise (*Figure 2.3 & 2.4*):

1. Organization and preplanning
2. Inventory of existing conditions and issues
3. Aviation demand forecasts
4. Requirements analysis and concept development
5. Airport site selection
6. Environmental procedures and analysis
7. Simulation airport plans

Figure 2.3 AIRPORT SYSTEM PLANNING(1)



Source: Airport Master Plans, FAA Advisory Circular AC 150/5070-6A, 1985

8. Airport plans
9. Plan implementation

Airport Layout Basic Factors And Types

A. The layout of an airport is determined by five basic factors:

1. The direction of prevailing winds (the major runway[s] being oriented to the prevailing wind with a back-up runway on a cross-wind alignment)
2. The size and number of terminal buildings
3. The ground transport system, especially the position of major access roads and railways
4. Mandatory clearance dimensions between aircraft and buildings
5. Topography and geology

B. Typical of the data that need to be gathered are:

1. Passenger statistics (international or domestic, scheduled or non-scheduled, arriving/departing or transit, weekly, daily or hourly flows)
2. Cargo statistics (similar breakdown as for passenger flows)
3. Aircraft (types, international or domestic, passenger or cargo, peak movements)
4. Visitors (meeters and greeters, airport visitors as non-travelling tourists, shoppers, business users)

C. For the passenger terminal, operational capacity is dependent upon the performance of the following key elements:

1. Landside access
2. Baggage handling
3. Passenger check-in capacity
4. Immigration control capacity
5. Security check capacity
6. Boarding gate capacity

D. Airport types

1. International airports serving over 20 million passengers a year
2. National airports serving between 2 and 20 million passengers a year
3. Regional airports serving up to 2 million passengers a year

E. Other factors relevant to typological classification include:

1. The split between domestic and international movements
2. The role of the airport as an international center for aviation or as a distribution hub
3. The scale of non-airport facilities, such as other transportation modes, hotels, business and conference centers.

F. The life of assets at airports

1. Runways, taxiways and aprons: 100 years

2. Terminal buildings, pier and satellite structures: 50 years
3. Tunnels, bridges and subways: 50 years
4. Terminal fixtures and fittings: 20 years
5. Transit systems: 20-50 years
6. Plant and equipment(runway lighting and building plant): 5-20 years
7. Motor vehicles: 4-8 years
8. Retail units, bars and restaurants: 3-5 years
9. Office equipment: 5-10 years.¹⁰

It is obvious that the impact of an airport extends far beyond its physical boundaries. Two types of masterplan are commonly met: that which structures the airport estate only (but with a statement of wider impacts), and that which structures both the airport and neighbor areas into a coordinated development proposal. The latter is increasingly adopted as airport developers, working usually with neighboring landowners and civic authorities, recognize that coordinating neighborhood land uses with airport expansion is mutually beneficial.

The physical and environmental planning of an airport and its surrounding land should seek to ease community conflict (from problems such as noise and traffic congestion) and realize the possibilities of development alongside the airport. The growth in service, such as air cargo, has led to an expansion of warehousing facilities near to airports. Therefore, airport expansion should recognize that much growth occurs outside the perimeter fence, and that both need to be structured in time and space to ensure that infrastructure demands (water, drainage, transport) and environmental impacts are foreseen and accommodated.

Sources and References:

1. **The Modern Terminal**, *Brian Edwards*, *New Approaches to Airport Architecture*, 1998
2. **Airport Land Needs**, *Warren H. Deem & John S. Reed*, *Author D. Little Inc.*, 1967
3. **Airport Engineering**, 3rd Edition, *Norman Ashford & Paul H. Wright*, *A Wiley-Interscience Publication*, 1991
4. **A Framework for Aviation Systems Planning**,” *Kanafani, A.*, *Course Notes for Airport Planning and Design Short Course*, *Institute for Transportation Studies, Berkeley, California*, 1988
5. **Airport Engineering**, 3rd Edition, *Norman Ashford & Paul H. Wright*, *A Wiley-Interscience Publication*, 1991
6. **The Modern Terminal**, *Brian Edwards*, *New Approaches To Airport Architecture*, 1998
7. **Airport Engineering**, 3rd Edition, *Norman Ashford & Paul H. Wright*, *A Wiley-Interscience Publication*, 1991
8. **Airport Engineering**, 3rd Edition, *Norman Ashford & Paul H. Wright*, *A Wiley-Interscience Publication*, 1991
9. **Airport, Aircraft and Airline Security**, *Kenneth C. Moore*, *Security World Publishing Co., Inc.*, 1976
10. **The Modern Terminal**, *Brian Edwards*, *New Approaches To Airport Architecture*, 1998

CHAPTER III

DESIGN DEVELOPMENT

Concept Development And Evaluation

My research into the concept of airport design has focused on combining four main scales of air transport-- international, continental, regional and commuter-- into one terminal building as the program for my thesis.

While the intercontinental and continental markets are met by jet aircraft, the lower end of the regional scale and commuter markets are increasingly served by turboprops. The new generation of turboprops offers distinct advantages over jet aircraft: they are less noisy, can operate at lower altitudes, have reduced emissions, and have shorter take-off and landing needs. Commuter jets and larger jets now have greater need to be on the closest apron for passengers to easily transfer. The main problem here is access from the terminal building to the plane; the usual pattern of elevated telescope gates will not suffice. Demarcation for commuter flights is normally directly over the apron alongside the terminal or by busing to locations further afield. In unsatisfactory weather conditions, passengers do not have any protection and need to face adverse weather without choice. Where large numbers of commuter passengers regularly use a terminal, there needs to be provision for direct and easy access to the apron area from the

departure lounge. For passengers' convenience, larger jets and smaller commuters could be combined on the same apron.

My research has targeted terminal design. The design of a terminal depends on the nature of the air traffic to be handled at an airport. The design concept chosen is a function of a number of factors, including the size and nature of traffic demand, the number of participating airlines, the traffic split between international, domestic, scheduled, and charter flights, the available physical site, the principal access modes, and the type of financing.

I researched several existing terminal building types to see if they are efficient. And the result is "No!"; they could be improved. The research developed step by step and the final concept was made with regard to several advantages. The advantages of the terminal type I have selected to concentrate on are:

1. A Round-shaped terminal building has maximum apron space.
2. The skylight roof of the apron area meets the minimum space requirement.
3. The roof of the apron area has a strong structure.
4. Passengers have the shortest distance for transferring between airlines.
5. Star-shaped terminal building with "angled-nose in" aircraft parking has the shortest corridor access from terminal to aircraft.
6. All air side service roadways could be easily added or modified underground.
7. Center navigation tower has the best view of all taxiways and runways.
8. Center navigation tower has minimum limitation of airport land.
9. Underground cargo level uses roadways separate from passengers' cars, providing better safety, convenience and attractiveness.

10. Additional round-shaped terminal buildings could be built easily later within a limited amount of airport land.

CHAPTER IV

DESIGN EVOLUTION

After I decided to explore airport design as my thesis project, I began collecting and evaluating materials, and established the design goal to meet not only passengers' but also airport staffs' needs and expectations, and the functional requirements of an airport.

That criteria helped me develop preliminary concepts which meet my design goals. I developed concepts and possible solutions through sketches and diagrams, and evaluated them based on the design criteria. I reported my progress to faculty weekly as my development evolved.

A. The Original Concept

The first concept I had was to build a roof above the apron—a paved area where airplanes are parked (*Figure 4.1*). The advantage of this concept is to provide passengers enclosed access to small aircraft. Thus, passengers who are boarding small aircraft have a service route to the aircraft without exposure to unfavorable weather conditions. Then, I started to develop and evaluate variations of aprons which are used in most existing airport terminals. As follows:

1. Unit Terminals (*Figure 4.2*)
2. Linear Terminals (*Figure 4.3*)

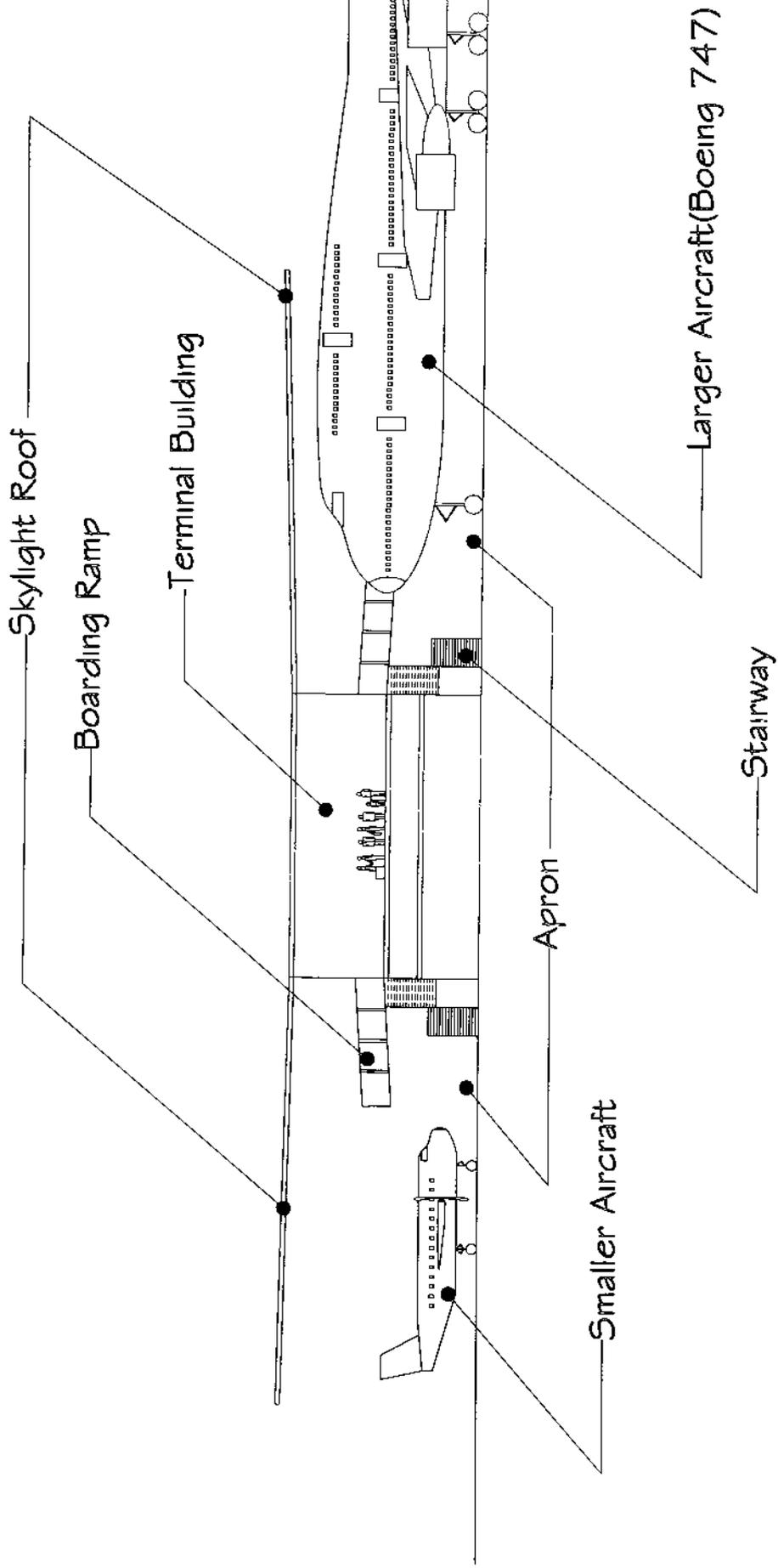


Figure 4.1 Original Concept(1)

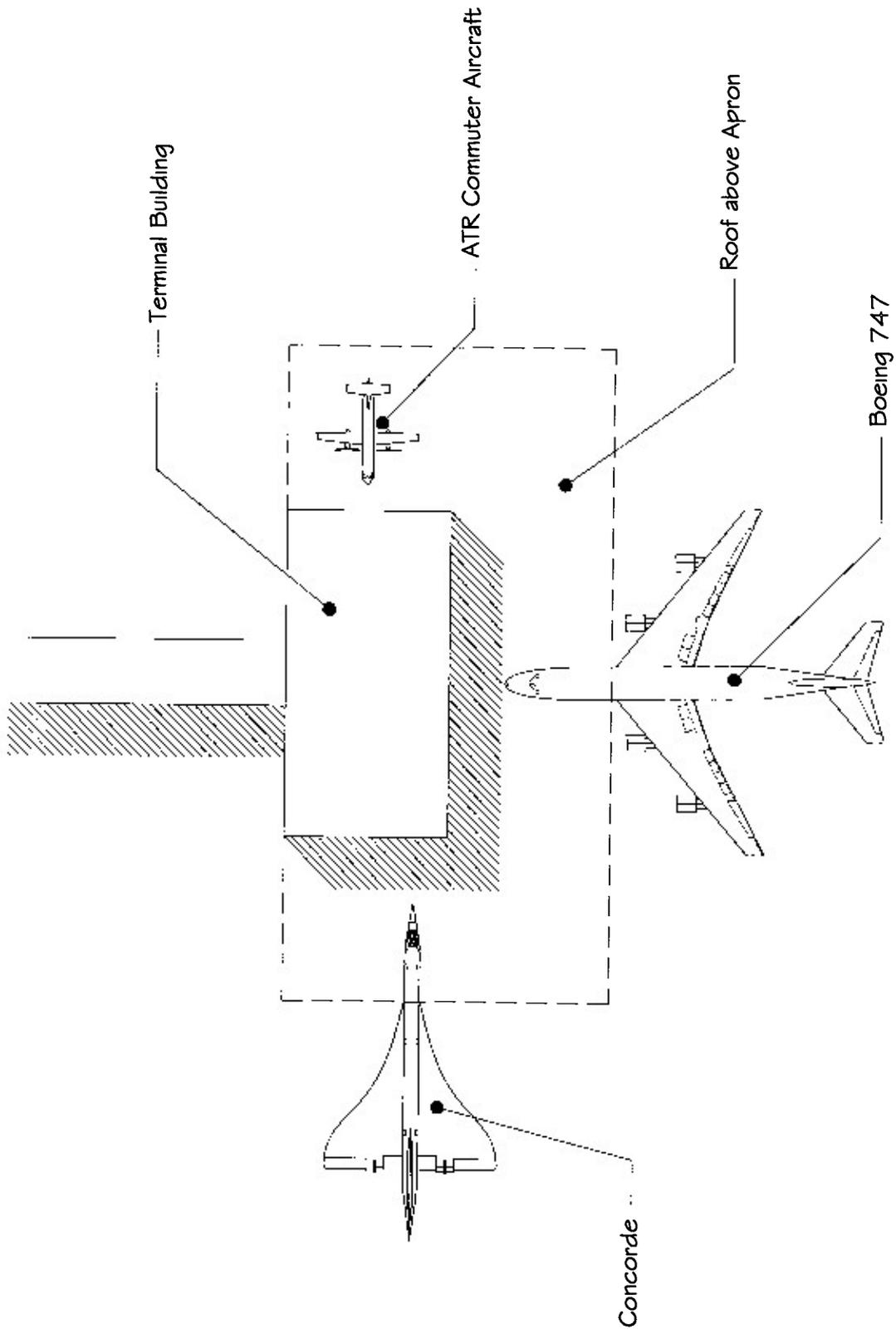


Figure 4.2 Unit Terminal (Concept 2)

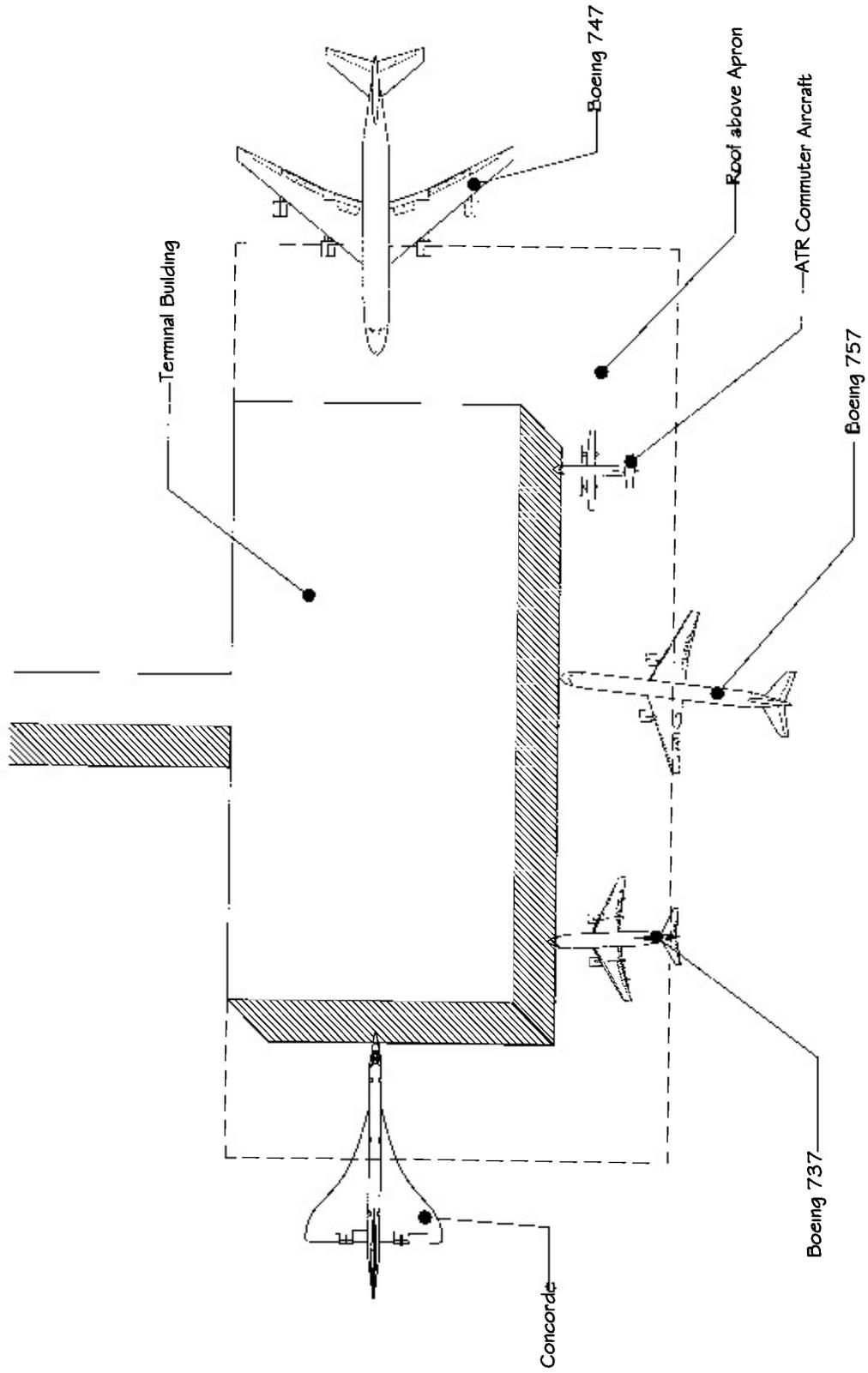


Figure 4.3- Linear Terminal (Concept 3)

3. Unit Terminals With Piers (*Figure 4.4*)
4. Terminal With Piers (*Figure 4.5*)
5. Terminal With Satellites (*Figure 4.6*)

B. Concept Evolution

After evaluating the five typical terminal types listed above, I found that most of them require greater square footage of roof area, which is less efficient and more difficult to construct. Then I thought of creating a triangular apron space (*Figure 4.7*) to both minimize the roof area, and strengthen the structure.

C. Final Concept

After experimenting with several variations, triangle-square, triangle-linear, triangle-round, etc., I selected the triangle-round apron type as the most successful solution (*Figure 4.8*).

1. Apron Roof Structure

The apron serves two functions: it is an area for parking airplanes and for performing servicing and minor maintenance work. The dimensions of the apron are determined by the first function. The facilities supplied on the apron and their locations are set by the servicing function. The principle services to be supplied are:

- Aircraft Fueling ;
- Electrical Supply ;
- Aircraft Grounding ;
- Apron Roadways.

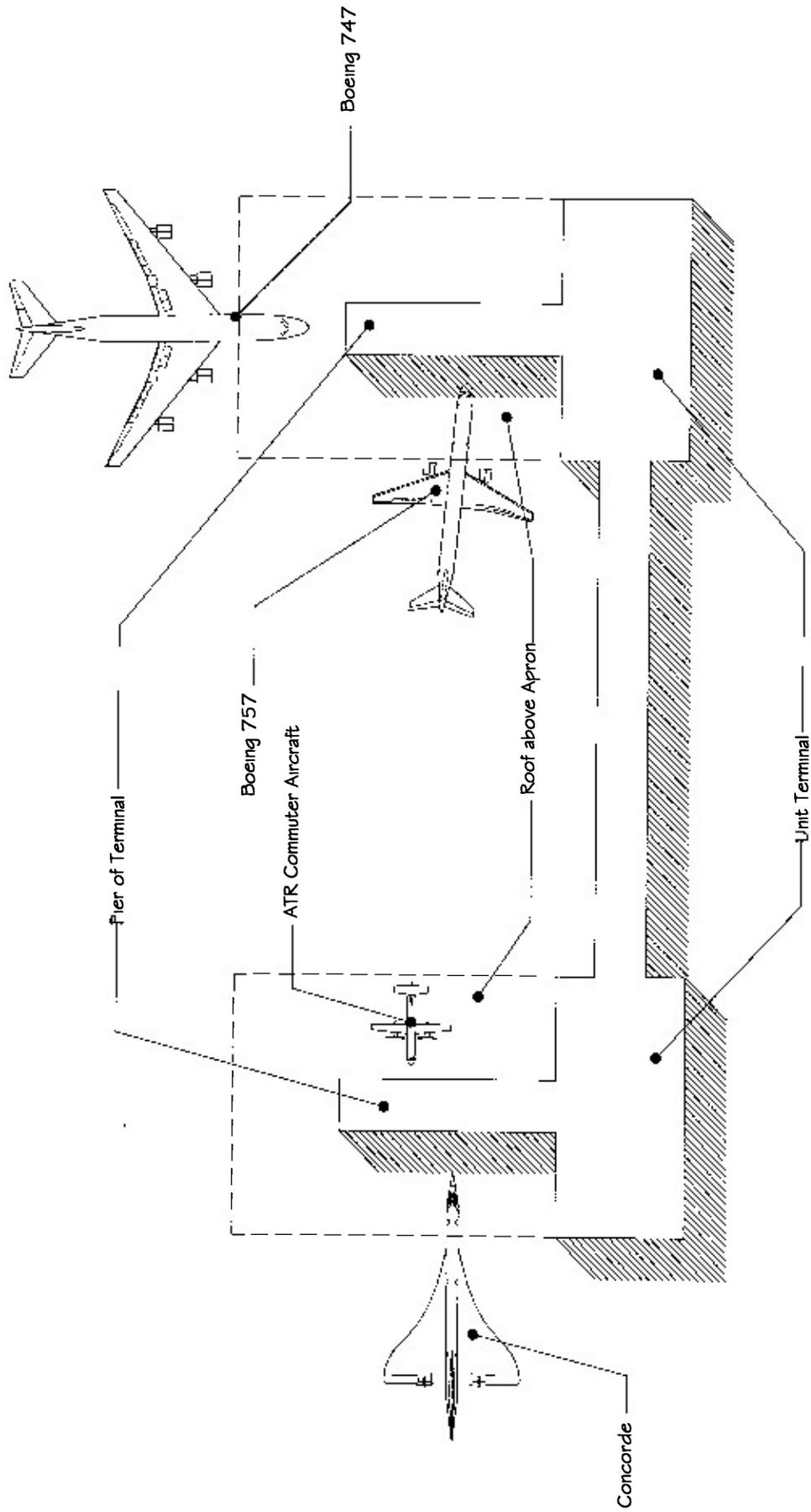


Figure 4.4 Unit Terminal with Piers (Concept 4)

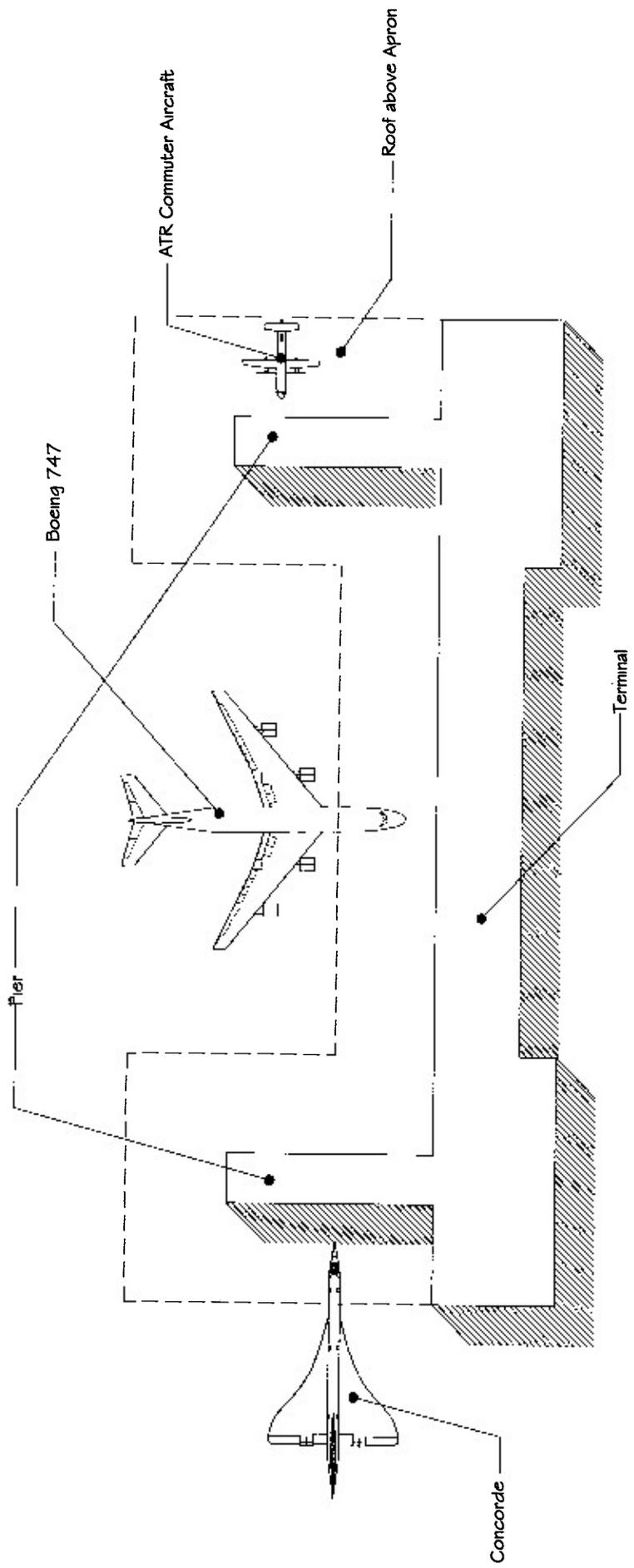


Figure 4.5 Linear Terminal with Piers (Concept 5)

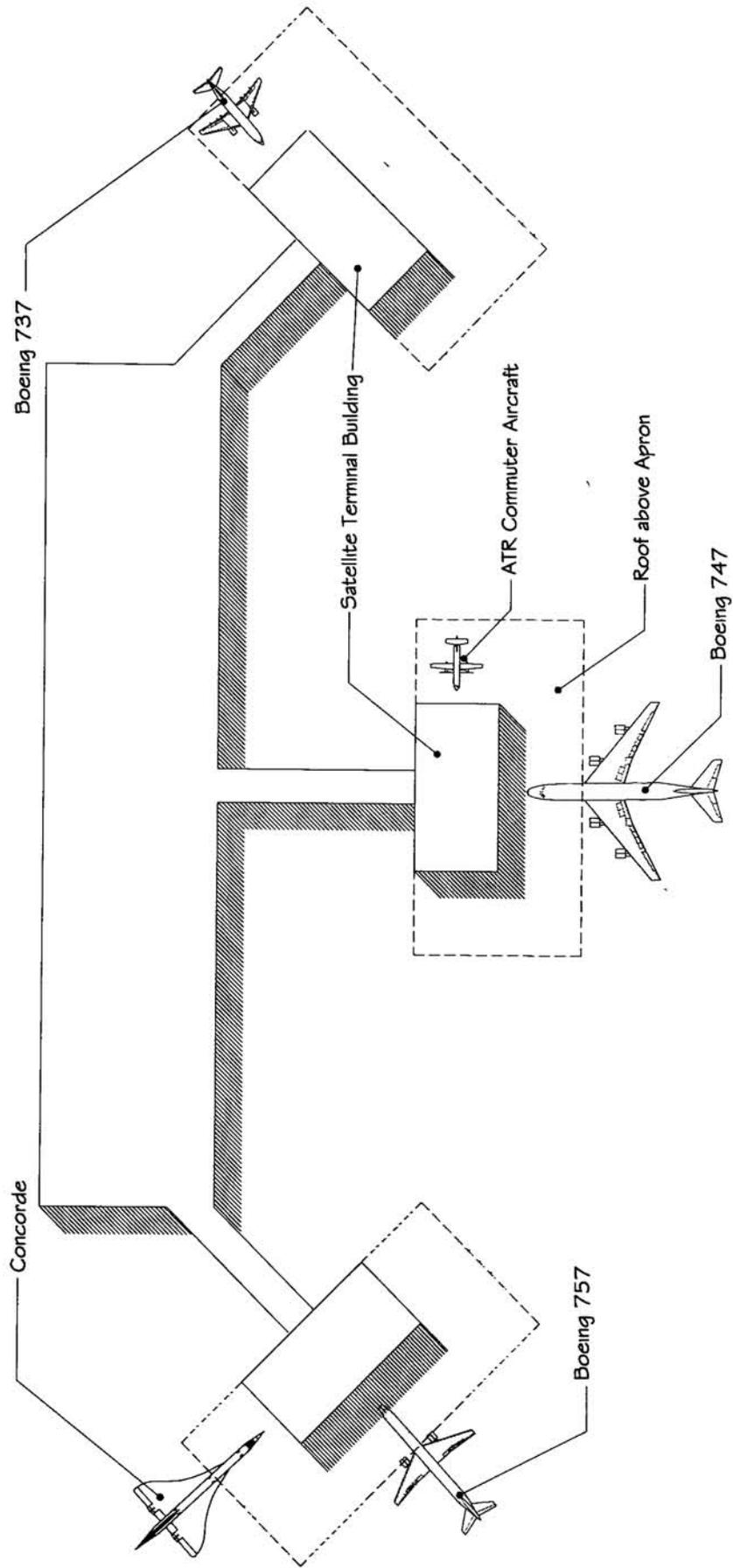


Figure 4.6 Unit Terminal with Satellite (Concept 6)

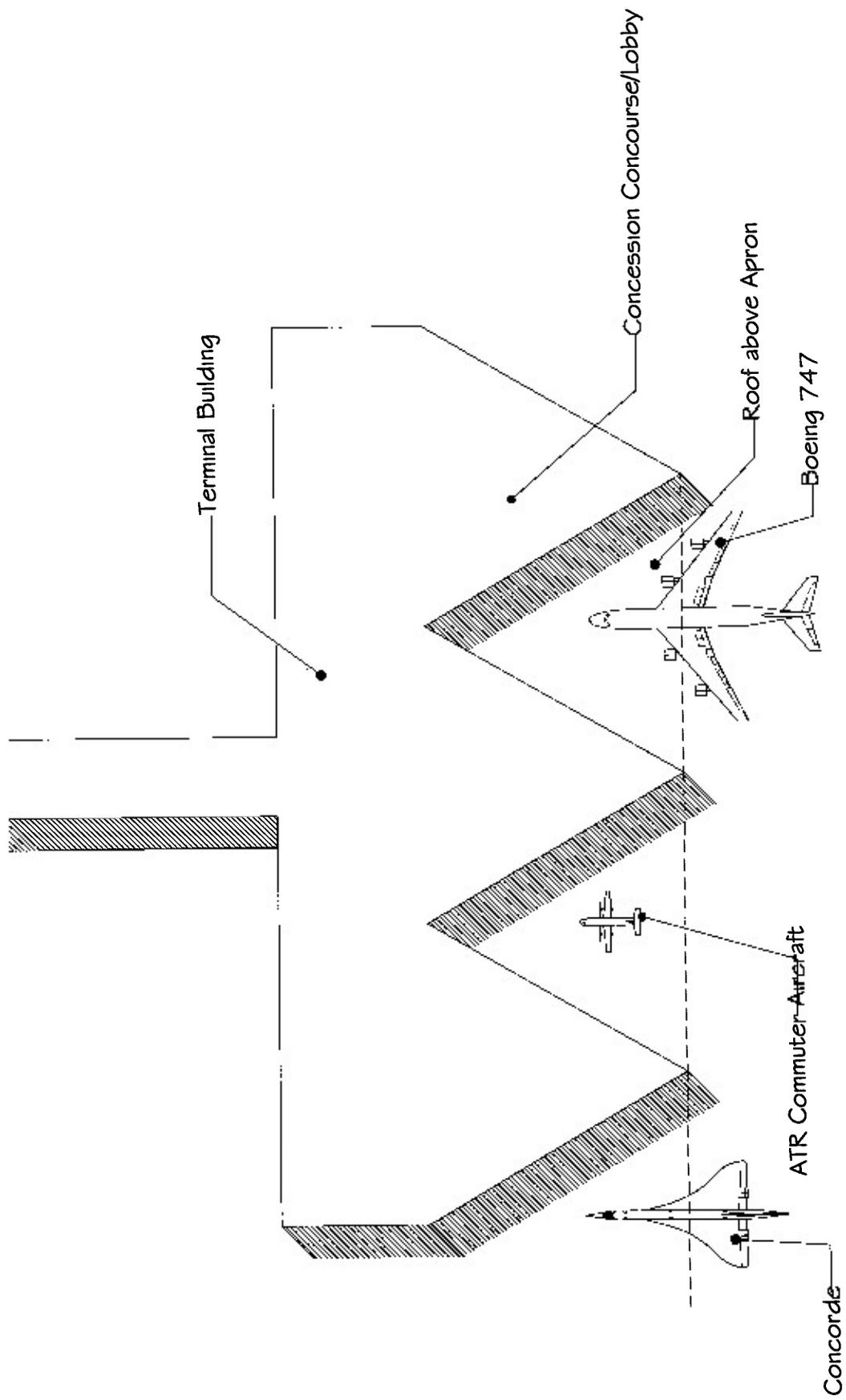


Figure 4.7- Triangle Terminal (Concept 7)

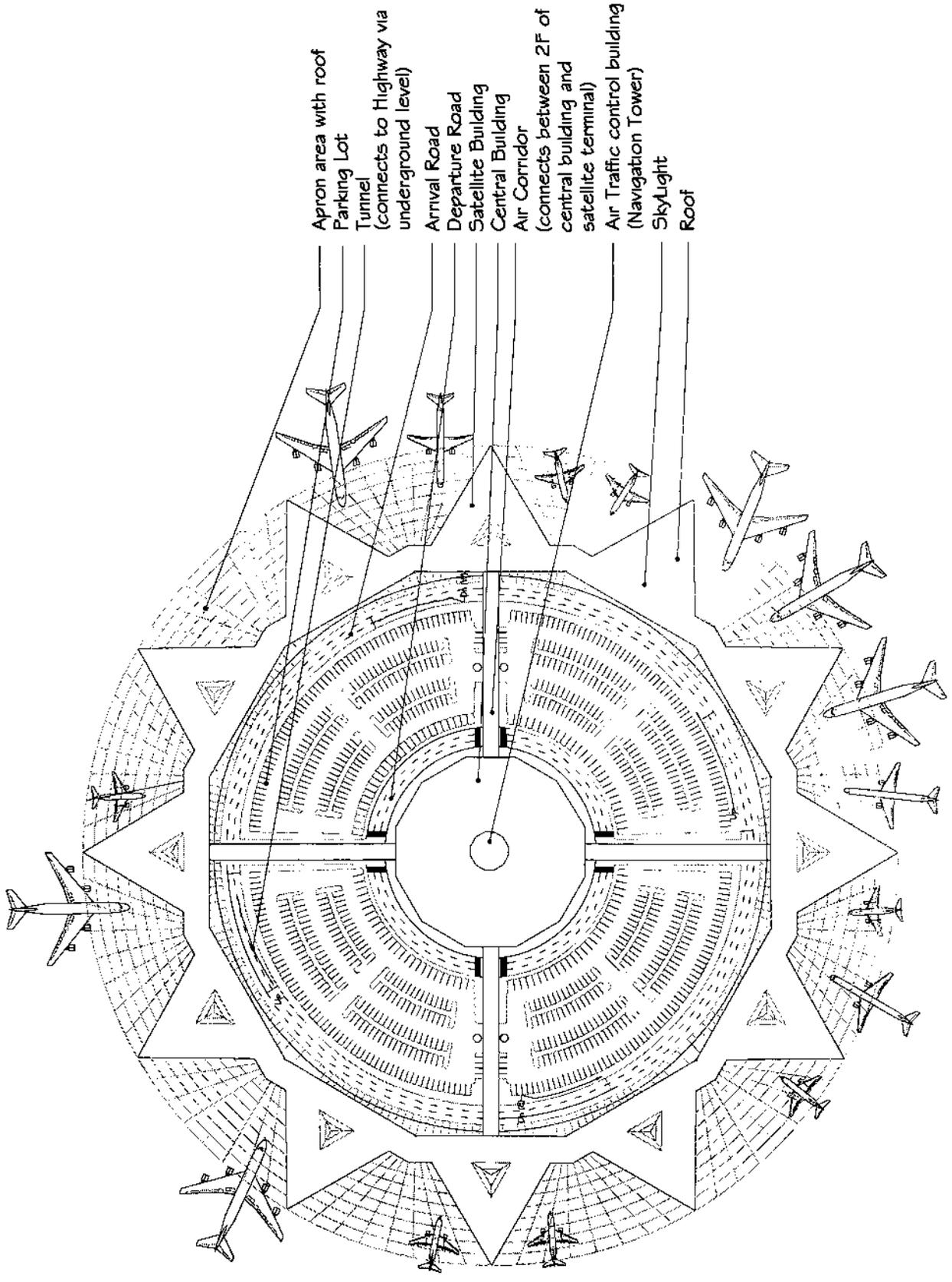


Figure 4.8 Roof Plan

“The Sun is the best lighting source” says I.M.Pei, a famous American architect. Indeed, a bright, sunlit environment is very welcoming. Thus, I chose a pyramid structure to support glass for the apron roof. This efficient structure had been used in ancient Egypt long ago. To accommodate parking configurations I determined that 15,000m² (161,450 ft²), large enough for the Boeing 747-400, would be required. The Boeing 747-400 is the largest, currently used commercial aircraft in the world.

2. Vertical Separation

There are four typical arrangements for vertical separation of passengers and baggage (*Figure 4.9*). I chose “one and one half levels” as my solution due to its simple circulation and operation system. It separates departures and arrivals without complex intersection routes. Also it provides an excellent circulation and operation system giving passengers and visitors easy access to the airport without confusion.

3. Central (Departure/Check-In) Building

Having selected the “One and One Half Level” scheme, I developed a new concept which, to my knowledge, has never been used in an existing airport. The concept places a center building as the check-in/departure building, and several satellite buildings as arrival/pick-up buildings. In addition, there is a freight level between the second floor and the first floor, which is only six-foot high. Passengers can check luggage at the center/departure building on the first floor, and then go to a coffee shop, restaurant or duty-free shop unencumbered by heavy baggage. Cargo transits on its specific route and level to the particular satellite terminal where the passenger will board (*Figure 4.10*).

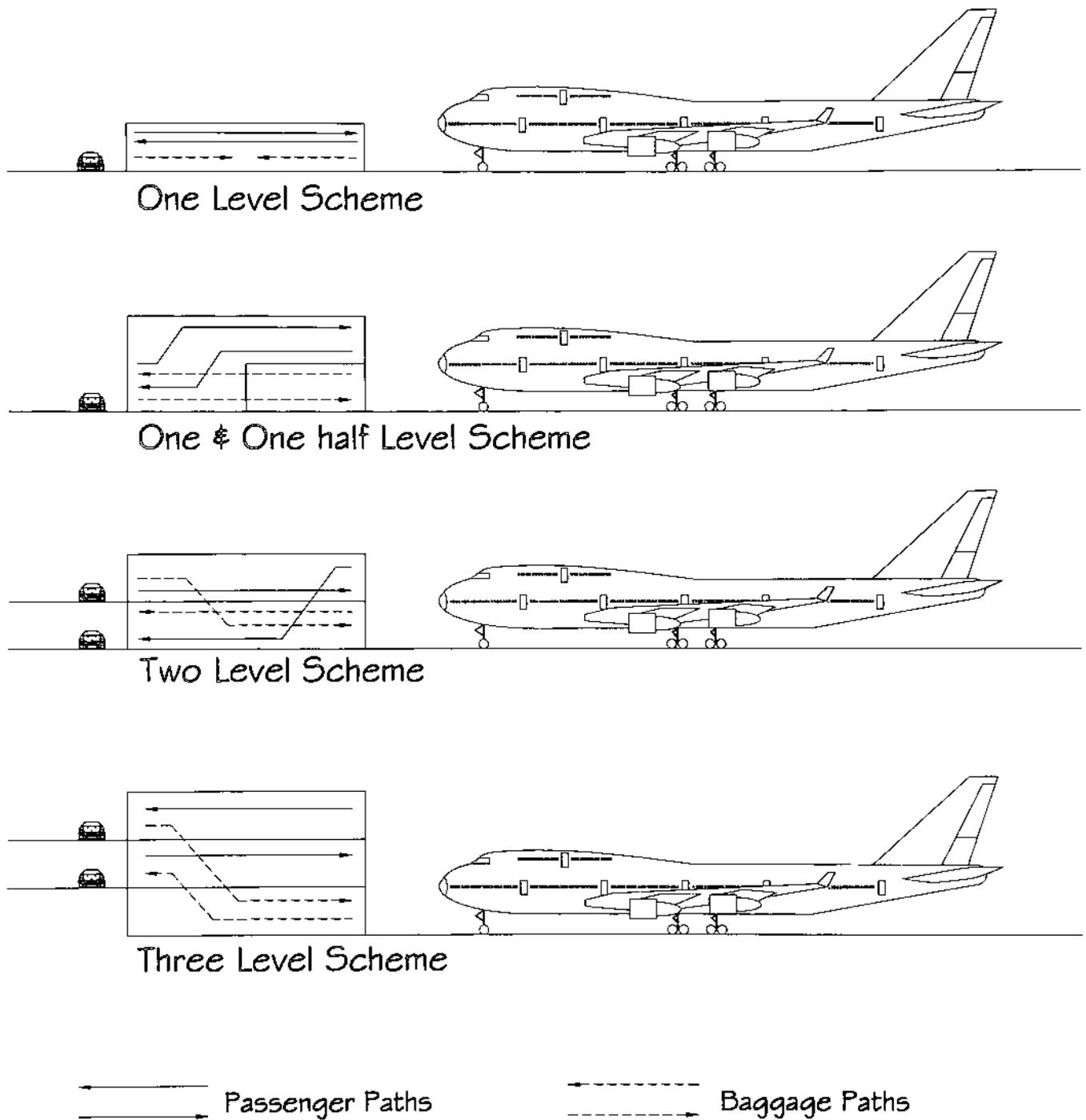


Figure 4.9
 Typical vertical separation arrangements for passenger and baggage

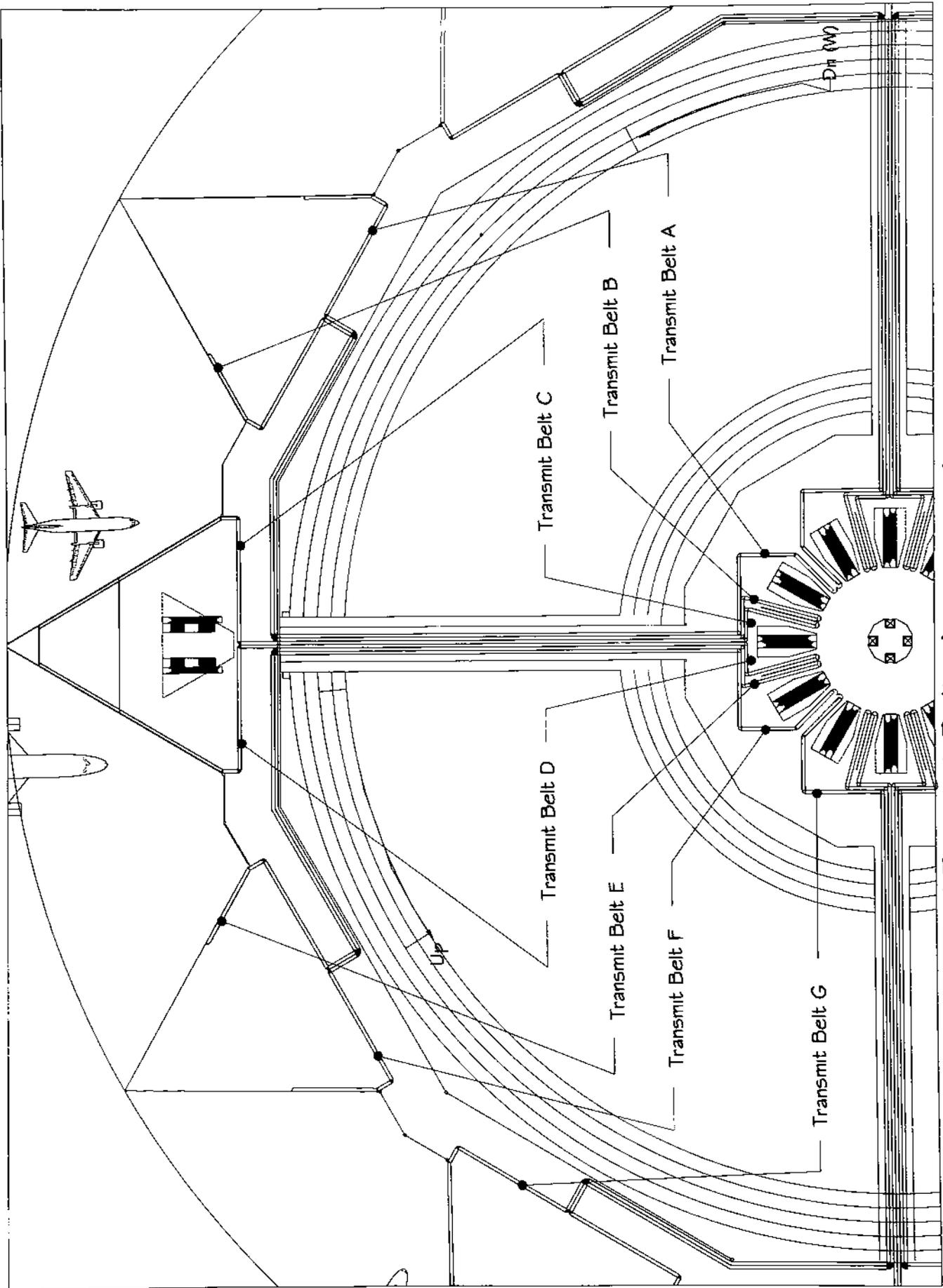


Figure 4.10- Cargo Level Transmit Belts Arrangement

The first floor (*Figure 4.11*), provides an enplaning curb (drop-off area) adjoining the departure road. Twelve 7' diameter, oversize, revolving doors, with two sets of entrance vestibules each are provided. The interior features twenty-four check-in counters, airline offices for each airline, eight escalators, and four 6' x 7' elevators for access to the second floor. Also provided, are a service/storage room, and maintenance/garbage collection room, both of which have individual elevators to the underground (maintenance/service) level.

The second floor (*Figure 4.12*) has four security check points. Every check point serves three terminals' passengers. Passengers can choose the closest check point to their boarding gates.

4. Air Traffic Control/Navigation Tower

The air traffic control tower is one of the most distinctive and architecturally prominent structures at airports. A visual landmark, it can do much to enhance the aesthetic profile of an airport. Its function is that of controlling the movement of aircraft in the air, and the movement of service vehicles and planes on the ground. Control towers direct and coordinate aircraft movements in the vicinity of the airport. Air traffic control staff monitor aircraft movement on apron areas, taxiways, runways, and in the air. To provide the control tower the best view to monitor all locations of aircraft is important. I located the control tower in the center above the center/departure building where it has, not only an excellent view for operation, but also is a safe location without using up valuable land. It is supported by two steel intersecting arches established on the parking lot (*Figure 4.13*).

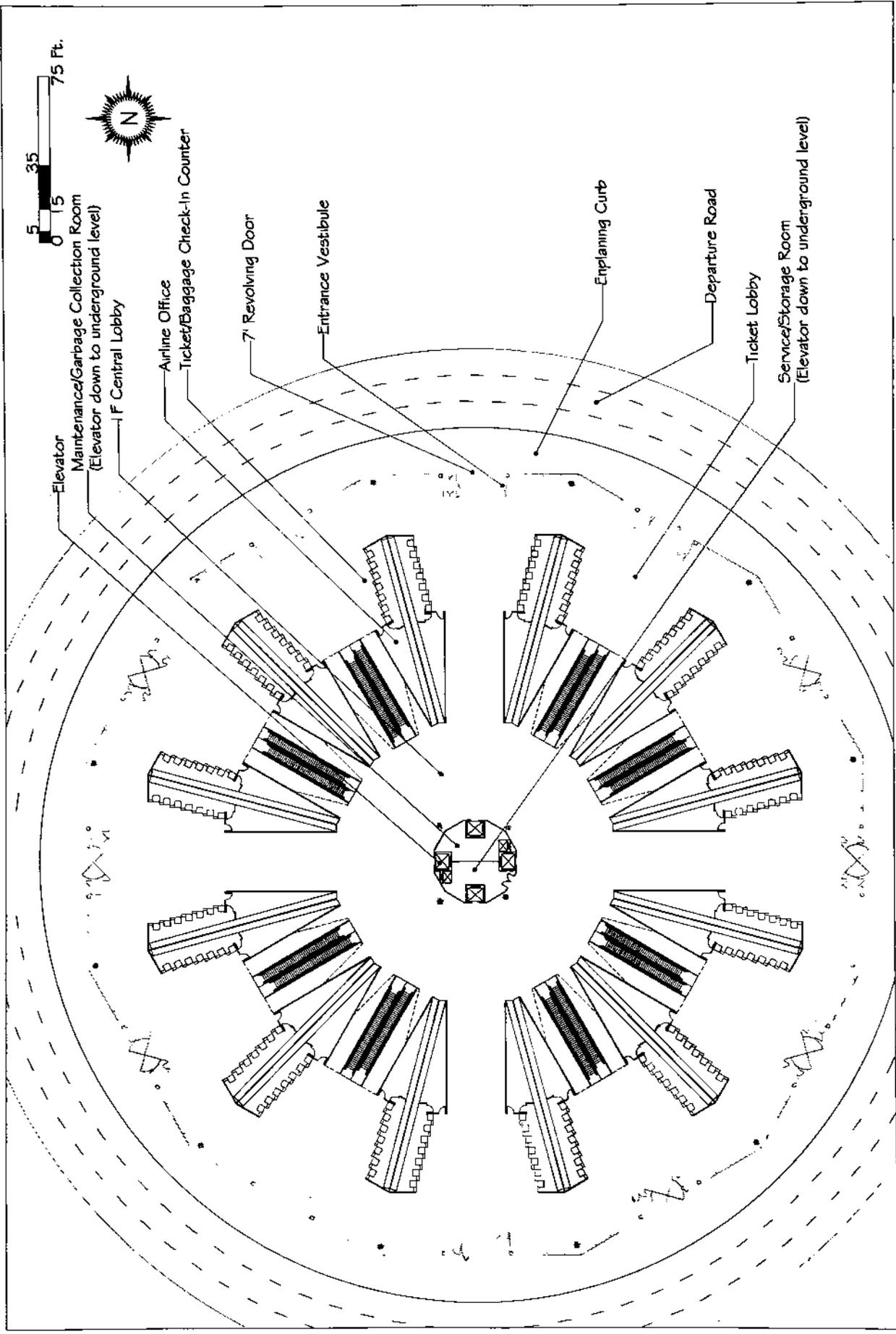


Figure 4.1 | - Central Terminal (Departure Building) | 1F Floor Plan

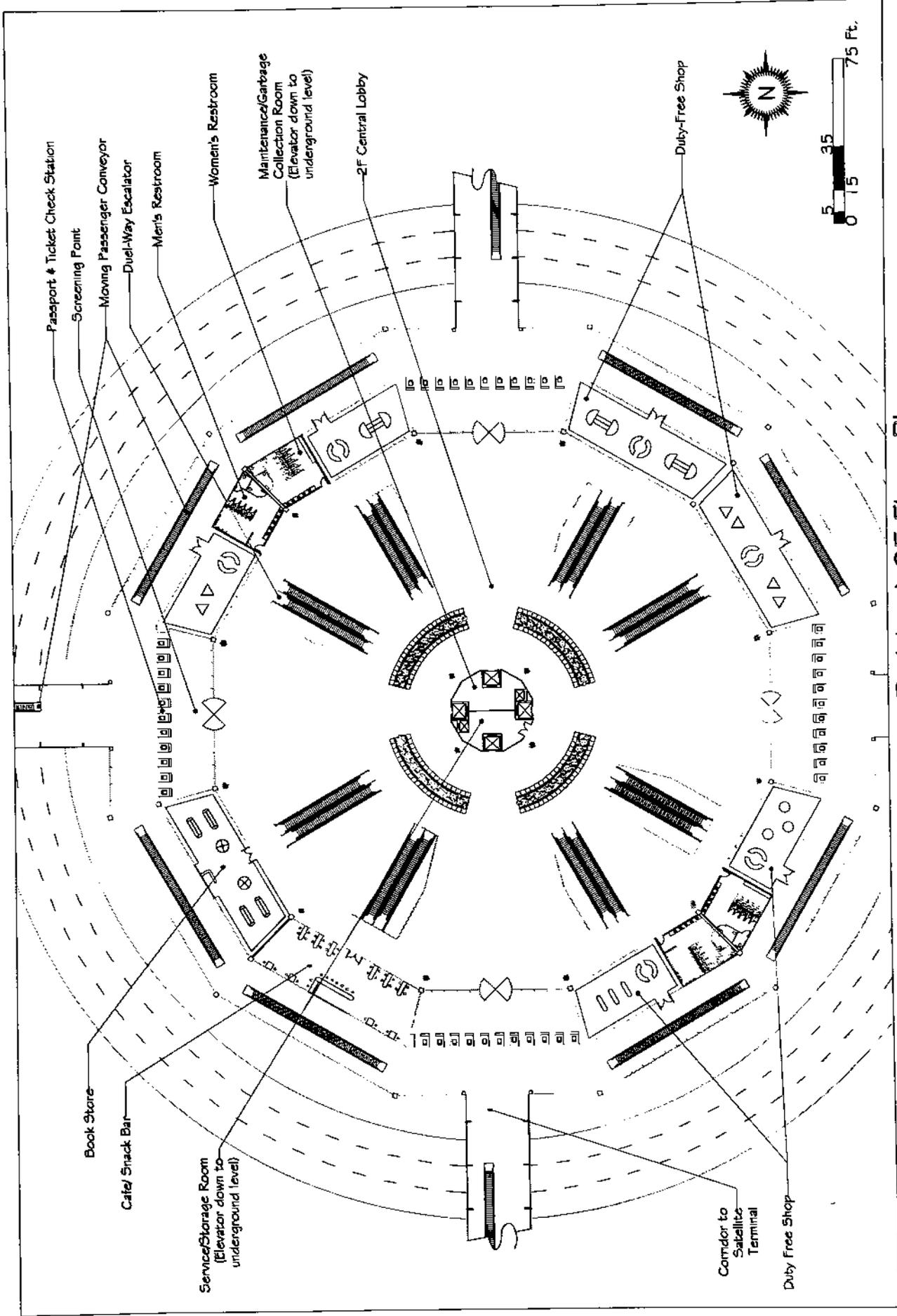
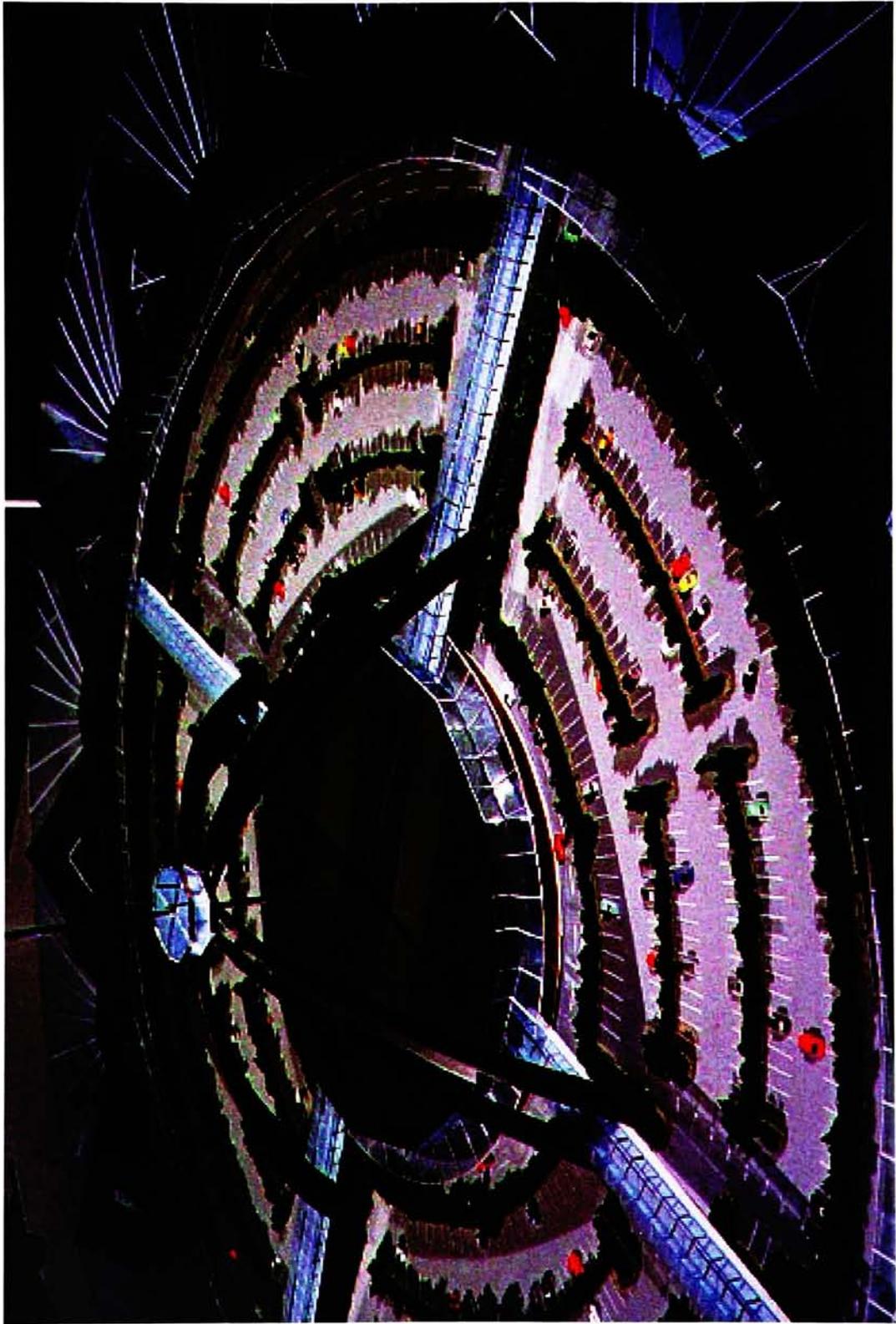


Figure 4.12 - Central Terminal (Departure Building) 2F Floor Plan



5. Satellite (Arrival/Pick-Up) Building

While considering the apron configuration, I evaluated airplane parking requirements as well. After studying them, I understood that having a 30°, 60° or 45° parking angle will assist with the better function of the airline.

$$720^{\circ} (\text{Exterior Angle of Polygon}) / 60^{\circ} (\text{Angle per apron}) = 12 (\text{Number of Apron})$$

Through experimentation, I finally decided to provide twelve satellite terminals; each with two adjoining aprons, for a total of twenty four in the airport prototype. With a seven-hundred-forty foot radius, round building, each apron has a minimum 75,000 ft² to a maximum 170,000 ft² area. It exceeds the standard suggested requirement for the Boeing 747-400, the newest, wide-bodied, four-engine jet aircraft.

The first floor (*Figure 4.14*), features a passenger pick-up area along side the arrival road, two seven-foot diameter oversize, revolving doors, and four sets of entrance vestibules. I provided women's and men's restrooms, telephone booths, two 112 ft² airline offices, a 30 ft² service/storage room, and a 30 ft² maintenance/garbage collection room, four 6' x 7' elevators, escalators, stairways, baggage claims and outbound baggage areas.

The second floor (*Figure 4.15*), provides passenger seating, telephone booths, airline offices, women's and men's restrooms, a maintenance/garbage collection room, and a service/storage room. The seating area provides seating for 322 people, an

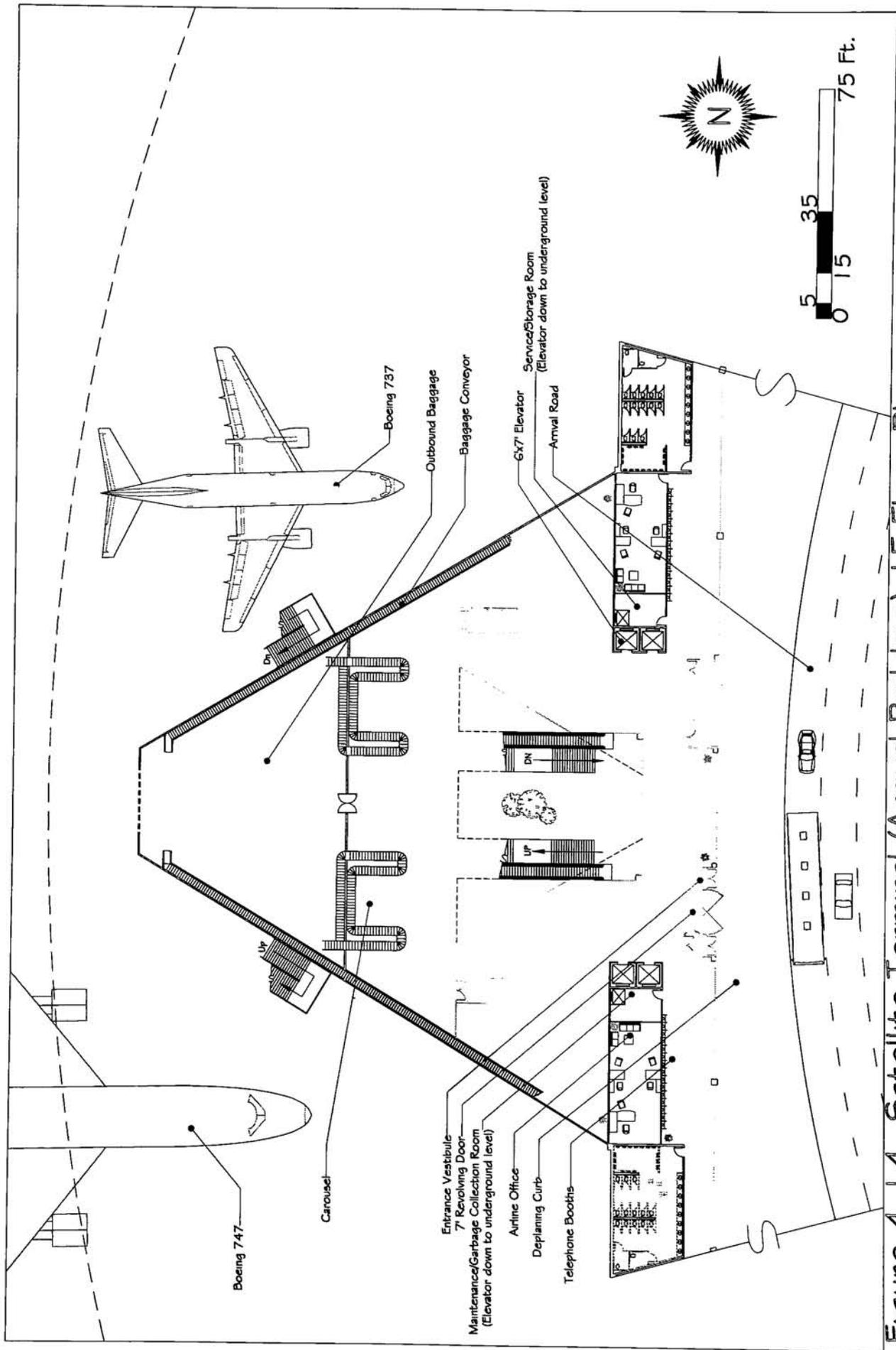


Figure 4.14- Satellite Terminal (Arrival Building) 1F Floor Plan

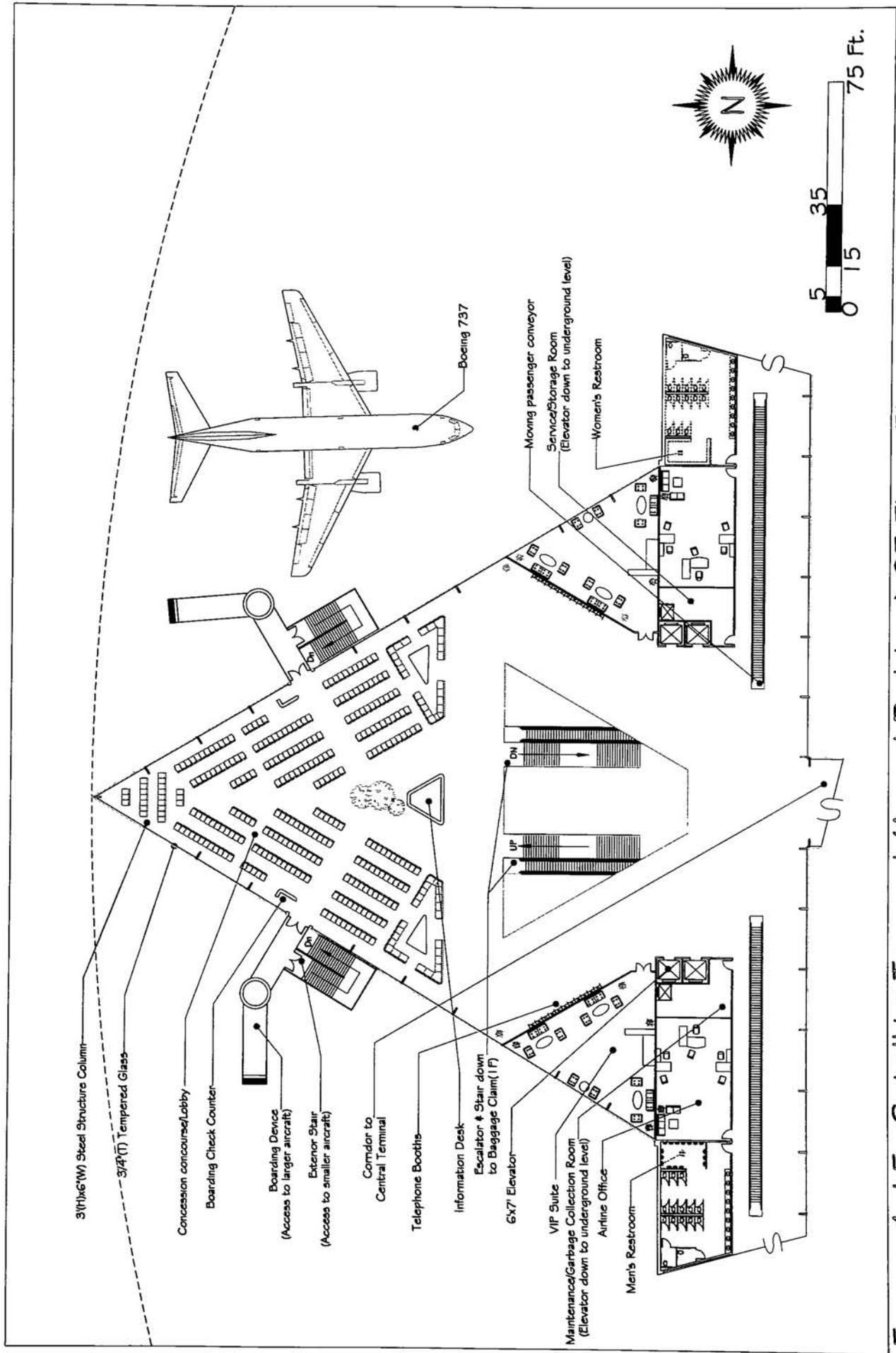


Figure 4.15- Satellite Terminal (Arrival Building) 2F Floor Plan

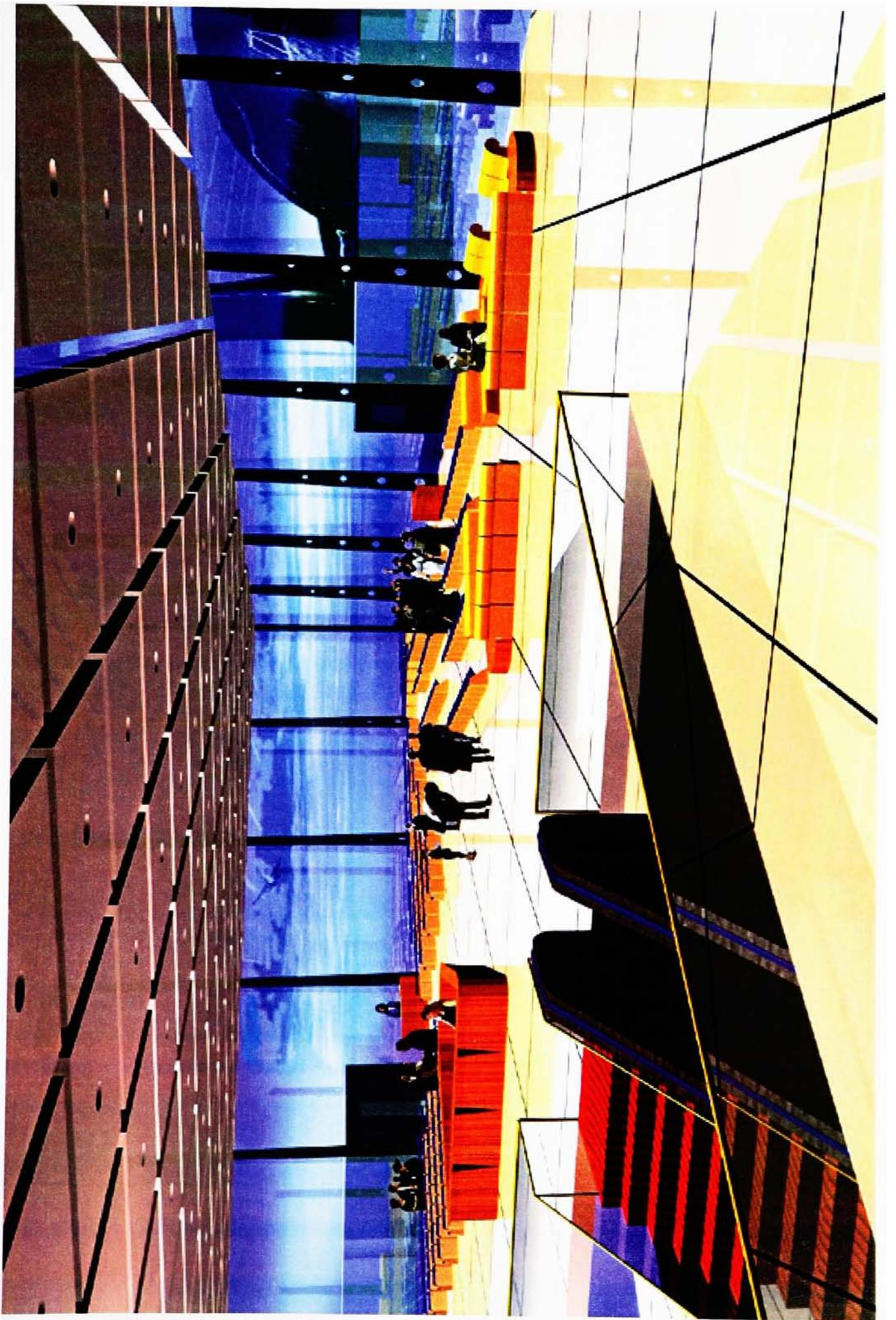
information desk, a boarding check-in counter in front of each boarding gate, two VIP suites, moving passenger conveyors, and a corridor to the central terminal (*Figure 4.16*).

The boarding gate features both ramp and stairway, to service both large jets and smaller commuter passenger jets. Not enclosed, they are sunlit, bright, and have a welcoming feeling (*Figure 4.17*).

Airport Prototype

Being introduced above, the prototype concept of the airport design has been clearly established.

I hope that the prototype I have designed clearly demonstrates my conceptual objectives, and improves the convenience and comfort of air travel, and efficiency of operations.



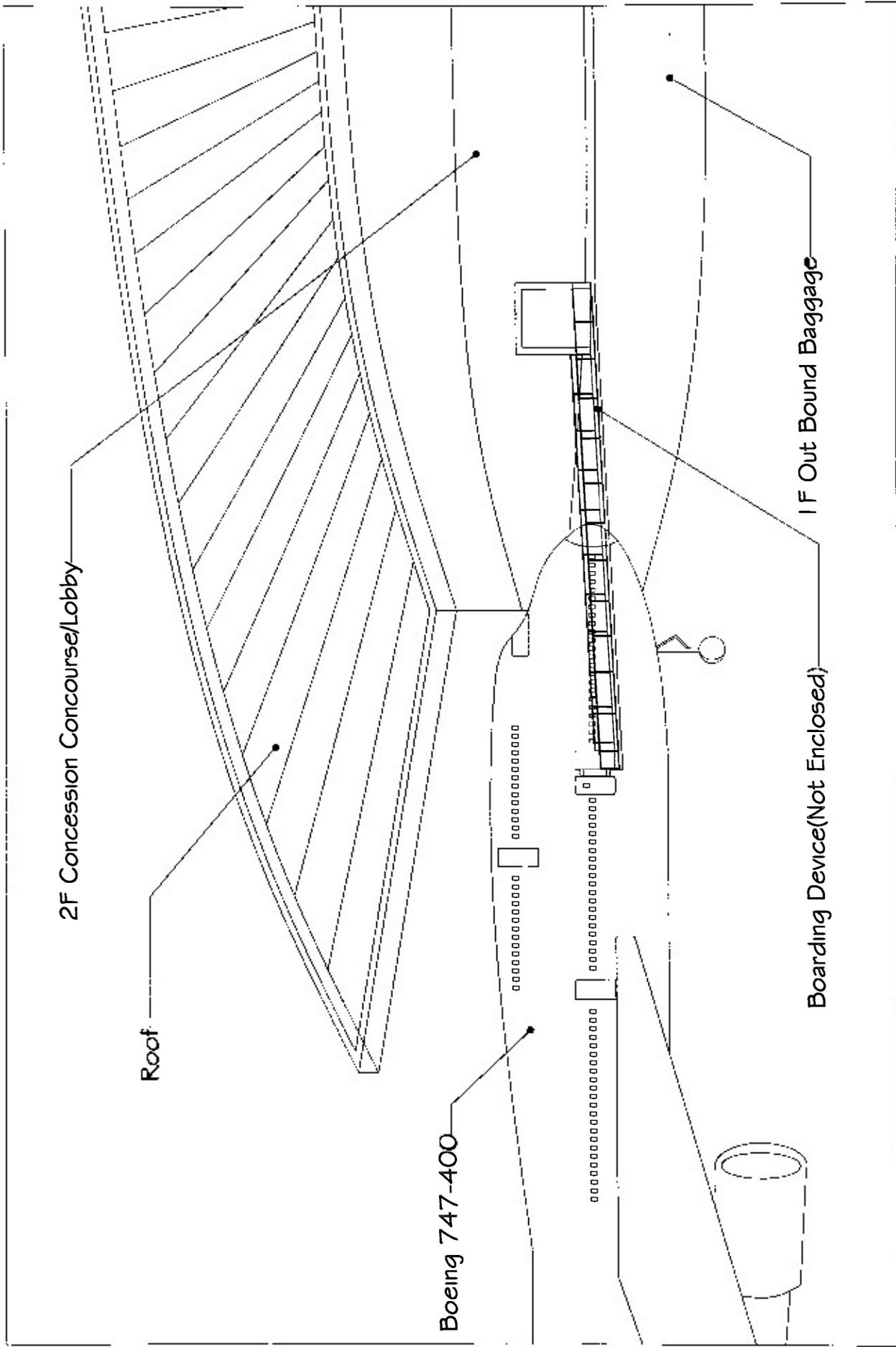


Figure 4.17 Concept of Apron

CHAPTER V

DESIGN RESULT

The design result of this thesis is presented by:

Floor plans and building sections generated by computer in AutoCAD R14;
an ABS plastic quarter model of the terminal at scale: 1/32"=1'-0";
and a computer rendering of the interior terminal which is built in 3D model in
Alias/Wavefront application

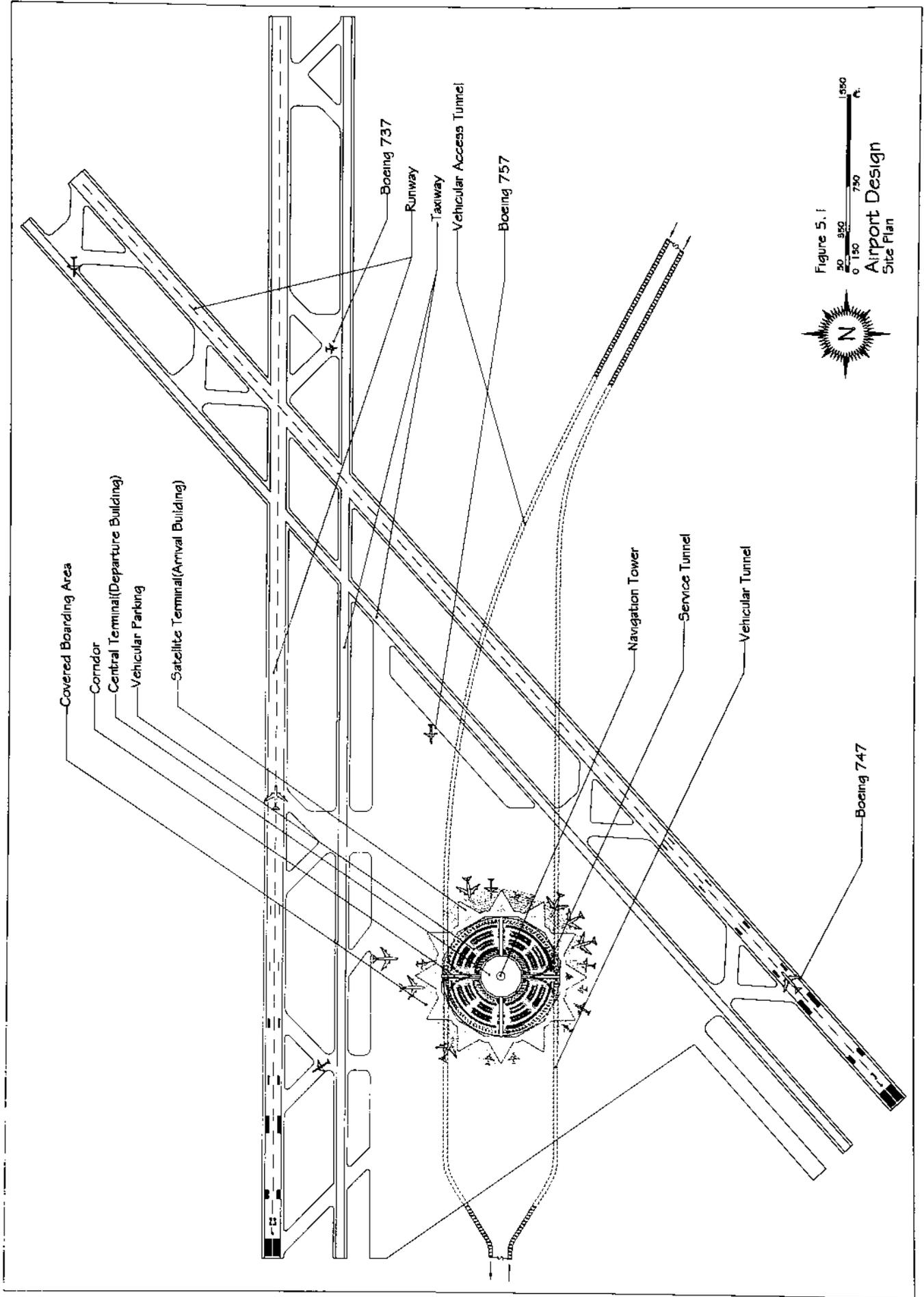


Figure 5.1
 Airport Design
 Site Plan

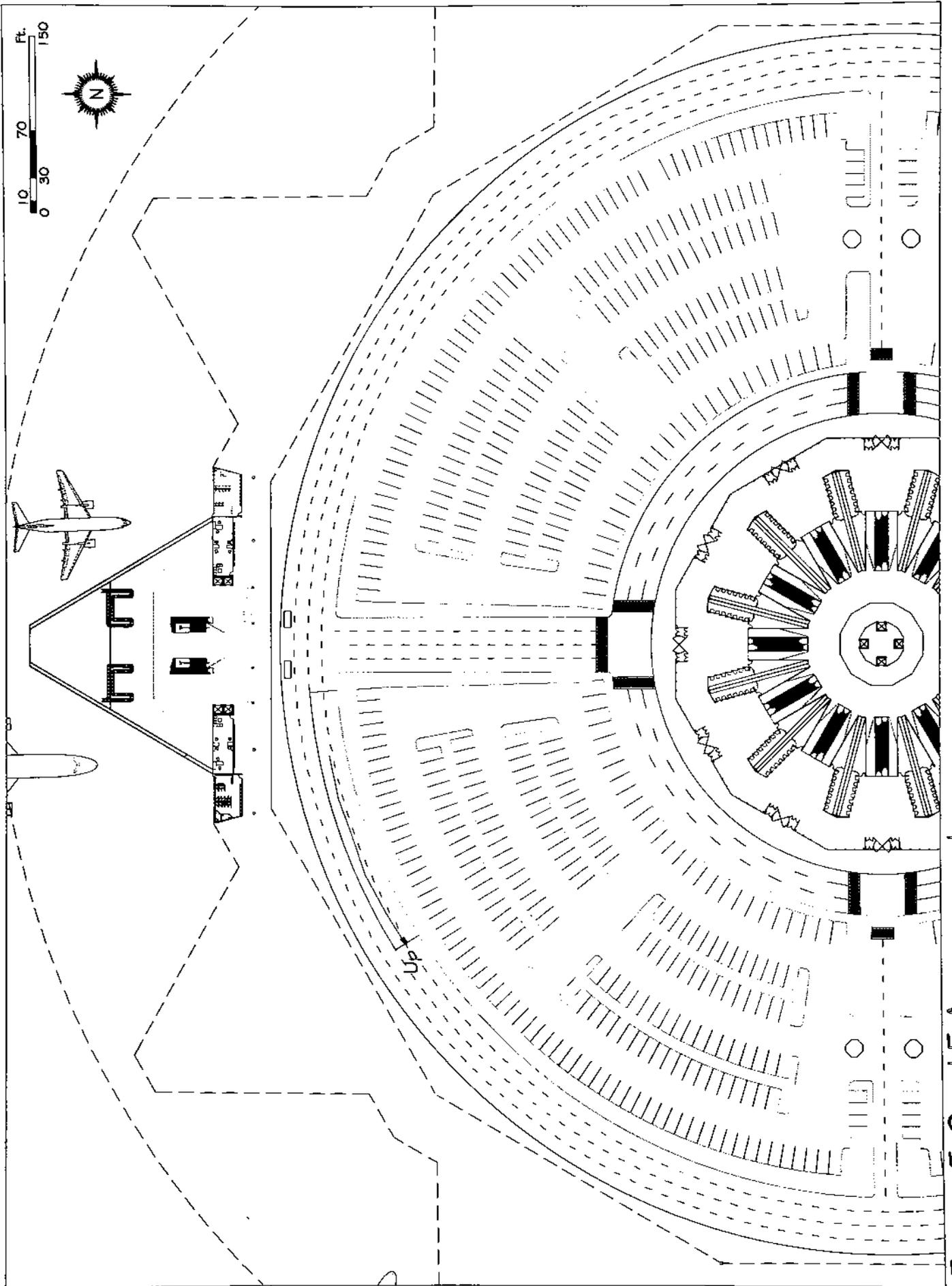


Figure 5.2 - IF Arrangement

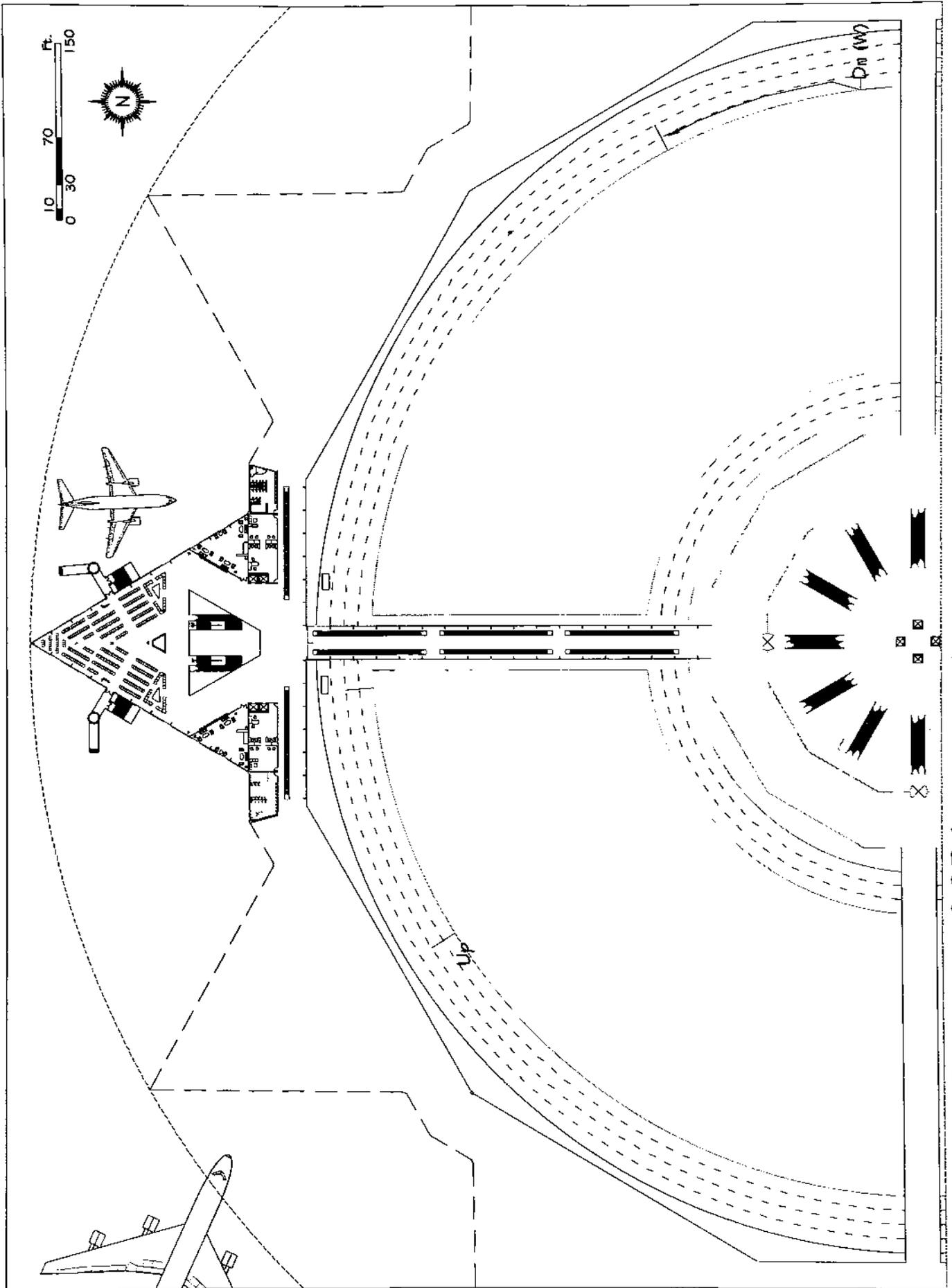
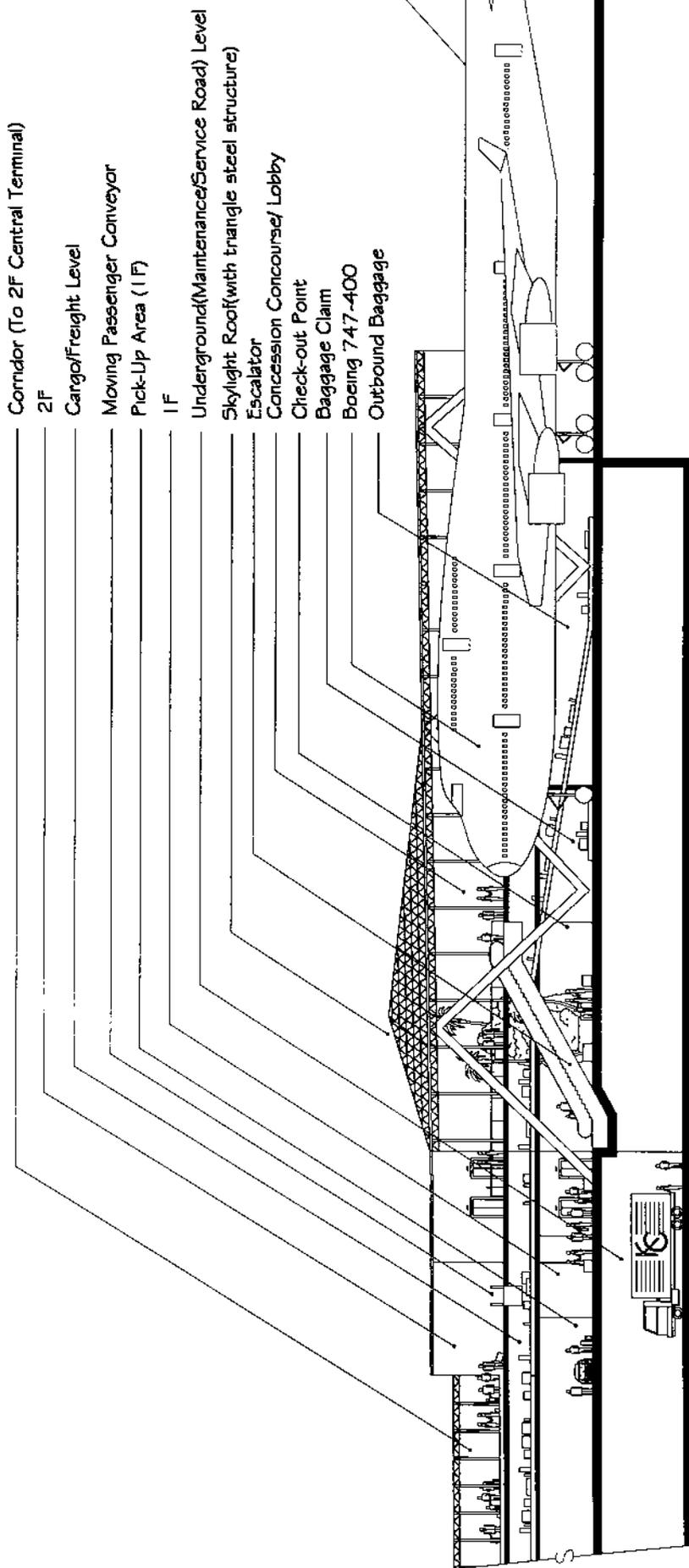


Figure 5.3- Top View of 2F Arrangement



Corridor (To 2F Central Terminal)

2F

Cargo/Freight Level

Moving Passenger Conveyor

Pick-Up Area (1F)

1F

Underground (Maintenance/Service Road) Level

Skylight Roof (with triangle steel structure)

Escalator

Concession Concourse/Lobby

Check-out Point

Baggage Claim

Boeing 747-400

Outbound Baggage

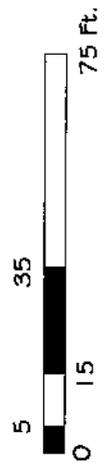
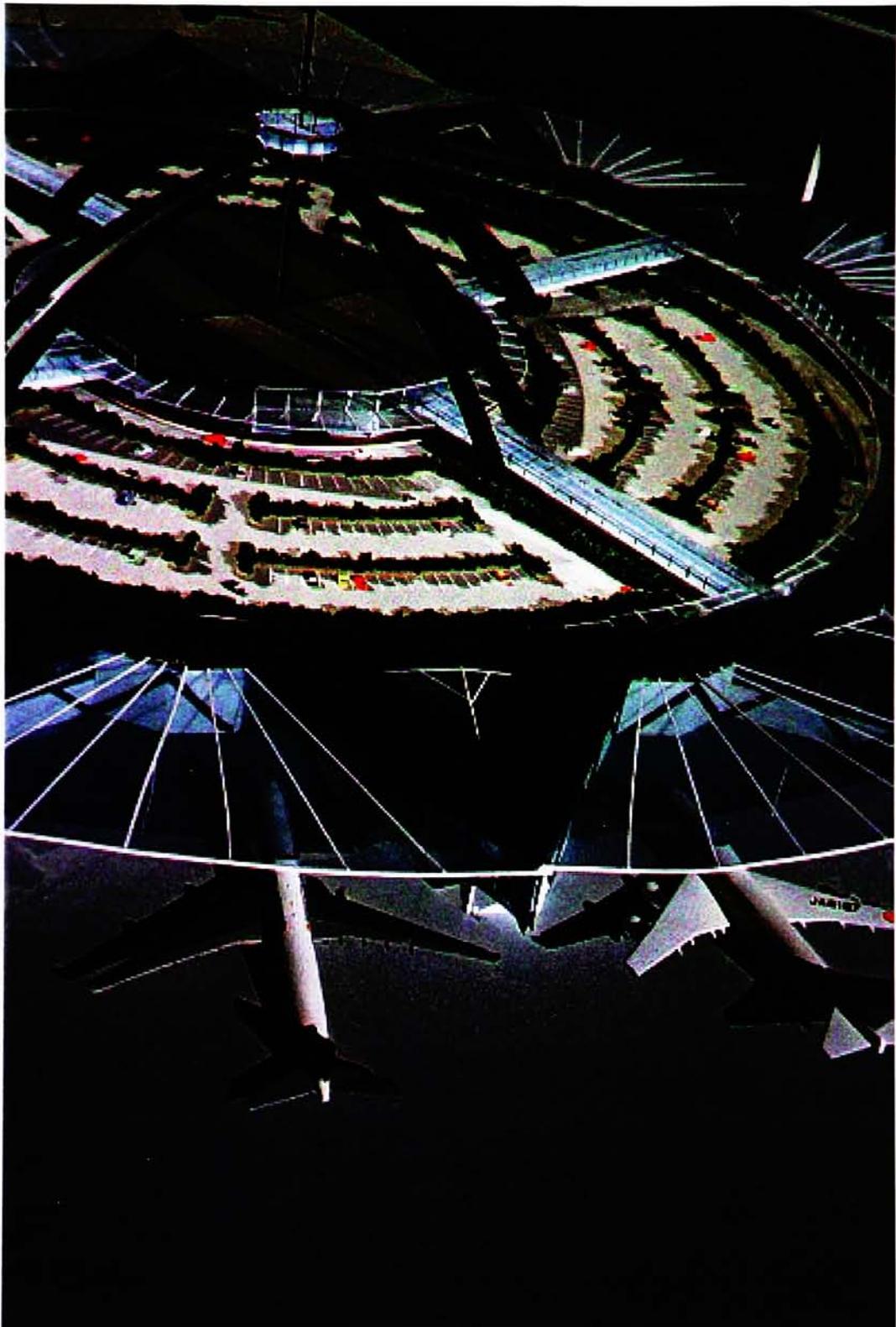
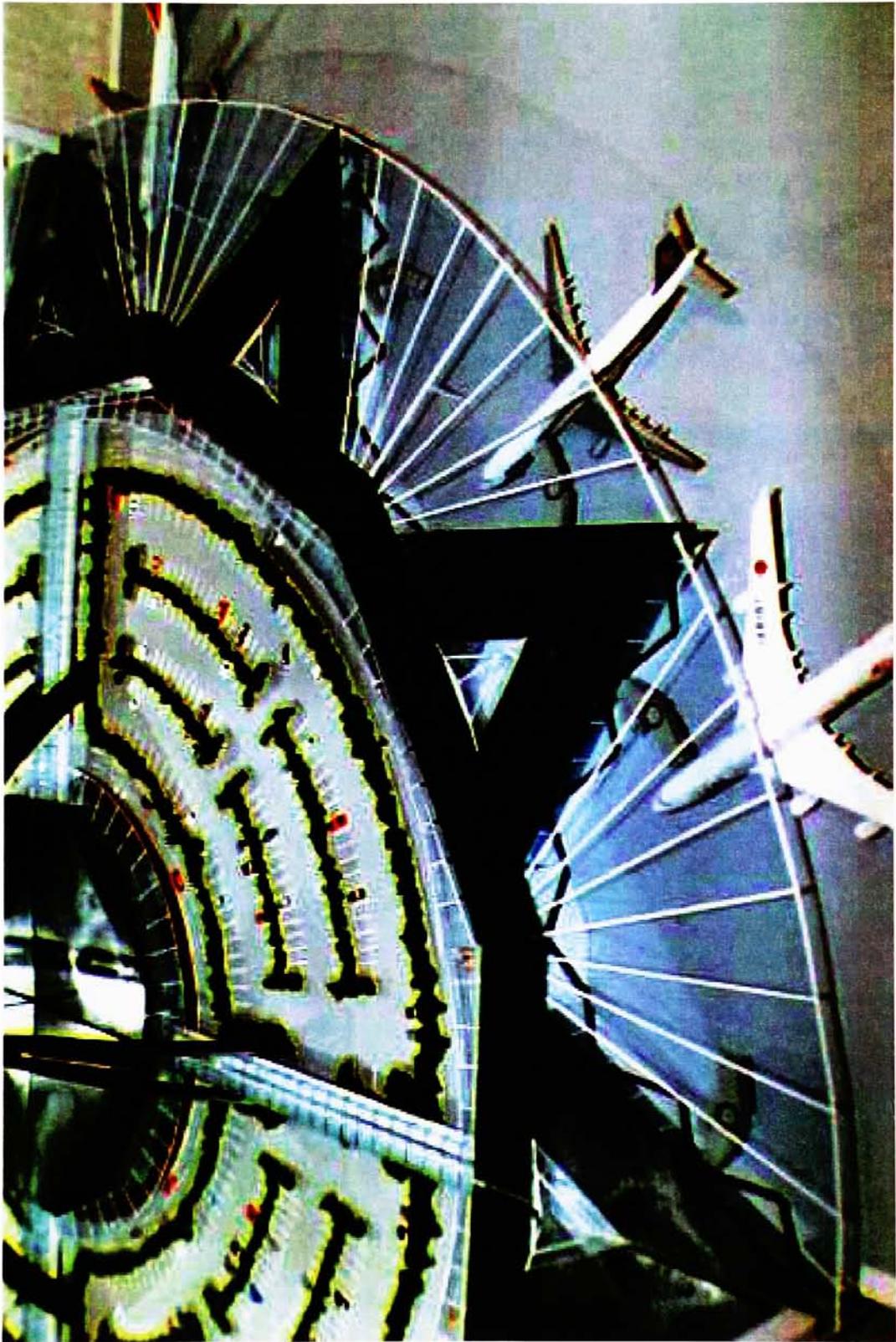


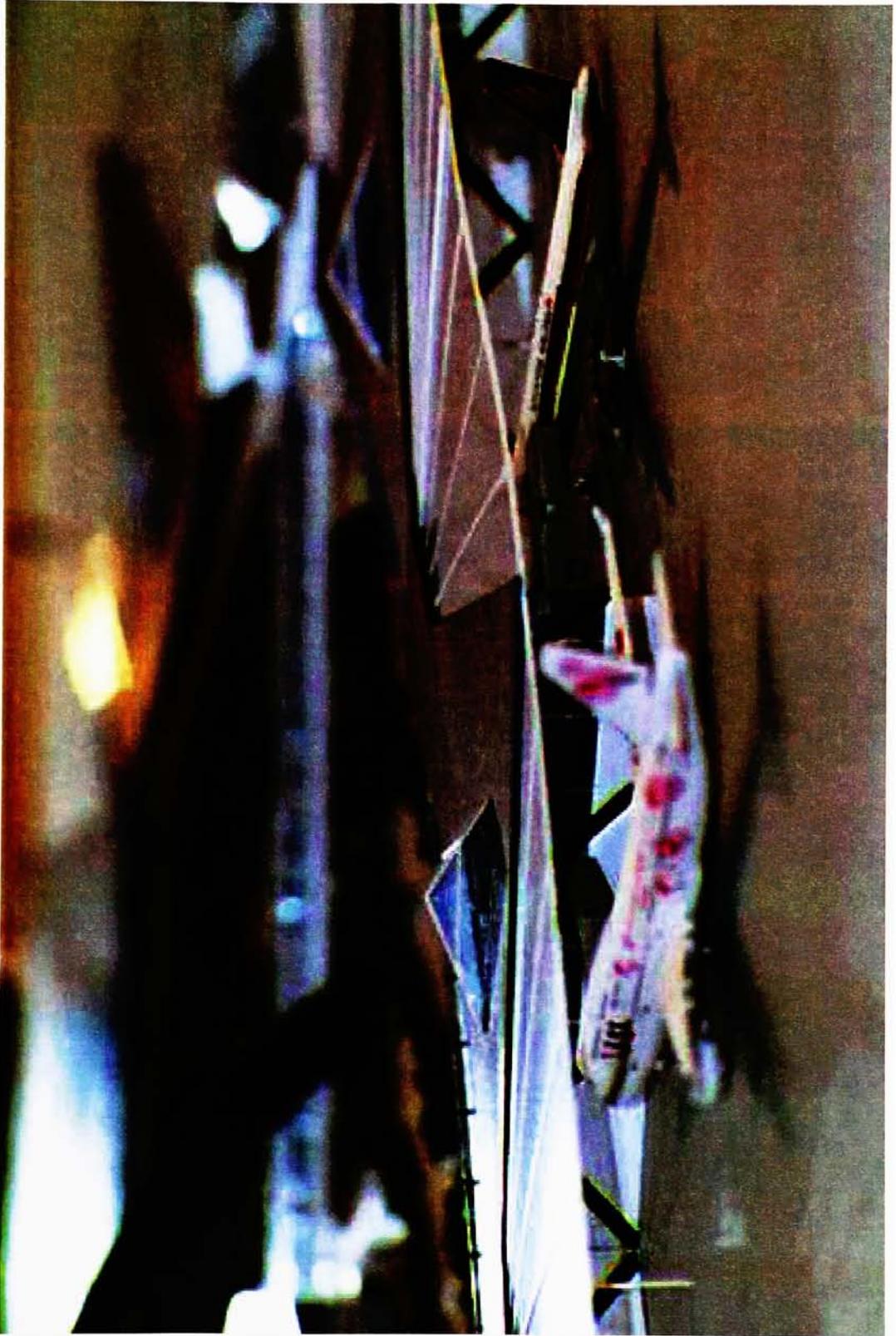
Figure 5.4- Section of Satellite Terminal (Arrival Building)

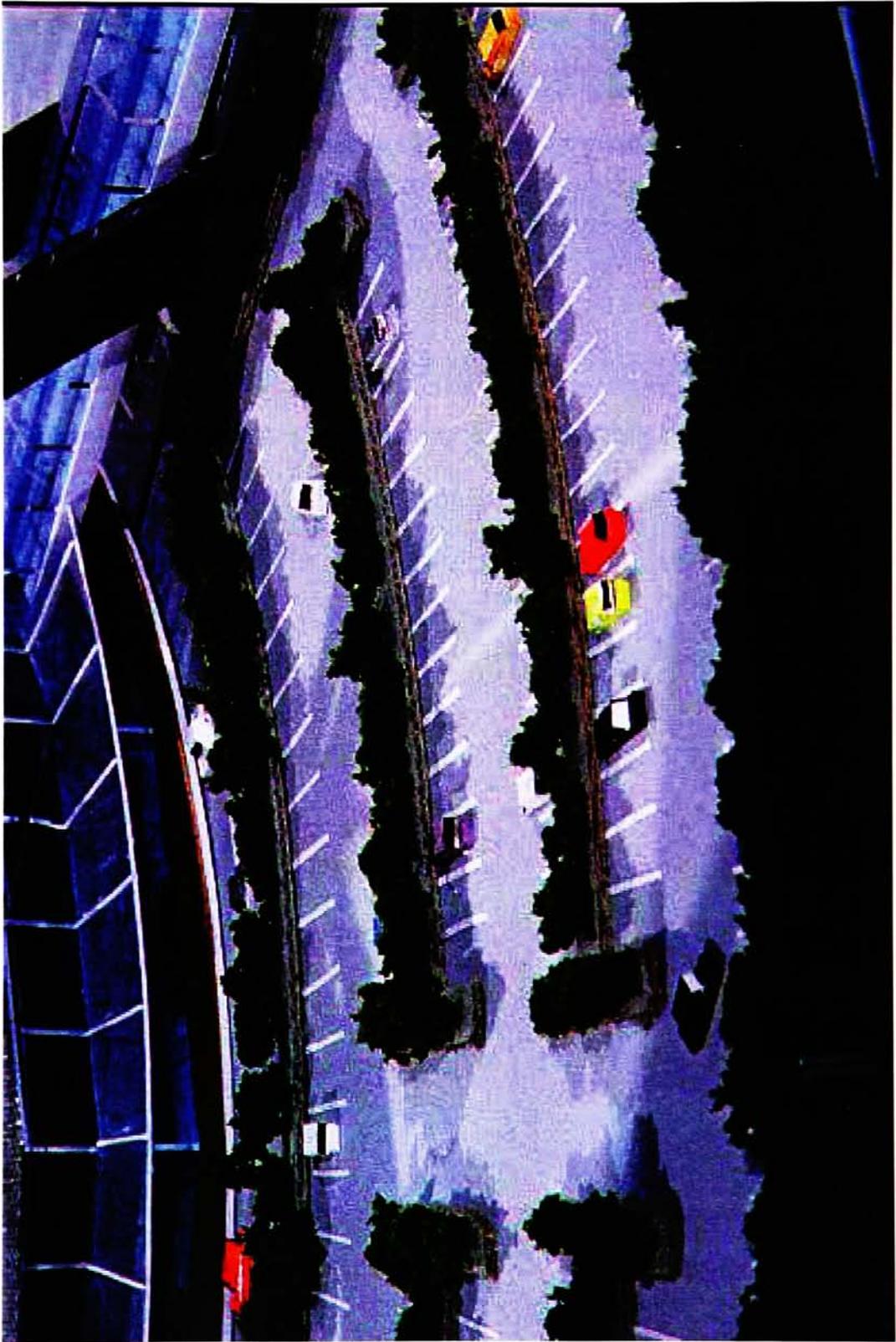








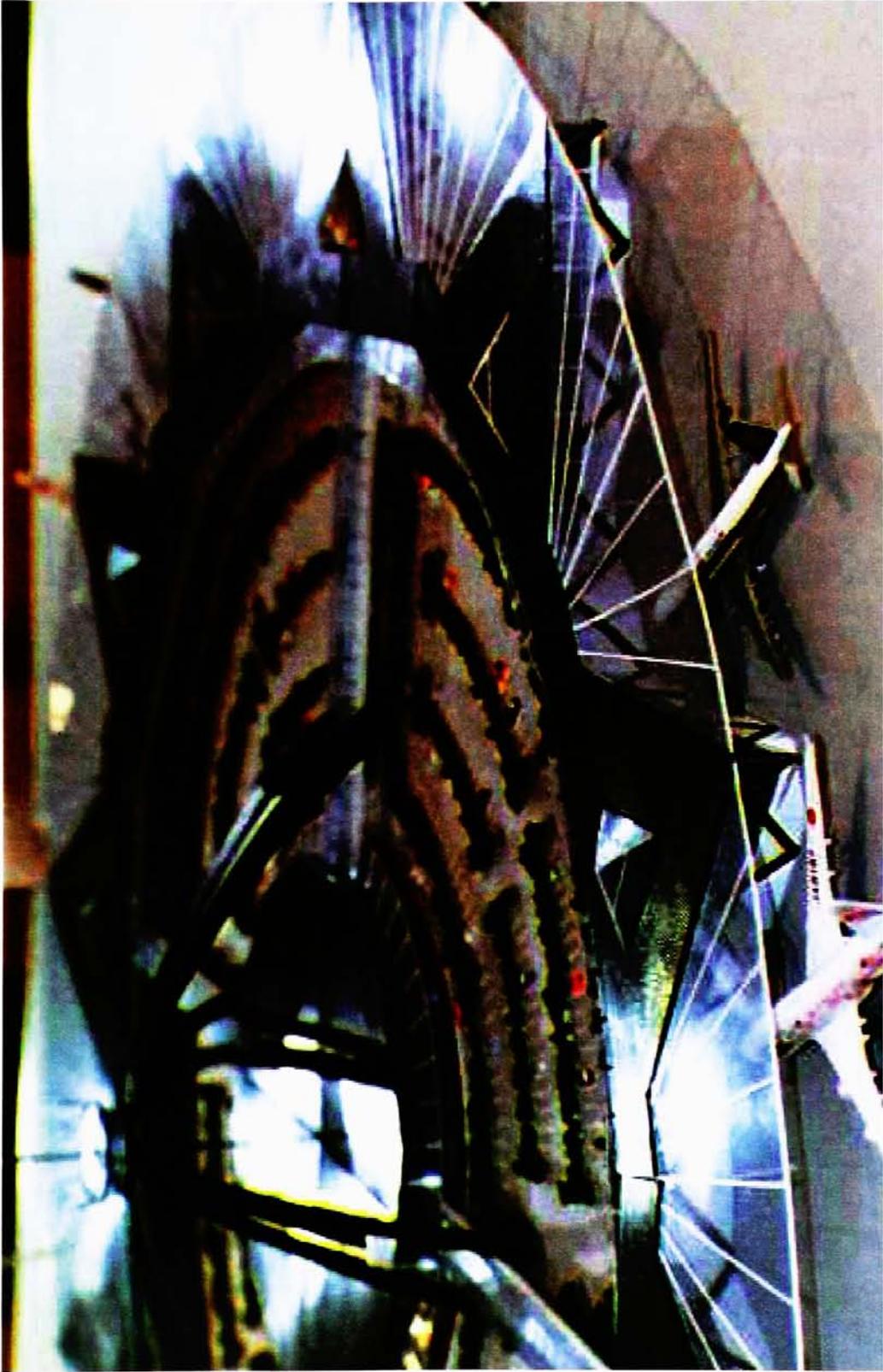




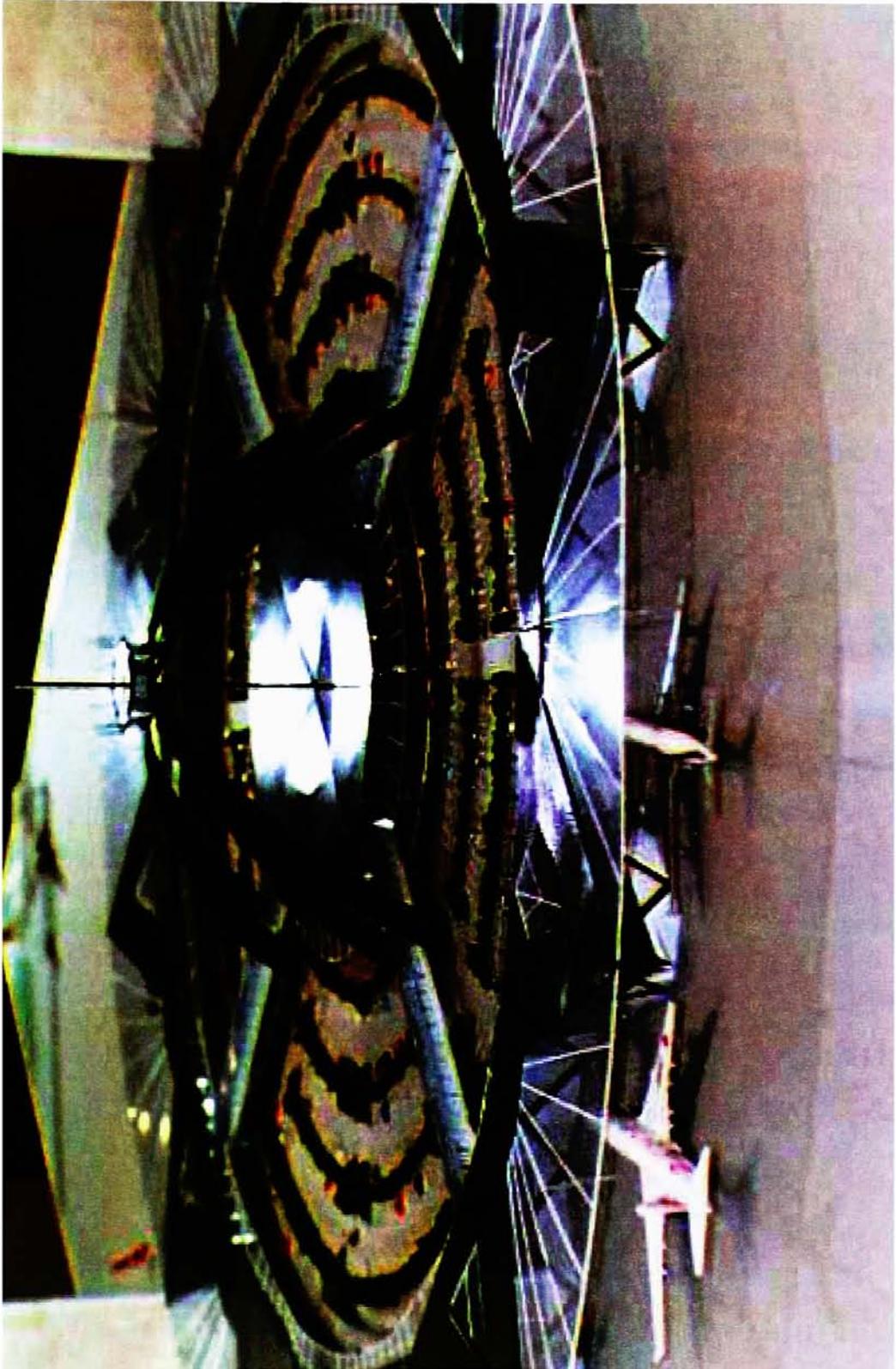












CHAPTER VI

CONCLUSION

Although it is impossible to predict the future of air travel, even over the next few years, several things appear to be fairly certain. One is that air travel will continue to grow rather quickly for the foreseeable future. A large number of people have learned to use the airplane just as they used trains in an earlier era or they use the automobile or bus today. Commuting by airplane has become common.

The goal of this thesis was to improve the current design of the airport terminal to better serve passengers. In the final result, shown in Chapter IV, the round-shaped terminal represents a Twenty-first Century terminal design for the near future. The future terminal will be quite different from that experienced at most airports today. The modern airport, and certainly the airport of the 21st century, is a huge, complex and noisy facility. It is a focus for a wide diversity of human activity--from travel to leisure, from shopping to health clubs, from plane-spotting to conferences, and from family reunions to church outings. The airport is as a new type of city in the twenty-first century.

I hope to see this multifunctional, convenient, safe, and comfortable prototype introduced to the public soon.

BIBLIOGRAPHY

Aerodrome Design Manual Part 2, *Taxiways, Aprons and Holding Bays*, 2nd Edition, Montreal: International Civil Aviation Organization, 1983.

Airport Design Standards- *Site Requirements for Terminal Navigational Facilities*, AC 150/5300-2D, Washington D.C.: FAA, 1980(Including Changes).

Airport Master Plans, FAA Advisory Circular AC 150/5070-6A, 1985.

Airport Planning Manual *Part 1, Master Planning*, 2nd Edition, Montreal: International Civil Aviation Organization, 1987.

Airspace Utilization Consideration in the Proposed Construction, Alteration, Aviation and Deactivation of Airports, 70-2D, Washington, D.C.: FAA, 1970.

Airport System Capacity, Special Report 226, Washington D.C.: Transportation Research Board, 1990.

Ashford, N., *Level of Service Design Concept for Airport Passenger Terminals: An European View*, *Transportation Planning and Technology*, Vol. 12, No. 1, 1987.

Ashford, N. J., *Planning and Designing for Air Cargo Under Condition of Technological and Market Change*, Avmark Conference Proceedings, *The Air Cargo Industry and Its Aircraft*, Capri, May 1990.

Ashford, N., *Predicting the Passengers' Choice of Airport*, Airport Forum, March 1989.

Ashford, N. J., *Problems in Long Term Air Transport Forecasting*, *Journal of Advanced Transportation*, Vol. 19-2, August, 1985.

Ashford, Norman J. & Wright, Paul H., *Airport Engineering*, 3rd Edition, A Wiley-Interscience Publication, 1991.

Avmark, Bennet D., *Meeting Air Cargo Demands*, Conference Proceedings, *The Air Cargo Industry and Its Aircraft*, Capri, May 1990.

Boeing Commercial Airplanes, *Current Market Outlook*, 1989.

Caves, R. E., **Airport System Planning- A U.K. Study**, *Transportation Planning And Technology*, 1980.

Cowan, Henry J. & Smith, Peter R., **Environmental Systems**, Van Nostrand Reinhold Company, 1983.

De Chiara, Joseph, Panero, Julius and Zelnik, Martin, **Time Saver Standards for Interior Design and Space Planning**, McGraw Hill Inc., 1991.

Deem, Warren H. & Reed, John S., **Airport Land Needs**, , Author D. Little Inc., 1967.

Department of Transportation, **Planning the Metropolitan Airport System**, Federal Aviation Administration, AC 150/5070-5, Washington D.C.: U.S., May 1970.

Department of Transportation, **Planning the State Aviation System**, Federal Aviation Administration, AC 150/5050-3B, Washington D.C.: U.S. January 1989.

Doganis, R. And A. Graham, **Airport Management**, London: Polytechnic of Central London, 1988.

Douglas, McDonnell, **Outlook for Commercial Aircraft**, 1988-2002. Long Beach 1988.

Edition, FAIA, The American Institute of Architects, 1994.

Edwards, Brian, **The Modern Terminal**, *New Approaches to Airport Architecture*, 1998.

FAA, **Airport Design**, Y 1150/53000-13-Yo, Washington D.C.,FAA, 1989.

Federal Aviation Administration, **FAA Aviation Forecast**, Fiscal Years 1989-2000, Washington D.C., , 1989.

Federal Aviation Administration, **Runway Length Requirements for Airport Design**, Ac 150/5325-4A, Washington D.C., January 1990.

Francis D.K. Ching *with Cassandra Adams*, **Building Construction Illustrated**, 2nd Edition, , Van Nostrand Reinhold, 1991.

Future Development of The U.S. Airport Network, Washington D.C.: Transportation Research Board, 1988.

Hoke, John Ray JR., **Architectural Graphic Standards**, an Abridgment of The 8th Edition, FAIA, The American Institute of Architects, 1994.

Horonjeff, R. and Mckelvey, Francis X., **Planning and Design of Airports**, 3rd Edition, New York: McGraw-Hill, 1983.

Jacobson, I. D., **Demand Modeling of Passenger Air Travel**, *NASA Report Cr-157469*, 1970.

Kanafani, A., **A Framework for Aviation Systems Planning**, *Course Notes for Aviation Planning and Design Short Course*, Institute for Transportation Studies, Berkeley, California, 1998.

Moore, Kenneth C., **Airport, Aircraft and Airline Security**, Security World Publishing Co., Inc., 1976.

Mumayiz, S. and Ashford, N., **Methodology for Planning and Operations Management of Airport Terminal Facilities**, *Transportation Research Record 1094*, Washington D.C.: Transportation Research Board, 1987.

National Fire Protection Association. NFPA 403, 412, and 424.

Neufville, De Richard, **Airport System Planning**, The MIT Press, Cambridge, Massachusetts, 1976.

Noise Control and Compatibility Planning for Airports, AC 150/5020/1, Washington, D.C.: Federal Aviation Agency, August 1983.

Office of the Federal Register, **U.S. Government Manual**, 1990-1991., *General Services Administration*, Washington DC: Government Printing, 1991.

Reznikoff, S.C., **Interior Graphic and Design Standards**, Whitney Library of Design, 1986.

Smith, Fran Kellogg & Bertolone, Fred J., **Bringing Interiors to Light**, *The Principles and Practices of Lighting Design*, Whitney Library Of Design, 1986.

Transportation In America, Transportation Policy Associates: Washington DC, May 1989.

United States Standards For Terminal Instrument Procedures(TERPS), Order 8260-3B, Washington, D.C.: FAA, 1991.

U.S. Department Of Transportation, **National Plan of Integrated Airport System(NPIAS)** 1986-1995, Washington D.C.: Federal Aviation Administration, November 1987.

Whitelaw, J., (Ed.), **Airports Of The 21st Century**, Thomas Telford Publications, London, 1995.

World Air Traffic Forecast, Seattle: Boeing, 1990.

Wright, Ian Allan, A. J. **World Airports**, London, 1991.

Zukowsky, John. **Building For Air Travel**, , *Architecture And Design For Commercial Aviation*, The Art Institute of Chicago, 1996.