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DEPARTMENT OF ARCHITECTURE
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Hargeisa, Somaliland

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APPROVAL

I certify that this thesis satisfies the partial fulfillment of the requirement for the award of the Bachelor Degree in Architecture in ADMAS University in Somaliland.

SUPERVISOR:
SIGNATURE: _______________________________
DATE: _________________________________

DEAN OF DEPARTMENT OF ARCHITECTURE:
SIGNATURE: ___________________________
DATE: _________________________________
DECLARATION

I declare that the thesis entitled ‘AIRPORT-TERMINAL BUILDING’ is an original and my own study except where otherwise acknowledged. To my knowledge no part of this thesis has been submitted to any other institution.

SUBMITTED BY:

AHMED MOHAMED ABDILLAHI
DEDICATION

This work is dedicated to my beloved parents who give me a continuous support during my study in Bachelor Degree of Architecture, besides I dedicated to our dear brothers and sisters.
ACKNOWLEDGMENT

In the name of Allah, the most Gracious and the most Merciful Alhamdulillah, all praises to Allah for the strengths and his blessing in completing this thesis. And again praise is to Allah who gave me the ability and power to complete this achievement smoothly and successfully.

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ABSTRACT

The aims of this thesis are to try and examine how best to integrate form, image and character with function in airport design and hence giving the passengers a meaningful experience through the airport terminal.

In the late 20th and the 21st century, the design of the airport begun to transform from just the design for function but it started to look and incorporate aesthetic issues in design.

This study will look at the transformation of airport design in relation to exterior or form and image.

The author will look at how airport character acts as visual representation and how it affects the user of the space. The thesis is attempting to resolve lack of meaning in modern airport design.
CHAPTER ONE

INTRODUCTION
1.0 INTRODUCTION

The airport is one of the most uniquely designed buildings of the 20th century. The earlier airplanes took off from open grass fields and the airport consisted of a hangar for storage and servicing of the plane and an observation stand for visitors. Today the airport has evolved into a new generation state of the art hybrid building with multi-functions.

The airport is the gateway to most countries and so the design of the terminal aesthetically as viewed from the air and the ground is such a crucial to any country. Since the design of the first airport a lot of transformation and evolution has taken place in the form, image, character, Spatial design, materials used in airport terminals.

Airports are a key transportation modal point and their design should stand through time to be appreciated by past, current and future generations.

The airport terminal is the central building of the airport system. Its architecture reflects the glamour, scale and technological prowess of this fast growing industry. As air travel become more popular and accessible, the airport has assumed greater importance as a fundamentally new and challenging building. It is a miniature city reflecting the values and aspiration of the society. National image is reflected more directly in the design of airports than in any other building type, with the passenger terminal the key element in public perception.

Airport authorities have been for half a century, one of the most adventurous patrons of modern architecture. From Eero Saarinen TWA terminal of 1959 at the JFK airport to Renzo piano’s Kansai airport of 1995, airport developers have been consistent in their support of innovative design whether expressed in formal or technological terms.
1.1 PROBLEM STATEMENT

Building should have a specific language in their form; one should be able to clearly tell the difference between institutional buildings from a transport terminal building or even from an office block. Airports as countries gateway should conform to some kind of design principle were the design should stay timeless in character, form and spirit.

The main problems inherent to airport terminals are posed by their large size and scale and their complexity in function. The design of the airport gave function and efficiency the first priority, form image character and passenger needs took the second place. As Charles A. Lindbergh said, life it serves.

In a small way, airports should try to solve the issue of critical regionalism where the design should borrow from the vernacular, picking up elements from it and developing it to a new level, like the TWA flight centre in the JFK international airport in Queens New York borrowed its airport design from the eagle which is the countries symbol. The consequence of not achieving regionalism in design of airports leads to the lacking of a language and meaning in airport design.

The aims of this thesis is to try and examine how best to integrate form image and character with function in airport design and hence giving the passengers a meaningful experience through the airport terminal.
1.2 BACKGROUND OF STUDY

Airports in the early 20th century mainly served as a transport terminal and nothing more. They were locations where people went if they needed to travel and so there was no much emphasis on the terminal building design. Their main objective was function rather than form.

In the late 20th and the 21st century, the design of the airport begun to transform from just the design for function but it started to look and incorporate aesthetic issues in design.

1.3 SCOPE

This study focuses on addressing form-making issues in the airport building and will focus on the following;

a) An overview of the evolution of the terminal building.

b) Analysis of the transformation of the airport building in terms of form, image and character.

c) Carrying out a critical examination of the form image and character of the terminal building.

1.4 JUSTIFICATION

This study will look at the transformation of airport design in relation to exterior or form and image.

The author will look at how airport character acts as visual representation and how it affects the user of the space. The thesis is attempting to resolve lack of meaning in modern airport design.

The thesis hopes to contribute to the larger debate about form image and meaning and its importance. In the aesthetical aspect of airport design, the author hopes to contribute to the local understanding on the importance of image and character.
1.5 RESEARCH OBJECTIVES

a) Analyze how through history the image and form of the terminal building is transforming and what is causing some of these transformations.

b) Establish best practices in the terminal design in terms of the form.

c) Identify variable that affects the form image and character of airport building.

Research Questions:  
ap) What variables are affecting airport buildings in relation to form image and character in reference to its built form?

b) How has an airport design transformed since the first airport to the most recent?

c) How does the form in airport design affect the different functions in the airport?

d) What factors have led to the transformation of the image, form and character of the terminal building?

1.6 LIMITATION

Part of the study relies on documented information and in this case the study of airport image and form has not been really looked at, instead most of the studies about image in buildings in general and not any specific type.

Research was conducted under harsh conditions due to the insecurity in the country. The airport officials will withhold drawings and other details involved in the research, this mainly after the September 911 bombing of the New York twin towers and the many various terrorist attacks through the years.

1.7 STRUCTURE OF RESEARCH PAPER
Chapter one

Chapter one contains the introduction, problem statement aims and objectives, scope and limitations of the research topic.

Chapter two

This is the literature review where the author will analyze the topic in reference to published and unpublished materials. This chapter involves analysis and determination of variables that affect form image and character in the airport building.

Chapter three

This chapter provides guidance on spatial requirements for functions carried out in an airport terminal building.

Chapter four

This chapter provides guidance on terminal building space and facility guidelines.

Chapter five

This chapter involves several case studies including two desktop studies.

Chapter six

This chapter involves about the site selection and analysis.

Chapter seven

This chapter involves the design of terminal building done by the author.
CHAPTER TWO

LITERATURE REVIEW
CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 INTRODUCTION
The airport design in terms of its form, image and character has several independent variables that affect everything to do with the image of an airport terminal building. These independent variables are impacted
on by dependant variables, which cannot exist without the independent variables. The breakdown is as follows:

2.2 DIFFERENT HISTORICAL TIMES

Winter (2007) says that Passenger volumes have increased through the years due to various factors and so the terminal building has evolved through the years. The following is a breakdown of different eras in the historic period and how passenger volumes have affected the terminal building through the years, and how it has evolved in its form and image.

2.2.1 THE INVENTION ERA (1903-1914)

Pearman (2004), he states that On December 17 1903 in the Kitty Hawk, North Carolina was the day that Orville and Wilber Wright succeeded in achieving flight with a fixed wing
heavier than air vehicle. This was the birth of aviation even though the flight only lasted some minutes. During this era, airplanes did not require a paved surface since there were no designated runways. What this invention era had were large field that one could land and take off from any direction but they had to remove the cows first.

This is where the first passenger flight took place in modified Wright airfield. Thus early airports were not really airport but aerodromes. These aerodromes consisted of grassy areas where planes could take off and land. Hangars were for storing planes and observation stands.

**TERMINAL BUILDINGS OF THIS ERA**

Oval field: The sheds built within reach of the main railway station in the cities. The airport building of the time was largely multipurpose acting as passenger building, aircraft factories and observation stands.

Pearman (2004) he talks about, in the early days, with airships challenging aero planes, the buildings of an airfield were principally to house and maintain the fragile planes. Unlike today, the craft were not building in themselves that could be left out in the open for long period, and airships were particularly vulnerable to side winds. Having no dead weight to hold them to the ground, they had to be kept afloat in huge hangars, the technology of which can be traced back to the large covered ship dock familiar throughout the world from the early 19th century.

Large span spaces that mutated first into botanical glass house then into railway sheds

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Figure 2.2: the Wright brothers in May 1904 with Their flyer 2 at Huffman prairie Ohio USA
Source: Airports a century of Architecture by Hugh Pearman
Operational airfield existed as early as 1909 but the first spaces built and dedicated as airports terminals were commissioned in Germany in 1910 for the Zeppelin airship operated by the Delag Company. By 1914, the airport had handled 3400 passengers.

FORM AND CHARACTER

Winter (2007) says that the form, aesthetics and technology were simple with locally available material such as timber used for construction of the sheds in this era thus was the design of airplanes.

He goes on to say Early design for an airport such as Erich Mendelsohn 1913 sketches for an aerodrome, created in plastic, expressionist style, envisage a large central building with ancillary building stretched to either side for fixed wing planes. Removal of the airships and reconsider the large central hall as a passenger terminal, and the layout of Mendelsohn’s terminal building are not very different from the layout of most airport terminals of today

2.2.2 THE WAR ERA (1914-1945)

According to Pear man (2004), he says and states that World War 1 started in the 1914 and it brought about a new impetus for rampant development in fixed wing aircraft to serve in military capacity as bombers and military personnel carriers. World War 2 saw the advancement with the introduction of multi engine plane that needed long paved runways to take off and land. After the war ended, commercial airlines began to share the military airfield and either built new facilities for passenger and passport and passenger control or converted existing hangars to those uses.

TERMINAL BUILDING OF THIS ERA

In this era terminal buildings were designed in such a way that airplanes on one side of the building and automobiles on the other side. This arrangement was this way because airplanes capacity was still significantly small and also because the passenger capacity was not that huge. The airports of this era united function into one building unlike the earlier predecessors .The airport was expanded and in some cases constructed new structures to meet growing passenger traffic and larger planes that needed more room for take-off.
Pearman(2004), he says and states that the only two surviving 1917 - 18 hangars of the Grahame-white aircraft factory demonstrates the shift from the 19th century technology of timber lattice, Belfast trusses (also to be seen at the historic Duxford aerodrome in Cambridge shire) to modern cross braced, steel trusses. He says that these hangars have now been restored to form a new aerodrome museum.

Airfields had naturally proliferated during world war one, and some dating from that period, such as Duxford in Cambridge shire (now an operation aviation museum), still possess some of the hangars and officers clubrooms from that time. The planes had advanced in leap and bounds, but not the airfield. In layout terms little has changed since Huffman prairie (one of the initial airports ever constructed), although the military airfield had more buildings, and more permanent ones at that. since large number of people doing different tasks had to be housed the preferred shape of the airfield was circular, oval, or (especially in the USA) square they were turfed, often with the most commonly used parts overlaid with ciders or gravel and, where possible, slightly domed to allow downhill runs into the wind in any direction. Paved runways were a relatively late invention and came into being because of the increasing weight of planes combined with the gradual reduction of their dependence on headwinds to get aloft.

Because the focus of the war had been in Europe, it was Europe, rather than the United States that had the airfield infrastructure to move straight on to civilian aviation after the armistice of 1918. the future began immediately the cessation of hostilities. Heavier than air bombers, readily convertible to civilian use, were littering the airfield of Europe.

**FORM AND CHARACTER**
Winters (2007) say that Terminals resembled train stations and hangars resembled train sheds. View fig Figure 2.7. Airplanes interiors also resemble Pullman rail cars. All of this was an effort to ensure passengers that there was really nothing strange and new about air travelers.

In 1922 at the Konigsberg Germany built the first permanent airport and terminal especially for commercial aviation.

2.2.3 MODERN AIR INDUSTRY (1950-1960)

Pearman, (2004) he says and states that the modernization of airports in the 1950 and 1960s was marked by the entry ushered in a new era of increased speed and capacity of up to 150 - 200 passengers resulting into rapid expansion activities in airports. The travel boom of the 1950s especially in the USA prompted many carriers to expand their fleet to keep up with surging demand of air transport.
As larger planes parked farther from the terminal in this era, buses and shuttles took passengers from the terminal to the planes. As jets were introduced which required even more space and the introduction of Pier finger and star shaped terminals appeared the 1950 in the United States and soon after in Europe. Passenger would congregate in a control area and then move out into the fingers or point of start of departure.

**MATERIAL**

This era saw the extensive use of reinforced concrete and glass in the construction of airport buildings or terminals. This improved technology helped the airlines achieve certain statements that they wanted to put across in the aviation industry.

**CONCEPTS**

This era so the coming up of the so-called connection or airport transport design which dealt with how planes accessed the terminal.

**TERMINAL BUILDING OF THIS ERA**

According to Robert Horonjeff et al (1993), he says this period marked the beginning of tailor made modern terminal in airports. Airlines intending to position themselves to serve the clientele were responsible for the construction of many terminals as architecture came to play a big role during this time. There was emphasis on form, aesthetics and appearance.

Pearman (2004) says that the new Dublin terminal was punching above its weight, suggesting an operational sophistication that was not there, it stood in the cups of two eras at the very end of the period of the 1930s heroic modernism and before the necessary rapid extension of the post war years into the modern era. Although the original building, much altered, is still to be found as part of the arrivals sequence today The tiered decks can be
read in terms of a ship and its square tower as the ships bridge, but there was also rounded, concrete, cantilevered wing on top deck, and in the early days, when it was seen from above, the plan was evident. This plan, which incorporated the landscaped approach sequence as well as the building itself. The curving terminal building (in this instance curving away from the apron rather embracing it as was more usual), formed the wings, and the control tower was the on top was the cock pit. The axial approach was laid out to suggest a fuselage and tail. This could have been banal, but for the fact that the shape of a plane in plan happens to be an excellent diagram of the movement of people through such an airport.

2.2.4 DEREGULATION ERA (1970-1990)

Pearman (2004) says that the passing of the deregulation act of 1978 in the United States signaled an end to the 40-year history of economic regulation of the airline industry. With this significant development, the market was opened to new carriers gained more freedom to enter or leave the market, change routes and compete on the basis of price including the entry of the small carriers that took over short distance flights. Major carriers concentrated on long distance flights and hub airports as small carriers carried passengers from different small airports into centralized hubs. The passenger numbers greatly increased due to the size of the planes. In this era, the planes had a passenger capacity of 200-
TERMINAL BUILDING OF THIS ERA

Pearman (2004) says and states that Due to the increased in passenger activity in a post deregulation environment have also led to a rapid desire for expansion in a very short period. In northern America since its economic performance and viability of both an airport and its airlines, this era coincided with the advent of the Boeing 747, which increased passenger capacity.

FORM AND AESTHETICS

The deregulation era saw airlines position themselves as hub airports where they invested in hug terminals facilities. Terminal buildings had to make a statement for the airlines and competition was based on the attractiveness of airport and included facilities. Thus, grander iconic design in airport buildings was very common. For example the Washington Dulles airport designed by architect euro Sarrien.

MATERIAL

During this era where aesthetics statements and form mattered, there was intense use of reinforced concrete, glass and steel in the building of the airport terminal. Steel was particularly important in the huge roof spans that were common in the design of airports in this period.

FUNCTION
Pearman (2004) believes that “With emphasis towards outward appearance and statements during this time function appeared to have been relegated to the back seat so and hence the terminal space ended up being huge bare spaces with exaggerated concourse and generally passenger unfriendly”

2.2.5 PRESENT ERAS (1990-TODAY)

Pearman (2004) says and states that, “Air transportation in this era is the defining mode of transportation of the 21st century and constitutes an existing long term growth industry. Air travel is becoming an ordinary part of today’s life and culture for many. New airports have been constructed and new policies adopted to improve the level of service of passengers. With the arrival of the airbus A380, airport terminal have been designed to cope with large flows of passengers per plane.”

Today airports terminals are central and intermediate location of moving passengers and freight from one location to another.

FORM AND AESTHETICS
Pearman (2004) believes that “The modern airport building or terminal is a highly charged symbolic iconic building. Airports in the 21st century will remain a symbol of cultural and memory of any country in the world. Terminal architecture will continue to give identity to an alienated environment. For example the Kuala-Lumpur to Schiphol confirm the change in emphasis from more functional or mechanistic function into a cultural memory, “image in the terminal”

2.3 PASSENGER VOLUME AND THE TERMINAL BUILDING

2.3.1 THE TERMINAL BUILDING

Figure 2.18: William B Hartsfield Atlanta Airport Ariel view
Source: www.sunshineskies.com

Figure 2.19: Kuala-Lumpur International Airport
Source: www.airbus-fyi.com

Figure 2.20: Amsterdam Airport Schiphol. On the airside
Source: www.airbus-fyi.com

Figure 2.21: Kuala-Lumpur International Airport
Source: www.airbus-fyi.com

Figure 2.22: Amsterdam Airport Schiphol. On the airside
Source: www.airbus-fyi.com
Pearman (2004), he says that Passenger volumes can be obtained from forecasts normally done in conjunction with airport planning studies. Two measures of volume are used. The first is annual passenger volume, which is used for preliminary sizing of the terminal building. The second is a more detailed Hourly volume.

**PASSENGER VOLUMES AND PLANNING OF SPACES**

Pearman (2004) states that there are factors which influence the extent of passenger amenities and terminal building design. Some of this includes the passenger volume, community size, the location and extent off-airport services, interests and abilities of potential concessionaires, and rental rates. The passenger volume affects the design and the size of the spaces in the terminal building. The following are spaces that are greatly affected by the passenger volume in the airport building at any particular point. The spaces are calculated according to the FAA regulations of airport design in reference to the passenger volume.

These are the spaces greatly affected by passenger volume.

1. Ticketing/check-in
2. Passenger screening
3. Hold rooms
4. Concessions
5. Baggage claim
6. Circulation
7. Airline offices and operations areas
8. Baggage handling
9. Baggage screening system
10. International facilities

**2.3.2 FUNCTION AND PLANNING**

Passenger volume has affected different functions in an airport and can affect the external form of the building in its character and image. There are different locations in an airport
terminal that have specific function and so the
design would conform to certain characteristics,
this is all according to Horonjeff et al (1993).

They debate about form follows function is not
considered in the airport industry design since the
trend these days is designing iconic terminals
then the function follow. But in some cases the
function may dictate the design of a terminal like
for example the blast area at the main entrance of any terminal affects form since they
would receive double reinforcement and the materials used there should be of high strength
to reduce the impact in case of a terrorist attack.

“Form Follows function” was coined by
American architect Louis Sullivan, and as a
result Frank Lloyd Wright, who was
Sullivan’s assistant in the office, adopted the
phrase “form follows function”. The
Guggenheim Museum is a good example of
Wright’s application of the principle. The
design with a spiral shape was intended to
allow visitors to easily view the artwork within.

The following are a couple of airport design that
has changed due to different passenger volumes
through the years. There are several basic approaches to the design of terminal buildings in
airports, and how they are evolving with time according to Horonjeff et al (1993).

2.3.2.1 THE CENTRAL TERMINAL WITH PIERS
Horonjeff et al (1993) they state that in this arrangement the gates are placed along a pier like concourse. This is the most common kind of configuration since it is relatively more economical the pier arrangement also provides a convenient place for security equipment at the end of each concourse.

This arrangement has its disadvantages in that:

I. It creates long walking distance, especially for passengers moving from one concourse to another.

II. Considerable congestion can occur at the end of each concourse as both enplaning and deplaning passengers have to pass through the same point.

III. The extent to which the piers can extend is also limited as these increases the already long walking distance.

The passenger volume in this terminal design is congested in one building, and the design is only successful if the circulation is greatly considered.

2.3.2.2 UNIT TERMINAL WITH PIERS
In this arrangement Horonjeff et al. (1993) says and discusses the combination of piers and unit terminal and how it attempts to reduce the long walking distance that occur when concourse are connected to a single large terminal building.

He says, “The arrangement also allows departing passengers to park closer to their departure gates since the number of people seeking access to each building is relatively small.”

Horonjeff et al. (1993) say that the unit terminal has added the advantage of being able to be expanded with ease without seriously disrupting the airport service. This design caters for larger passenger volumes since they can easily expand for whatever reason. They say,” the major disadvantage of this configuration or system is the redundancy or duplication of services which result in higher construction and operation cost”

### 2.3.2.3 UNIT TERMINALS

In this configuration, planes are required to dock at the terminal themselves. This arrangement reduces the walking distance that passengers have to cover. It also requires less square footage and provides better aircraft accessibility. This configuration also allows airlines that want to centralize their operations to acquire its own building and freely develop its own identity

### 2.3.2.4 LINEAR TERMINALS

Horonjeff et al. (1993) he states that in this configuration of terminal design takes two divergent forms:
I. At small airport with few gates, the terminal allows planes to dock alongside the main building. This results in a relatively low cost structure that is easily secured and convenient for both enplaning and deplaning.

II. At large airports the linear terminal concept has resulted in the elimination of a central ticketing and baggage facility and opted for a string of gates immediately adjacent to the parking areas.

Horonjeff et al (1993) says “This configuration presents problems in that through the structure may be low in cost and also very convenient to enplaning passengers due to the reduced distance, the system is costly to operate due to the large number of entrances“.

2.3.2. 5 LINEAR TERMINALS WITH SATELLITES
This configuration aims to circumvent some of the problems associated with large linear terminal such as passenger volumes by combining them with remote satellite terminals. This allows the linear terminal to remain at a reasonable length without excessive distance between its farthest gates. An added advantage of the remote satellites is the increased number of planes that are double loaded concourse can accommodate.

The main disadvantage is that the relatively large amount of acreage required and the high cost of people movers or passenger traffic.

**2.3.2.6 CENTRAL TERMINALS WITH SATELLITES**

In this configuration, Horonjeff et al (1993) states that the aircraft are docked on remote aprons far from the terminal and people are bused to and from their planes. This design would not cater for larger passenger capacities since it would be great hustle to cater for the transportation of passengers to and from the terminal building.

He says that it is necessitated by the size and noise of the jet aircraft, which suggests their isolation. However, the disadvantage is the time it takes to load passengers on and off the buses and the cost and potential trouble of operating the vehicles.

Horonjeff et al (1993) alternatively they says that the ticketing, security and baggage can be handled from a central terminal and then the people can be moved by either automated train or moving walkways to the remote satellite. Those results in reduce walking distance and easier access to the gate. For example the Indianapolis international airport was designed and built in 2008 is a terminal building with satellites. This configuration however requires more acreage and is also more expensive to build and operate.

**2.3.2.7 TERMINAL WITH**
CONNECTED SATELLITE

Horonjeff et al (1993) states that this arrangement connects a satellite to the main terminal via piers. He says “This reduces the drawbacks of remote satellites; hence it can be both less costly and require less acreage, and also simplifies the walk of passengers to their gate”.

He discusses and says “However it reduces some of the accessibility of the aircraft. This arrangement has the advantage that it allows for the centre of the concourse to be opened up for day light. Passengers can also change planes without walking through the terminal.”

2.4 SECURITY IN THE TERMINAL BUILDING

2.4.1 TERMINAL BUILDING DESIGN
Security screening of passengers is an extremely important function in an airport terminal. The security screening area will include a checkpoint for identification inspection, walk-through metal detectors, and x-ray equipment for carry-on baggage inspection. The location and size of the screening area will be dictated primarily by passenger volume with consideration to issues of queuing, physical search, and passengers requiring additional processing, this is according Horonjeff et al (1993).

2.5 NEW AIRPLANE DESIGNS AND THE TERMINAL BUILDING

2.5.1 HISTORY OF AIRPORT DESIGN

According to Edwards (1998) he says that the introduction of wide bodied aircrafts such as the Boeing 747 in the 1970 resulted in the not only lengthening of the runway but also in the enlargement of the terminal building and the access piers to accommodate the influx of passengers arriving in great waves.

It is feasibly today to design and build aircrafts capable of carry 1000 passengers, but with double Decker planes, they would need double Decker piers and greater terminals.

Aircrafts in the 1990s has concentrated upon new safety levels, greater comfort, less noise and more fuel-efficient planes. Such aircrafts have stabilized at seating levels of about 450-500 (as in the Boeing 777) but with the new design from the airbus of the A380 carrying more than 850 passengers, it has led to the revolution of the air industry. If by chance a terminal receives, three such planes with full capacity the terminal would come to a standstill and so the design needs to be improved for such occasions.

Hugh Pear man(2004),says that architects of today’s airport buildings are celebrated, from Eero Saarinien to Renzo Piano, Richard Rogers and Norman Foster to Ricardo Bofill, but it is more rare to regard a designer such as Joseph F. Sutter ,creator of the Boeing 747.according to Norman foster he thinks of him as an architect. in 1991 foster said; ‘with about three thousand square feet of floor space, fifteen lavatories, three kitchens and a capacity for up to three hundred and seventy guest ,this is surely a true building. The fact that we call this an aero plane rather than a building-or engineering rather than architecture-is really a historical

Figure 2. 41: airbus A380
Source: www.wikepidia.com
hangover because for me, much of what we have here is genuinely architecture both in design and in its thinking.

2.5.2 AIRCRAFT TYPES AND PASSENGER TERMINAL DESIGN

According to Edwards (1998) he states that there are four main scale of air transport and they are intercontinental, continental, regional and commuter and are each served by their own type and category of aircraft. Transport by the first is in such aircraft as the Boeing 747(with seating capacity for 400), the second by say the European Airbus A310 (seating 250), the third by the Boeing 737(Seating 150 -200) and the fourth by the SAAB 340 (seating 35). Each scale of jet has its own apron, servicing and terminal design needs though there are overlaps between the four main categories of aircraft, and the designer of the airports knows that if each scale is accommodated, then those planes between the capacity bands will fit comfortably into the system. as a general rule journeys over 3000km are seen as intercontinental, between 3000 and 1500km as continental, under 1500km as regional and under 300km as commuting.

While the intercontinental and continental market is met by jet aircraft, the lower end of the regional scale and commuter market is increasingly served by turboprops (a type of turbine engine which drives an aircraft propeller using a reduction gear). The new generation of turboprops offers distinct advantages over jet aircraft: they are less noisy, can operate at lower altitudes; have reduced emissions and shorter take-off and landing space needed.

Edwards (1998) says that the growth in commuter journeying by plane is being meant not by small noisy jets but by relative quiet and fuel efficient turboprops
such as the SAA 2000. In fact while larger jet aircrafts are increasingly constrained by environmental regulations of one kind or another, the new generation of turbo props with their improved performance readily meet international standards.

According to him, the terminal building has to be capable of accommodating all four scales of commercial aircraft listed earlier. The most problematic area is normally concerning commuter aircrafts, where smallness of size, the need to take off and land quickly, and unusual aircraft design features put terminal, gate lounge, runways and apron facilities under greatest strain. Edwards (1998) says “However, looking further to the future (10-20 years), a new generation of aircraft now undergoing technical investigation may require wider modifications to airport design.”

Edwards (1998) argues that two trends are emerging that, if realized will alter the assumption under which the airline and airport industries operate. The first concerns the re-emergence of supersonic passenger aircraft. Design and technological research is being devoted to a new generation of supersonic aircraft based upon the experience of Concorde. Several manufacturers are collaborating to develop a quieter, faster, more fuel efficient and large capacity planes. With business travel growth still buoyant, and the world’s biggest trading nations at opposite geographical regions, aircraft designers realized that very high speed travel has commercial advantages. The age of mass supersonic commercial air transport will probably occur well within the life time of airport currently being designed (being 50 years). The second innovation concerns very large aircrafts, perhaps capable of carrying 1000 or more passengers. The Airbus industries, Boeing and McDonnell Douglas are developing prototypes designs in this field. Because of this the passenger terminal the implications for the organization and distribution of space, catering, ticketing and baggage handling will be profound. To meet such demands design of the terminal building has to be robust in concept and capable of multiple adaptations over time.
According to Edwards (1998) the life of an airport terminal, is about 50 yrs., is two or three times as long as the aircraft it serves, and frequently longer than the life of an airline company. In an industry of little stability, the airport is the one permanent feature. Even the airport, though, does not stand still; it replaces obsolete ground transport system, and regularly upgrades air traffic control facilities. At the Heathrow there are now four terminals(with a fifth designed), while terminal 1 has been substantially rehabilitated and extended at least twice in its 30 years of life. These changes are driven by two main factors: the increase in passenger volume, and the evolving of aircraft design. Innovation in aircraft design triggers a chain reaction throughout the industry, which airline management, airport operation and passenger terminal design have them to meet. Due to very high passenger volume increase and changes in aircraft design this must be resultant and it should affect the terminal design. The passenger terminal has to be capable of meeting change, but the architect is rarely able to anticipate what specific shape or direction that change will take. Flexibility expandability and functional adaptability are the obvious design philosophies to adopt within the constraints of structural robustness and aesthetic appeal.

2.5.3 DIFFERENT HISTORICAL PERIODS PLANE DESIGN AND EFFECT ON THE TERMINAL BUILDING
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<th>AIRCRAFTS OF THIS ERA</th>
<th>TERMINAL BUILDINGS OF THE ERA</th>
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<td><strong>The invention era</strong></td>
<td><strong>Figure 2.48: Lon greens biplane</strong></td>
<td><strong>Figure 2.49: Wright brothers first hangar</strong></td>
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<td>(1903-1914)</td>
<td><strong>Source: <a href="http://www.holisticvanity.com">www.holisticvanity.com</a></strong></td>
<td><strong>Source: airport architecture, Hugh pearman</strong></td>
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<td>-simple pioneer aircrafts</td>
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| **The war era**            | **Figure 2.50: Avro Lancaster bomber plane**             | **Figure 2.51: Karachi Airport in 1943 during World War II** |
| (1914-1945)                | **Source: www.holisticvanity.com**                       | **Source: www.wikepidia.com**              |
| -vaulted roof hangars      |                                                          |                                            |
| -buildings scattered on airfield |                                                        |                                            |
| -development influenced by war |                                                        |                                            |
| -military aircrafts        |                                                          |                                            |

| **Modern air industry**    | **Figure 2.52: B-24 bomber plane**                      | **Figure 2.53: Miami International Airport, Florida** |
| (1950-1960)                | **Source: www.holisticvanity.com**                      | **Source: www.pbase.com**                   |
| -increased passengers capacity |                                                        |                                            |
| -entry of the jet engine   |                                                          |                                            |
| -use of reinforced concert  |                                                          |                                            |
| -a desire for an architectural statement |                             |                                            |
Deregulation era (1970-1990)
-the rise of the hub in airport design
-advent of the Boeing 747
-intense of reinforced concrete and glass
-a desire for an architectural statement

Figure 2.54 Boeing 747 copter plane
Source: www.archdaily.com

Figure 2.55: Santiago Calatrava
Source: www.calatrava.com

Entry of the present eras (1990-today)
A380
-emphasis on functionality and efficiency
-multifunctional building
-inter modality airport design came up

Figure 2.56: Airbus A380
www.wikepidia.com

Figure 2.57: Beijing International Airport
landsie view
Source: www.ardaily.com

2.5.4 TRANSFORMATION OF FORM
Nikolaus(1996) says that as a result of new aero plane design the airport building is greatly affected in its design and nowadays airport architect have conformed and hence there has being a revolution and transformation of form in airport buildings. Transformation in any building is described and broken down in various ways.

According to form space and order Ching (1996) he says, Transformation can be understood as a manipulation of the primary solids. Transformation of form is created by variations, which are generated by the manipulation of one or more dimensions or by additional, or subtraction of elements. There are a couple of types of transformation of form and they include;

**Dimensional transformation**

According to Ching(1996) This is when a form can be transformed by altering one or more of its dimensions and retain its identity as a member of a family of form for example a cube can be transformed into similar prismatic forms through discrete changes in width, height or length.

**Subtractive transformation**

On the extent of the subtractive process the form can retain its initial identity for example a cube can retain its identity even though a portion of it is removed.

**Additive transformation**

A form can be transformed by the addition of elements to its volume. The nature of the additive process and the number and relative sizes of the elements being attached determine whether the identity of the initial form is altered or retained.

### 2.6 MANAGEMENT OF THE TERMINAL BUILDING
Management or the ownership of the airport terminal is either publicly owned or privately owned and according to Edwards (2005) he discusses and breaks down the effect on the terminal building design in terms of form image and character.

### 2.6.1 TERMINAL BUILDING DESIGN AND EFFECT ON FORM IMAGE AND CHARACTER

Edwards (2005) says that the trend these days is away from ownership of airports by the state (either central or regional government) towards either private ownership or partnership between the government and private investors. London Stansted is owned by BBA (which is wholly private and quoted in the stock exchange), and other major airports, such as the Stuttgart in Germany and Milan in Italy, have been denationalized and are now no longer state owned. He says the reasons are clear: airports require massive injection of funds to adapt to changing regulations, market conditions and commercial opportunity. Only with private capital can the outmoded infrastructure of airports be kept up to date.

In the developing world according to Edward (2005) he says that it is still a commonplace for the state or local authority to own and manage airports, but as soon as they become profitable they are quickly sold, often to international organizations. Although many governments cling to the idea that their major airports are part of the national infrastructure of public utilities, in reality the past 10 years have seen a shift worldwide away from government towards some sort of consortium ownership or total private ownership.

Edward (2005) says, “The pattern of ownership throughout the world tends to follow the varying ideologies of the respective government rather than any obvious regional or subcontinental pattern”.

Ownership of airports by the government is declining, there remains a strong group of airports (such as the Kansai in Japan) run by a consortium of state and local government with private companies having financial stake. Sometimes
the airport may be owned by the arm of the government, but the principal building (such as the passenger termini) are owned, leased or managed by a private organization such as airline companies. The mix of ownership has implications for the operation of the airport and- to some extent- for the design of the part. Where ownership is vested in government they tend to be a controlling hand over the appearance of the whole airport estate, from hotels to car parks, terminal building to control towers.

Edward (2005) says that where ownership is fragmented, or resides in a consortium, there is usually greater pluralism in the approach to design, and often the employment of a wider selection of architects, designers and engineers. Where there is a split in ownership between the airport and its key building (as the Kennedy Airport, New York) the pattern is usually one where different airlines own specific terminals. Therefore, the terminal building have very different image in terms of form image and character because of different ownership. This allows them to compete with each other as integrated terminal based service- including ticketing, baggage handling and concessionary shop-all managed by the airline company with which the passenger is flying.

CHAPTER THREE

RESEARCH METHODOLOGY
CHAPTER 3

3.0 RESEARCH METHODOLOGY

This chapter illustrates the different methods used to obtain and acquire data for this research. It gives a detailed explanation to the application of the research methods. The techniques used and how the data is collected, interpreted and documented.

3.1 RESEARCH PURPOSE
The research purpose chosen to be used would be explanatory, because the research carried out would look to try to define and analyze form image and character of the airport building and how they have transformed through the years and in different terminal buildings.

The study is not only restricted to fact-finding but it may eventually result to the understanding of the variable that affect the airports built form. The findings may eventually lead to the understanding of the terminal buildings built form and would get to understand where the design and technology is moving towards.

### 3.2 RESEARCH STRATEGY

The research is a case study based approach. Some of the factors, which are guiding the author in the choosing of a case study, include form transformation, which refers to airports with a rich history in their built form. Another criterion is choosing airports with more than one building terminal and then looking at the most prominent terminal building that gives the airport its recognition and statute. This also applies to the other chosen cases; terminal 3 in the Beijing international airport and the most recent terminal building in the Barajas airport in Madrid. After the cases are chosen then an in-depth analysis of its form image and character is undertaken.

The desktop studies intended to be studied are:-

I. Barajas airport Madrid Spain

II. Beijing international airport

### 3.3 TIME HORIZON OF STUDY

For this particular study, the time horizon is a longitudinal study where the data collection is done on the selected case study and a long critical study analyze the transformation of the airport buildings built form is undertaken.

The study was carried out in 5 to 6 weeks.

### 3.4 SAMPLING METHOD

Non probability sampling is used because there are specific criteria used in the selection of case studies. The main reason used in choosing the named case studies is looking at airports with multiple terminal buildings but out of the many terminals one stands out and gives the airport a statues and recognition in terms of its passenger volume, image, character and even its form.

### 3.5 DATA SOURCE

Primary sources
3.5.1 Observations

Direct observation enabled the researcher to put the elements of study in context and therefore understanding them better. It also enables first hand documentation of the situation as it is in the study area. The researcher used structured and unstructured observation method. The structured observation would assist the author to answer research questions while the unstructured one was to make sure any other relevant information found in the field is not left out purely because it was not covered in the predefined observation list. Sketches, photographs and measured drawings were used to capture the observations made.

Photographs

All the subjects of the study were captured in photographs and analyzed in sketches. Photographs were the major tool in capturing the existing situation in the area of study. Images of both the exterior and interior of the terminal were taken to give a clear understanding of the same. The photographs are used to support text in the analysis of the information obtained from the field.

Secondary sources

Documents, plans, drawings and any other literature on the field of study. Documents will be source from the following sources; the JKIA data were sourced from the architects who include the Gensler international firm. Other drawings were sourced from initial archives from the Kenya airports authorities.

3.6 DATA PRESENTATION

After carrying out an analysis of all the data collected from the case studies and desk studies, the findings will be sorted and expressed in various presentation formats. These include:

I. Photographs

One of the strongest tools if communication employed in the study is photographs. Each element studied was recorded in terms of clear photographs of different times and at different angles. The photographs were used mainly to show material, form and context. The photographs showed the experience of the spaces and the overall form and image of the terminal buildings.

II. Architectural drawings
Measured drawings of the subject of study include plans, elevations and sections are used to present the findings of the study to ensure easy interpretation of the findings. Of interest were the plans, sections and mainly elevations, which were used to show the image and character of the terminal building concerning the elements studied.

CHAPTER FOUR
DATA COLLECTION
CHAPTER 4
TERMINAL BUILDING SPACE AND FACILITY GUIDELINES

4.1. GENERAL

This chapter provides guidance on spatial requirements for functions carried out in an airport terminal building. The guidance is indicative of the design range in use at U.S. airports to accommodate domestic scheduled passenger operations. Adjustments may be necessary for international, charter, nonscheduled, or third level operations. Airport terminals should be
designed for a capacity to meet the projected needs of the community being served. This guidance should only be applied after consultation with the airlines, FAA, other users, and tenants. Modifications to the guidance may be warranted after such discussions.

4.2. GROSS TERMINAL BUILDING AREA ESTIMATES

**a. Gross Terminal Area per Gate:** The relationship between annual enplaned passengers and gross terminal area per gate for a 10-year and 20-year forecast is approximated in Figures 4.1 and 4.2, respectively. The profile of the curves is based on predicted growth in seats per aircraft for each forecast period; specifically, the growth in predicted aircraft mix during the peak hour of the average day of the peak month of the design year.

**b. Rule-of-Thumb:** A rule-of-thumb of about 150 square feet (14 m²) of gross terminal building area per design peak-hour passenger is sometimes used for rough estimating purposes. Another rule using 0.08 to 0.12 square feet (0.007 to 0.011 m²) per annual enplanement at airports with over 250,000 annual enplanements can similarly be applied.

4.3 SPACE ALLOCATIONS.

The terminal building area is comprised of both usable and unusable space.

Unusable space involves those areas required for building columns and exterior and interior walls, about 5 percent of the total gross area. The usable space can be classified into the two broad categories of rentable and non-rentable space. Usually, 50 to 55 percent is allocated to rentable space and 45 to 50 percent to non-rentable space. Figure 5.1 presents a further breakdown of these basic categories.

4.4 PUBLIC LOBBY AREAS.

Lobbies provide public circulation and access for carrying out the following functions: passenger ticketing; passenger and visitor waiting; housing concession areas and other passenger services; and baggage claim.

**a. Ticketing Lobby.**

(1) As the initial objective of most passengers, the ticketing lobby should be arranged so that the enplaning passenger has immediate access and clear visibility to the individual airline ticket counters upon entering the building. Circulation patterns should allow the option of bypassing counters with minimum interference.
Provisions for seating should be minimal to avoid congestion and encourage passengers to proceed to the gate area.

(2) Ticket lobby sizing is a function of total length of airline counter frontage; queuing space in front of counters; and, additional space for lateral circulation to facilitate passenger movements. Queuing space requires a minimum of 12 to 15 feet (4 to 5 m). Lobby depths in front of the ticket counter range from 20 to 30 feet (12 to 15 m) for a ticket area serving 50 gates or more.

b. Waiting Lobby.

(1) Apart from providing for passenger and visitor circulation, a centralized waiting area usually provides public seating and access to passenger amenities, including rest rooms, retail shops, food service, etc. The sizing of a central waiting lobby is influenced by the number, seating capacity, and location of individual gate waiting areas. If all gate areas have seating, the central waiting lobby may be sized to seat 15 to 25 percent of the design peak hour enplaning passengers plus visitors. However, if no gate seating areas are provided or planned, seating for 60 to 70 percent of design peak hour enplanements plus visitors should be provided.

(2) Visitor-passenger ratios are best determined by means of local surveys. In the absence of such data, an assumption of one visitor per peak hour originating passenger is reasonable for planning purposes.

c. Baggage Claim Lobby.

(1) This lobby provides public circulation space for access to baggage claim facilities and for egress from the claim area to the deplaning curb and ground transportation. It also furnishes space for such passenger amenities and services as car rental counters, telephones, rest rooms, limousine service, etc.
(2) Space required for the baggage claim facility is discussed in paragraph 75. Allowance for public circulation and passenger amenities outside the claim area ranges from 15 to 20 feet (5 to 6 m) in depth at small hub airports, 20 to 30 feet (6 to 9 m) at medium hubs, and 30 to 35 feet (9 to 11 m) at those airports serving large hubs. Lobby lengths range from 50 to 75 feet (15 to 23 m) for each baggage claim device. For approximating lobby length and area, one claim device per 100 to 125 feet (30 to 38 m) of baggage claim frontage should be assumed.

d. Combined Lobbies

(1) Airports handling less than 100,000 annual enplanements frequently provide a single combined lobby for ticketing, waiting, and baggage claim.

(2) For a combined lobby serving 100,000 to 200,000 annual enplanements, space requirements for various functions should be identified and sized separately, as discussed in preceding paragraphs.

(3) Above 200,000 annual enplanements, each of the three lobby types should be identifiable as distinct elements and space requirements estimated accordingly.

4.5 AIRLINE TICKET COUNTER/OFFICES

The Airline Ticket Counter (ATO) area is the primary location for passengers to complete ticket transactions and check-in baggage. It includes the airline counters, space and/or conveyors for handling outbound baggage, counter agent service areas, and related administrative/support offices. In almost all cases, ticket counter areas are leased by an airline for its exclusive use. Therefore, the planning, design, and sizing of these areas should be closely coordinated with individual airlines.

a. Ticket Counter Configurations.

Three ticket counter configurations are in general use. They include:
(1) **Linear.** Linear configuration is the most frequently used one (see Figure 4.2). Multi-purpose positions indicated are those in which the agent performs several functions such as ticketing, baggage check-in, and the other services an airline may consider appropriate. During peak periods, multi-purpose positions may be utilized for a single function to expedite passenger processing for those requiring only one type of service. At high volume airports, permanent special-purpose positions may be justified.

(2) **Flow-through Counters.** Flow-through counters, as depicted in Figure 4-3, are used by some airlines, particularly at high-volume locations with a relatively high percentage of “baggage only” transactions. This configuration permits the passenger to check-in baggage before completing ticketing transaction and increases outbound baggage handling capability by providing additional belt conveyors. This type of counter requires more floor space, an additional 50-70 square feet (4.7-5.1 m²), than the linear type and involves increased investment and maintenance costs. Future application will probably be limited to relatively few airports.

![Figure 4.2. Linear Counter](image)

![Figure 4.3. Flow-through Counters](image)
(3) **Island Counters.** The island counter shown in Figure 4.4 combines some features of the flow through and linear arrangements. The agent positions form a “U” around a single baggage conveyor belt (or pair of belts) permitting interchangeability between multipurpose or specialized positions. As with flow through counters, this configuration has relatively limited application.

![Figure 4.4. Island Counters](image)

**b. Office Support.** The airline ticket counter/office provides space for a number of airline support activities. These activities include: accounting and safekeeping of receipts; agent supervision; communications; information display equipment; and personnel areas for rest, personal grooming, and training. At low activity locations, the ticket counter area may provide space for all company administrative and operational functions, including outbound baggage. Figure 4.5 depicts two typical layouts for low activity airports with single-level terminals. At high activity locations, there is more likelihood that additional space for airline support activities will be remotely located from the ticket counters.

![Figure 4.5. Typical ATO layouts-Single Terminal](image)
c. Sizing. Figure 5-10 may be used in estimating airline ticket counter frontage for the three counter configurations previously discussed. It utilizes the EQA factors discussed in paragraph 25. The frontage obtained from the chart is based on counter positions typically required for airline peaking activities. The values determined from the chart do not include conveyor belt frontage at flow-through counter configurations. Fewer frontages may be required when individual airlines provide curb check-in and ticketing at gates.

In determining the counter working area, the frontage obtained from the chart is multiplied by a depth of 10 feet (3 m). Figure 4-4 shows typical ranges of AT0 support space. This is presented separately from counter working area since many of these support functions are remotely located at higher activity locations.

For gate or gate equivalents exceeding those shown in this figure, quantities appropriate to the separate lobbies ‘or sections of lobbies, unit terminals, and the like, should be used. This normally occurs at airports with over 50 gates.

4.6. PUBLIC CORRIDORS.

a. Corridors are provided for public circulation between aircraft boarding gates and various lobbies and other areas within the terminal building. The effective corridor design width is the total width less obstacles (e.g., telephones, wastebaskets, benches, protruding displays, etc.) with a minimum clearance of approximately 2 feet (0.6 m) on each side. This clearance is provided because of the phenomenon known as “boundary layer” in which a person will normally maintain such a clearance between corridor, walls and obstacles. Viewing areas for video displays and passenger queue areas extending into the corridor should also be treated as obstacles in design width determinations.

b. Figure 4.2 illustrates an effective corridor +sign width. The design width is determined by dividing the peak corridor population per minute (visitors and passengers) by the corridor width capacity factor expressed in people per unit width per minute. Table 4-2 provides a corridor capacity matrix based on an average walk rate of 242 feet (74 m) per minute. For example, the bosom line of Table 4-2 indicates a capacity of 330 to 494 persons per minute for a corridor with a 20 foot (6 m) effective design width, for a pedestrian occupancy width of 2.5 feet (0.76 m) and depth separation ranging, from 4 to 6 feet (1.2 to 1.8 m). While a relatively abrupt introduction of deplaning passengers into a corridor may retard the walk rate, it will be offset somewhat by a decrease in their depth separation. A congregation of people awaiting the arrival of passengers may also retard the flow rate. This capacity reduction is usually only brief and local in nature and does not ultimately affect the overall corridor design capacity. This congestion can be minimized by providing areas for flow surge and greeters in the corridor width.

<p>| Table 4-2. Corridor Capacity in Persons per Foot (0.305 m) Width per Minute |
|-----------------------------------------------------------|------|</p>
<table>
<thead>
<tr>
<th>Effective Corridor Design Width</th>
<th>Capacity Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 feet (6 m)</td>
<td>330 to 494 persons per minute</td>
</tr>
<tr>
<td>24 feet (7.3 m)</td>
<td>370 to 550 persons per minute</td>
</tr>
<tr>
<td>26 feet (7.9 m)</td>
<td>400 to 600 persons per minute</td>
</tr>
<tr>
<td>28 feet (8.5 m)</td>
<td>430 to 650 persons per minute</td>
</tr>
<tr>
<td>30 feet (9.1 m)</td>
<td>460 to 700 persons per minute</td>
</tr>
<tr>
<td>32 feet (9.8 m)</td>
<td>490 to 790 persons per minute</td>
</tr>
<tr>
<td>34 feet (10.3 m)</td>
<td>520 to 900 persons per minute</td>
</tr>
<tr>
<td>36 feet (10.9 m)</td>
<td>550 to 1000 persons per minute</td>
</tr>
<tr>
<td>38 feet (11.6 m)</td>
<td>580 to 1100 persons per minute</td>
</tr>
<tr>
<td>40 feet (12.2 m)</td>
<td>610 to 1250 persons per minute</td>
</tr>
<tr>
<td>42 feet (12.8 m)</td>
<td>640 to 1400 persons per minute</td>
</tr>
<tr>
<td>44 feet (13.3 m)</td>
<td>670 to 1550 persons per minute</td>
</tr>
<tr>
<td>46 feet (14.0 m)</td>
<td>700 to 1700 persons per minute</td>
</tr>
<tr>
<td>48 feet (14.6 m)</td>
<td>730 to 1850 persons per minute</td>
</tr>
<tr>
<td>50 feet (15.2 m)</td>
<td>760 to 2000 persons per minute</td>
</tr>
<tr>
<td>52 feet (15.8 m)</td>
<td>790 to 2150 persons per minute</td>
</tr>
<tr>
<td>54 feet (16.5 m)</td>
<td>820 to 2300 persons per minute</td>
</tr>
<tr>
<td>56 feet (17.1 m)</td>
<td>850 to 2450 persons per minute</td>
</tr>
<tr>
<td>58 feet (17.8 m)</td>
<td>880 to 2600 persons per minute</td>
</tr>
<tr>
<td>60 feet (18.3 m)</td>
<td>910 to 2750 persons per minute</td>
</tr>
<tr>
<td>62 feet (18.8 m)</td>
<td>940 to 2900 persons per minute</td>
</tr>
<tr>
<td>64 feet (19.3 m)</td>
<td>970 to 3050 persons per minute</td>
</tr>
<tr>
<td>66 feet (20.0 m)</td>
<td>1000 to 3200 persons per minute</td>
</tr>
<tr>
<td>68 feet (20.6 m)</td>
<td>1030 to 3350 persons per minute</td>
</tr>
<tr>
<td>70 feet (21.4 m)</td>
<td>1060 to 3500 persons per minute</td>
</tr>
<tr>
<td>72 feet (22.0 m)</td>
<td>1090 to 3650 persons per minute</td>
</tr>
<tr>
<td>74 feet (22.7 m)</td>
<td>1120 to 3800 persons per minute</td>
</tr>
<tr>
<td>76 feet (23.2 m)</td>
<td>1150 to 3950 persons per minute</td>
</tr>
<tr>
<td>78 feet (23.9 m)</td>
<td>1180 to 4100 persons per minute</td>
</tr>
<tr>
<td>80 feet (24.5 m)</td>
<td>1210 to 4250 persons per minute</td>
</tr>
<tr>
<td>82 feet (25.2 m)</td>
<td>1240 to 4400 persons per minute</td>
</tr>
<tr>
<td>84 feet (25.8 m)</td>
<td>1270 to 4550 persons per minute</td>
</tr>
<tr>
<td>86 feet (26.5 m)</td>
<td>1300 to 4700 persons per minute</td>
</tr>
<tr>
<td>88 feet (27.1 m)</td>
<td>1330 to 4850 persons per minute</td>
</tr>
<tr>
<td>90 feet (27.6 m)</td>
<td>1360 to 5000 persons per minute</td>
</tr>
<tr>
<td>92 feet (28.3 m)</td>
<td>1390 to 5150 persons per minute</td>
</tr>
<tr>
<td>94 feet (28.9 m)</td>
<td>1420 to 5300 persons per minute</td>
</tr>
<tr>
<td>96 feet (29.5 m)</td>
<td>1450 to 5450 persons per minute</td>
</tr>
<tr>
<td>98 feet (30.1 m)</td>
<td>1480 to 5600 persons per minute</td>
</tr>
<tr>
<td>100 feet (30.5 m)</td>
<td>1510 to 5750 persons per minute</td>
</tr>
</tbody>
</table>
4.7. SECURITY INSPECTION STATIONS

a. Air carriers using over 60 passenger scat aircraft in scheduled or public charter operations are required by Federal Aviation Regulations (FAR) 121.538 to screen all passengers prior to boarding in accordance with the provisions of FAR Part 108. This activity is normally handled inside the terminal building at a security screening station.

b. There are three types of passenger inspection stations, depending on the location of the station in relation to the aircraft boarding area.

These include:

   (1) Boarding Gate Station;
   (2) Holding Area Station; and
   (3) Sterile Concourse Station.

c. A sterile concourse station, from both the standpoint of passenger security facilitation and economics, is the most desirable type of screening station. It is generally located in a concourse or corridor leading to one or several pier finger(s) or satellite terminal(s) and permits the screening and control of all passengers and visitors passing beyond the screening location. It thus can control a considerable number of aircraft gates with a minimum amount of inspection equipment and personnel. Pier and satellite terminal concepts are well suited for application of the Sterile Concourse Station, since the single-point entrance connector element facilitates isolation of boarding areas.

d. Because of building geometry, especially that associated with linear and transporter terminal concepts,) the Sterile Concourse Station is not always feasible. Under these circumstances, several inspection stations may be required to control a number of holding areas or departure lounges. In the worst situation, a screening station may be required at each boarding gate.

e. Except at low activity airports, where manual search procedures may be employed, a security inspection station will generally include a minimum of one walk-through weapons detector and one x-ray device. Such a station has a capacity of 500 to 600 persons per hour and requires an area ranging from 100 to 150 square feet (9 to 14 sq.m). Examples of security inspection station layouts are illustrated in Figure 4-21.
Figure 4-21. Security Inspection Station Layouts
f. Space leading to the security inspection station should allow room for queuing as the flow of passengers through security is often interrupted when a passenger requires a rescreening or physical search. Queuing space should not extend into or block other circulation elements.

g. The boarding area beyond a security screening checkpoint, whether a holding area concourse or departure lounge, requires a design which will enable security to be maintained. In this respect, the design and location of entrances, exits, fire doors, concessions, etc., require special consideration.

4.8 DEPARTURE LOUNGES.

a. The departure lounge is the waiting or holding area for passengers immediately prior to boarding an aircraft. At most airports (excepting some low activity airports), departure lounges are normally included in the space leased and controlled by individual airlines.

b. The departure lounge normally includes: space for one or more airline agent positions for ticket collections, aircraft seat assignment, and baggage check-in; a seating and waiting area; a queuing area for aircraft boarding; and an aisle or separate corridor for aircraft deplaning. Figures 5-22, 5-23, 5-24, and 5-25 illustrate typical departure lounge layouts.

c. The number of agent positions/desks is determined by the user airlines on the basis of individual airline standards for passenger waiting, processing, and boarding procedures. A queue length of at least 10 feet (3 m) in front of agent positions should be provided in departure lounges at larger airports.

d. The departure lounge area is a function of the number of passengers anticipated to be in the lounge 15 minutes prior to aircraft boarding. Table 4.3 presents information for estimating departure lounge areas on the basis of aircraft seating capacity and load factors. The average depth of lounge area generally considered to be reasonable is 25 to 30 feet (8 to 9 m).

Table 4-3. Departure Lounge Area Spa& Requirements

<table>
<thead>
<tr>
<th>Aircraft Seating Capacity</th>
<th>Departure Lounge Area Square Feet (Square Meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>35-45 percent</td>
</tr>
<tr>
<td>Up to 80</td>
<td>350 (33)</td>
</tr>
<tr>
<td>81 to 110</td>
<td>600 (56)</td>
</tr>
<tr>
<td>111 to 160</td>
<td>850 (79)</td>
</tr>
<tr>
<td>161 to 220</td>
<td>1,200 (111)</td>
</tr>
<tr>
<td>221 to 280</td>
<td>1,500 (139)</td>
</tr>
<tr>
<td>281 to 420</td>
<td>2,200 (204)</td>
</tr>
</tbody>
</table>
e. When a lounge area serves more than one aircraft gate position, the estimated total lounge area shown in Table 5-3 may be reduced 5 percent for each aircraft gate position, up to a maximum of six gates.

f. Departure lounge seats are not generally provided to accommodate all passengers boarding an aircraft. A number of passengers will elect to remain standing in the waiting area while others will only arrive shortly before or during the boarding process. Between 15 and 20 square feet (1.4 to 1.9 m²) including aisle, space, is required per seat.

g. The deplaning area is generally a roped aisle or separate corridor directly leading deplaning passengers from the loading bridge or apron gate to a public corridor. Separation from the rest of the departure lounge is provided to avoid interference and congestion between deplaning passengers and those waiting to board the aircraft. Six feet (2 m) is an acceptable width for this area.

4.9 BAGGAGE CLAIM FACILITIES

a. Inbound baggage handling requires both public and nonpublic building areas. The public space (claiming area) is that in which passengers and visitors have access to checked baggage displayed for identification and claiming. Nonpublic space is used to off-load bags from carts and containers onto claim devices or conveyor systems for moving into the public area.

b. The claiming area should be located adjacent to a deplaning curb and have convenient access to ground transportation service and auto parking facilities. Passenger access from arriving flights should be direct and avoid conflicting with enplaning passengers. The claim area should also be readily accessible from the aircraft apron by means of carts, tractors, or mechanical conveyors for quick and direct baggage delivery.

c. At low activity airports, a simple claim shelf is the most common baggage claim scheme. As passenger activity increases, several types of mechanical claim devices may be utilized to help reduce the overall required claim area length. A discussion of the more common claim schemes follows.

(1) The simple shelf or counter is merely a shelf or counter provided in a public area on which baggage from an arriving aircraft is placed for passenger identification and retrieval. Width of the shelf is generally 30 to 36 inches (75 to 90 cm). Passengers merely move laterally along the shelf until their baggage is located and claimed.

(2) Flat-bed plate devices are particularly applicable when direct feed loading areas are immediately adjacent and parallel to the claiming area and on the same floor level.

(3) Sloping-bed devices are somewhat more adaptable for remote feed situations where the loading area cannot be immediately adjacent to the claiming area or must be located on a different floor level. In some cases, the width of the sloping bed is sufficient to provide storage of two rows of bags.
d. At low volume airports, exclusive-use facilities are not usually economically justified and claim facilities are shared or assigned preferentially to several airlines. The use of a Design Day Activity Analysis (see paragraph 24) is recommended to size baggage claim facilities. In this analysis, passenger arrivals in periods of peak 20 minutes are used as the basis for sizing. However, when exclusive facilities are planned, each airline determines its baggage claim frontage and space requirements according to its own criteria for sizing space, systems, and staffing.

e. A public claiming area may require railings or similar separation from other public space and controlled egress to enable inspection of removed baggage for assurance of “positive claim.” At some terminals, additional space may be needed adjacent to the claiming area for storage and security of unclaimed baggage and for airline baggage service facilities (lost and found).

f. For planning purposes, claim display frontage can be estimated by the use of either Figure 5-27 or 5-28. These nomographs utilize “Equivalent Aircraft Arrivals” (see paragraph 28) to approximate deplaning passengers in a 20 minute peak period, assuming an average of 1.3 bags per deplaning passenger. The value presented includes: space for public circulation; area normally required within a controlled ‘positive-claim’ facility; and space for airline baggage service facilities. It should be recognized that considerable variance in space requirements occurs between airports due to airline company policies and the number of airlines using a claim area.

g. Figure 5-30 can be used to approximate the nonpublic space required to input and load bags onto claim devices. The figure assumes a 22 foot (7 m) depth, 20 feet 6 m) for the fixed shelf, behind the input section or belt for offloading carts and for passing/maneuvering. At many airports in mild climates, the nonpublic baggage input area may be satisfied without complete enclosure in the “terminal building through use of overhead canopies. This can also apply to the public baggage claim area at some low volume airports.

4.10. AIRLINE OPERATIONS AREAS
a. Airline operations areas are those areas occupied by airline personnel for performing the functions related to aircraft handling at the gate. Composition of functions will vary among individual airports. The following areas are most commonly required:

(1) Cabin Service or Commissary - an area for the storage of immediate need items for providing service to the aircraft cabin.

(2) Cabin Service and Ramp Service Personnel - an area for training facilities and a ready/lunch room.

(3) Aircraft Line Maintenance - for supplies, tools, storage, personnel, etc.

4) Office Area - for managerial personnel and clerks.

(5) Flight Operations Facilities - includes a message center, area for meteorological data and flight ‘U plans, and flight operations personnel.

(6) Flight Crew and Flight Attendant Facilities - includes an area for resting, toilet facilities, and personal grooming area.

(7) Secure Area Storage - for items requiring secure storage because of either the value or fragility of the items.

(8) Volatile Storage - for items requiring extra precautionary storage due to instability in handling and storage.

b. Storage and administrative areas often can and are combined. Depending on flight schedules, flight crew and flight attendant facilities may not be required or can be combined with facilities for other airline personnel. Similarly, facilities for flight operations and administrative personnel can be combined.

c. The area required for airline operations may be estimated for planning purposes on the basis of 500 square feet (46.5 m²) per equivalent peak hour aircraft departure. This factor includes all of the operations areas previously described. However, at some airports one or more airlines may use additional terminal space for regional or airline system functions and/or other support services beyond those functions common to daily airport operations.

4.11 FOOD AND BEVERAGE SERVICES
a. These services include snack bars, coffee shops, restaurants, and bar lounges. The basic service offered at small airports is the coffee shop, although separate restaurants at some smaller city airports can be successful, depending on the community and restaurant management. Large airports usually can justify several locations for snack bars, coffee shops, bar lounges, and restaurants. Requirements for more than one of each type are highly influenced by the airport size and terminal concept involved. Unit terminals, for instance, may require coffee shops and/or snack bars at each separate terminal.

b. Generally speaking, a coffee shop seating less than 80 is considered an uneconomical operation at airports enplaning over one million passengers annually. At smaller airports, the seating capacity minimum may be somewhat lower, depending on such factors as local labor costs and concessionaire lease arrangements.

c. The following ranges appear representative for food and beverage services:

(1) Turnover rates: 10 to 19 averages daily per seat. Some operators appear satisfied averaging 10 to 14 daily.

(2) Space per seat: 35 to 40 square feet (3.3 to 3.7 m²) per coffee shop/restaurant seat, including support space.

(3) Snack bars: 15 to 25 percent of coffee shop/restaurant overall space requirements.

(4) Bar lounges: 25 to 35 percent of coffee shop/restaurant overall space requirements.

d. The sizing of food and beverage services involves applying “use factors.” Use factors are determined by dividing the average daily transactions by average daily enplanements. Figure 5-31 shows ranges of food and beverage service areas for coffee shop and restaurants, snack bar, bar lounge and kitchen support space for various “use factors.”

e. For estimating and for initial planning purposes, the following average daily use factors are suggested:

(1) 40 to 60 percent at terminal airports with a high percentage of long-haul flights;

(2) 20 to 40 percent at transfer airports and through airports; and,

(3) 15 to 25 percent at terminal airports with a low percentage of long-haul flights.

4.12. CONCESSIONAIRE AND BUILDING SERVICES.
The following building and concessionaire services are provided at airport terminals as appropriate for the size and activity of the airport. General area ranges for many of these services are presented for planning purposes.

a. News and tobacco are physically separate at most airports where annual enplanements exceed 200,000 per year, and may be combined with other services at airports with lesser traffic.

Space allowance: 150 square feet minimum and averaging 600 to 700 square feet (56 to 66 m²) per million annual enplanements.

b. Gift and apparel shops operations are combined with a newsstand at smaller airports. Separate facilities normally become feasible when annual enplanements exceed one million.

Space allowance: 600 to 700 square feet (56 to 66 m²) per million annual enplanements.

c. Drug store, including sale of books, cards, and liquor, may be feasible as separate operation when annual enplanements exceed 1.5 million. Space allowance: 700 square feet (66 m², minimum and averaging 600 to 700 square feet (56 to 66 m²) per million enplanements.

d. Barber and shoe shine operations at some large airports allow one chair per million annual enplanements.

The most successful operations range from three to seven chairs. Space allowance: 110 to 120 square feet (10.2 to 11.2 m²) per chair with 150 square feet (14 m²) for a minimum facility.

e. Auto rental counters vary according to the number of companies. Space allowance: 350 to 400 square feet (33 to 37 m²) per million annual enplanements.

f. Florist shop operation as a separate function may become feasible when annual enplanements exceed 2 million. The usual space allowed is 350 to 400 square feet (31.5 to 32 m²) per terminal.

g. Displays (including courtesy phones for hotels). Space allowance: 90 to 100 square feet (8.4 to 9.3 m²) per million annual enplanements.

h. Insurance (including counters and machines). Space allowance: 150 to 175 square feet (14 to 16 m²) per million annual enplanements.

i. Public lockers require in the range of 70 to 80 square feet (6.5 to 7.4 m²) per million annual enplanements.

j. Public telephones space requirement is 100 to 110 square feet (9.3 to 10.2 m²) per million annual enplanements.
k. Automated post offices may be found desirable to the extent of providing one station, 125 square feet (11.6 m²) for each terminal serving at least 2.75 million annual enplanements.

1. Vending machine items supplement staffed facilities, especially when extended hours of operation are not justified by low volumes or multiplicity of locations. When vending machines are provided, they should be grouped and/or recessed to avoid encroaching upon circulation space for primary traffic flows. Space allowance: 50 square feet (4.7 m²) minimum or 150 square feet (14 m²) per million annual enplanements.

m. Public toilets are sized for building occupancy in accordance with local codes. Space allowances applied at airports vary greatly. They range from 1,500 to 1,800 square feet (140 to 167 m²) per 500 peak hour passengers (in and out) down to 1,333 square feet (124 m²) per million annual enplanements at large hub airports.

n. Airport management offices’ space requirements vary greatly according to the size of staff and the extent to which airport authority headquarters are located in the terminal.

o. Airport Police/Security Office space needs vary according to based staff and nature of arrangements with local community law enforcement agencies.

p. Medical aid facilities’ space requirements range from that needed for first-aid service provided by airport police to that for branch operations at off-airport clinics.

q. USO/Travelers: Aid facilities vary considerably. Space requirements are relatively minor, 80 to 100 square feet (7.4 to 9.3 m²), except at airports with annual enplanements of over one million.

r. Nursery facilities for travelers with small infants have been provided at airports with annual enplanements of over 1 million. The most practical solutions include a private toilet room of 50 to 60 square feet (4.7 to 5.6 m²) with facilities for changing and feeding. The number of such facilities may range from two up, depending upon terminal size and configuration.

s. Building maintenance and storage varies, depending upon the types of maintenance (contracted versus authority operated) and storage facilities available in other authority-owned buildings.

t. Building mechanical systems (HVAO space ranges from 12 to 15 percent of the gross total space approximated for all other terminal functions. A value of ‘10 to 12 percent is used in relation to the connector element space. This allowance does not cover separate facilities for primary source heating and refrigeration (H&R plants).
u. Building structure space allowance for columns and walls is 5 percent of the total gross area approximated for all other functions.

v. Other space, as determined on a case-by-case basis, may be required at some airports for information services, government offices, contract service facilities and the like.

4.13 TERMINAL BUILDING FACILITIES

- Terminal facility requirements
  - Ticketing/check-in
  - Passenger screening
  - Hold rooms
  - Concessions
  - Baggage claim
  - Circulation
  - Airline offices and operations areas
  - Baggage handling
  - Baggage screening system
  - International facilities—Federal Inspection Services
  - Support areas
  - Special requirements
  - Building systems

- Functional relationships

- Flow sequences
  - Passengers
- Visitors
- Employees
- Baggage
- Deliveries
- Waste removal

• **Passenger movements**
  - People mover systems
  - Passenger way finding and signage

• **Terminal concept development**
  - Domestic and international terminals
  - Concourse configurations
  - Centralized and decentralized terminals
  - Single vs. multi-level terminals
  - Flexibility and efficiency
  - Common-use terminal equipment
  - Swing gates
CHAPTER FIVE
CASE STUDIES/DESKTOP STUDIES
5.1 MADRID BARAJAS AIRPORT

5.1.1. INTRODUCTION

The New Terminal Satellite Building has a combined area of 470,000m² which includes Parking Access Roads 309,000m². The project was designed by Architect - Richard Rogers Partnership, Structural Engineer - Anthony Hunt Associates/TPS with OTEP/HCA Services Engineer - TPS/INITEC, Quantity Surveyor - Hans comb Ltd/Gabinete, Co Architects - Estudio Lamella.

5.1.2 HISTORY

The new airport was formally opened by the Spanish Prime Minister, Jose Luis Rodriguez Zapatero on Saturday 4 February 2006. The New Terminal Area (NAT), designed by a consortium of Richard Rogers Partnership, the Spanish practice Estudio Lamella and two engineering companies TPS and Initec, will establish Madrid as a major European hub, and consolidate its position as the focal connection between Europe and America. It is expected that the new terminal will accommodate between 65 and 70 million passengers per annum. Passenger numbers are expected to outstrip Schiphol in the Netherlands, Europe’s second largest airport, in five years’ time. With a total area of 1,200,000 sq m, the NAT is one of the largest buildings in Europe and will have a significant urban, economic and social impact on both Madrid and Spain itself.
5.1.3 FORM IMAGE AND CHARACTER ANALYSIS

5.1.3.1 PASSENGER VOLUME IN THE TERMINAL BUILDING

Responding to the demands of 21st-century travel, the New Terminal at Barajas will be efficient, economic and functional, accommodating the anticipated growth in passenger traffic, which could be up to 35 million per annum in 2010 and 50 million in 2020, doubling the capacity of the old airport. The design process has focused on delivering an improved passenger experience, creating an attractive, peaceful atmosphere. This led to the utilization of materials and finishes which would convey a sense of calm. The simple palette of materials and the use of a kit-of-parts approach to detailing reinforce the simplicity of the architectural concept. Despite the size of the building, it still allows passengers to easily orientate themselves easily using the many visual references. A straightforward linear diagram and a clear progression of spaces for departing and arriving passengers contribute to the legibility and usability of the terminal for passengers and workers alike.

Figure 5.3: View looking down the pier from the north end, showing the gradation of color applied to the steelwork.
Source: www.richardrogers.co.uk

Figure 5.4: The interior of the building is protected from strong sunlight by roof overhangs and tubular steel Shading system, which, at the same time allows clear views of the outside. Source: www.richardrogers.co.uk
1. THE TERMINAL BUILDING DESIGN CONCEPT

Airport terminals are normally surrounded by secondary elements (Airside and land side,) Those obscure orientation through the airport. In this design, such structures are integrated into the main building, taking into account the topography of the local area. The canyons – large courtyards full of daylight - establish a sequence that incorporates the landscape into the interior space .And so the design concept is a linear terminal building with the bridges perpendicular to the terminal building.
2. FUNCTION AND PLANNING

Barajas is a model of legibility, with a straightforward linear diagram and a clear progression of spaces for departing and arriving passengers. The accommodation is distributed over six floors; three above ground for check-in, security, boarding and baggage reclaim, and three underground levels for maintenance, baggage processing and transferring passengers between buildings. The flow of passengers starts in the forecourt and goes through the check-in counters and the security control until the boarding lounge.

Figure 5.7: The undulating wooden roof provides a natural balance to the hi-tech check-in area and air conditioning units

Source: www.richardrogers.co.uk
The Terminal Building is characterized by three lineal modules (Check-in spine, Processing spine, Pier), and serves different functions according to the passengers Flow (arrivals or departures). Reception of passengers, check-in counters, control and boarding for departure flights; disembark, luggage collection and departure of passengers from the building for arrival flights.

These modules are separated from each other by light-filled canyons that provide natural illumination to the lower levels of the building. This contributes to the environmental strategy – reducing the energy consumption. In addition, this also reduces the maintenance and upkeep costs. In these spaces, the vertical movement of passengers takes place, via stairs, ramps or lifts.

These are a very important element for the orientation of the passenger as they indicate the sequence of actions that the passenger needs to carry out when arriving or departing. There are several factors which led to the need for a remote.

Figure 5.6: The interior of the building is protected from strong sunlight by roof overhangs and a tubular steel shading system, which, at the same time allows clear views of the outside. Source: www.richardrogers.co.uk
Figure 5.8: Terminal level +2
www.richardrogers.co.uk

Figure 5.9: Terminal level +1
www.richardrogers.co.uk
Figure 5.9: Terminal level 0
Source: www.richardrogers.co.uk

Figure 5.10: Terminal level -2
Source: www.richardrogers.co.uk
It was necessary to create a building that could for security reasons separate the passenger flows. In order to do this, the pier of the Satellite has been provided with an elevated spine (level +2) where the flow of non-Shengen and international arrivals can be isolated.

The Terminal and Satellite buildings are separated due to aeronautical reasons, responding to the layout of the two new runways, aircraft taxi lanes and aircraft stands. The two buildings are connected by a tunnel that runs under the runways. The tunnel has two levels with three chambers in each level. The upper level has two side areas of approximately 10 meters width for the circulation of authorized vehicles and a central space of 13 meters, where the Automatic People Mover (APM). The lower section, with three spaces of identical dimensions, is totally devoted to the automatic baggage handling system (SATE). Regardless of the type of flight, all the passengers who use the NAT Barajas have to go through the Terminal building as all checking-in and luggage collection are concentrated in here. The use of the APM systems (lifts, escalators and travelators) allows the simultaneous movement of both, luggage and passengers. In this way the Satellite building is mainly reserved for the security controls of the international flights and for the boarding/disembark of this kind of flight. There is direct access to the Satellite from the exterior roads but it is reserved for authorized staff, not for airport users.

The New Barajas will have the capacity to move 18,000 at peak periods. Despite the size of the project, the design of the NAT Barajas offers a functional and comfortable area for the passenger, an urban and architectural space with human scale both externally and internally and a harmony with the surroundings, minimizing the environmental impact.
3. MATERIAL AND TECHNOLOGY

Despite the extreme heat of summer in Madrid, the design team was committed to the use of passive environmental systems wherever possible, while maximizing transparency and views towards the aircraft and the mountains beyond. The building benefits from a north-south orientation with the primary facades facing east and west – the optimum layout for protecting the building against solar gain. The facades are protected by a combination of deep roof overhangs and external shading. A low energy displacement ventilation system is used in the pier, and elsewhere a more conventional high velocity system is used. Given the multi-level section, a strategy was also needed to bring natural light down into the lower levels. The solution is a series of light-filled ‘canyons’. The canyons are spectacular full-height spaces, spanned by bridges in which arriving and departing passengers, though segregated, can share the drama of the imposing space.

The construction of the Barajas Airport terminal has been undertaken in three constructional layers the basement which drops to as much as 20 meters (66 feet) below ground in some places, the three storey concrete frame above ground, and the steel-framed roof. The concrete work is in-situ, although special attention has been focused on areas where the concrete will be visible, such as the edge strips to the canyons in which steel shuttering has been used. In a bid to limit the height of the building, post-tensioned concrete beams restrict the depth of the beams to only 90 centimeters (three feet). The beams were cast in lengths of 72 meters (236 feet), with concrete planks used to span between them to create the 18 by 9 meter (60 by 30 foot) grid.

Figure 5.13: the roof structure still in its skeleton state

Source: www.richardrogers.co.uk
Above, the concrete tree trunks on the top floor provide fixed base points for setting out the roof steelwork. The structural system for the roof works outwards from the tree trunks where four inclined branches prop a pair of double-S modules. In this way, each pair of tubes plus the roof steel stabilize the roof structure in both directions.

The roof then passes over the cladding line at the edges of the building, emphasizing the roof rather than the facade. To further reduce the visual impact of the facade, shading is not introduced at the cladding line but is hung from the roof overhang which is propped with elegant Y-shaped props at the ends of each module.

The facade structure is in the form of cable ‘kipper’ trusses at nine meter (30 feet) centers. A pair of cables begin at a common point at ground level, one arcing in and one out, held apart by compression struts that also support the horizontal glazing mullions. As the cables approach the roof they come back together, held by a V-bracket, making a fish outline, hence the name ‘kipper’ truss. A ‘jacking’ system was used between the roof and terminal floor during erection which when released ensures that adequate permanent tension was introduced in the cable trusses.

4. STEEL WORKS AND WOOD

The new terminal features a clear progression of spaces for departing and arriving travelers. The building's legible, modular design creates a repeating sequence of waves formed by vast wings of prefabricated steel. Supported on central 'trees', the great roof is punctuated by roof lights providing carefully controlled natural light throughout the upper level of the terminal. Light-filled 'canyons' divide the parallel floors that accommodate the various stages of passenger processing - from point of arrival, through check-in and passport and security controls to departure lounges and, finally, to the aircraft.

A simple palette of materials and straightforward detailing reinforce the direct character of the architecture. Internally, the roof is clad in bamboo strips, giving it a smooth and seamless appearance. In contrast, the structural 'trees' are painted to create a kilometer-long vista of graduated color. The lower levels of the building house baggage handling, storage and plant areas, and offer a striking contrast with the lightweight transparency of the passenger areas above.
Figure 5.15: Undulating timber ceiling design
Source: www.richardrogers.co.uk

Figure 5.16: Interior view of canyons, bamboo roof and skylight
Source: www.richardrogers.co.uk

Figure 5.17: departure lounge
Source: www.richardrogers.co.uk
Figure 5.18: Detail of southern pier end
Source: www.richardrogers.co.uk

Figure 5.19: The undulating wooden roof provides a natural balance to the hi-tech check in area and air conditioning units
Source: www.richardrogers.co.uk
In this terminal design, the larger planes like the Airbus A380 have been considered since there are double and triple boarding air bridges on nearly all plane-boarding docks.

Figure 5.20: plan of the terminal and its satellite of level +1 and level +2

Sources: www.richardrogers.com
1. The New Terminal at Barajas is efficient, economic and functional, accommodating the anticipated growth in passenger traffic, which could be up to 35 million per annum in 2010, and 50 million in 2020, doubling the capacity of the old airport.

2. The terminal building design concept is a linear terminal building with the bridges perpendicular to the terminal building.

3. The building benefits from a north-south orientation with the primary facades facing east and west – the optimum layout for protecting the building against solar gain.

4. The construction of the Barajas Airport terminal has been undertaken in three constructional layers the basement which drops to as much as 20 meters (66 feet) below ground in some places, the three storey concrete frame above ground, and the steel-framed roof.

5. The building's legible, modular design creates a repeating sequence of waves formed by vast wings of prefabricated steel. Supported on central 'trees', the great roof is punctuated by roof lights providing carefully controlled natural light throughout the upper level of the terminal.
5.2 BEIJING AIRPORT

5.2.0 FORM IMAGE AND CHARACTER ANALYSIS

5.2.1 HISTORY

Figure 5.21: Ariel view of the Beijing international airport

Source: www.foster+ partners.com
The airport is supposed to be built in the Daxing district in China located 46 km south of Tiananmen which is China’s political centre. The airport was completed as the gateway to the city because of the opening of the Beijing 2008 games. Beijing terminal is the largest and most advanced airport building in the world; it is not only technologically but also in terms of passenger experience, operational efficiency and very sustainable.

5.2.2 INTRODUCTION

Beijing capital international airport was initially built in 1959. After several renovations and expansions, until in 1999 it has now two terminal buildings and two parallel 4E runways which were able to operate independently since October 27th 2005. Terminal 1 has an area of 79500 square meters with a capacity of 8 million passengers per year and the second terminal two has an area of 326500 square meters with a passenger capacity of 27 million passenger per year. After terminal two was opened the first one was closed making the building to hold a capacity of 27 million passengers per year. Some features in the Beijing terminal include; the roof area is 360,000 meters and the external cladding area of 275,000m².

The daily peak workforce is approximately 40,000 people working in shifts 24 hours per day, 7 days per week.

The actual total airport site area is about 1480 hectares this includes the expected site and terminal expansion. The design of the building made sure that the services are from below, freeing up the roof space for day lighting. The designed roof has a generous overhang to the south, providing shading from the sun. The government suggested that the airport should integrate with mass public transport to the city centre of Beijing. This was to include high speed trains system.

5.2.3 PASSENGER VOLUME IN THE TERMINAL BUILDING

1. THE TERMINAL BUILDING
In 1999, the traffic in Beijing international airport was 18.6 million passengers and this grows to 21.6 million in 200. Based on this growth rate, it is predicted that they would reach its saturation point by 2005. However, by the end of 2004, the traffic through the airport was already 34.8 million passenger and 670 tons of cargo. In addition in July 2001, Beijing was awarded to host the 2008 summer Olympics games it was estimated that the passenger peak per month would reach 5.6 million. The first building on the terminal is used to break the one million square meter barrier; it will accommodate an estimated 50 million passengers per annum by 2020.

Figure 5.23: entrance lobby on the landside
Source: www.foster+ partners.com

Figure 5.24: Beijing airport from the second level on the entrance or approach
Source: www.foster+ partners.com

Figure 5.25: baggage hall in the Beijing International airport
Source: www.foster+ partners.com
2. TERMINAL DESIGN AND PLANNING

The length from north to south in of the terminal 3 building is three and a quarter kilometers, the visual links between the three elements are maintained by strong sight lines as well as visual connections between the lower level and an open mezzanine level above. All spaces are naturally lit and there is generous glazing and skylights maintain a link with the outside and its changing sky. Views along the central axis are marked by the distinctive red columns, which continue along the external edges of the building into the distance, evocative of traditional Chinese temples.

On arrival to the terminal building one has an embracing curved cantilever of the terminal which greets passengers arriving by road. Departures and arrivals are on separate levels. The traditional airport diagram has been inverted at T3B, with dramatic space from the best vantage point.

The single unifying roof canopy is perforated with skylights to aid orientation and bring daylight deep into the building. The color palette moves through 16 tonnes from red at the entrance at
T3A (terminal 3 A) through to orange and finally yellow at the far end of T3B. This establishes a subtle zoning system that breaks down the scale of the building and enables easy way finding. This color design palette is also applied from the north to south in the ceiling above the arrivals and departures halls, heightening the sense of curvature in the roof plane.

Connections between T3A(terminal 3 A) and T3B(terminal 3 B) take place on a high speed automated people mover (APM) which travels at up to 80kph, with a journey time of just two minutes. The APM is easily accessed from the main departure level and set within a landscaped ‘green’ cutting, exposed to daylight and views up and through the building, all of which helps to maintain a sense of orientation. The Beijing terminal building is one of the world's most sustainable buildings, incorporating a range of passive environmental design concepts, such as the south-east orientated skylights, which maximize heat gain from the early morning sun, and an integrated environment-control system that minimizes energy consumption.

Figure 5.28: Roof sun inlet perforations to let in natural light
Source: www.foster+ partners.com

Figure 5.29: entry hall a view from the second level, showing the triple volume and the element articulation
Source: www.foster+ partners.com
3. MATERIAL AND TECHNOLOGY

Figure 5.30: Beijing international airport terminal 3 A, B, C floor plan.
Source: www.foster+partners.com

Figure 5.31: Beijing international airport in China master plan in reference to terminal 1, terminal 2 and the current massive terminal 3.
Source: www.foster+partners.com
The roof is a steel space frame with triangular roof lights and colored metal decking. It curves, rising at the midpoint to create a dramatic central cathedral-like space, and tapering towards the edges of the building to provide more intimate areas as passengers travel towards the gates and the aircraft piers. The trusses that support the glazing echo the changing color system in the roof shifting from red to orange to yellow. The high transparency of the curtain walling is made possible by extra-large mullions, which are generously spaced to allow larger spans of suspended glazing.

The terminal building is one of the world’s most sustainable, incorporating a range of passive environmental design concepts, such as the south-east orientated skylights, which maximize heat gain from the early morning sun, and an integrated environment-control system that minimizes energy consumption. Rather than the sprawl of many separate buildings, it uses less land by bringing everything closer together for ease of communication in one efficient structure, yet it is still 17% bigger than the combined floor space of all of Heathrow’s terminals 1, 2, 3, 4 and the new Terminal 5. In construction terms, its design optimized the performance of materials selected on the basis of local availability, functionality, application of local skills, and low cost procurement.
Figure 5.34: Ariel side view of the terminal 3 building in the Beijing airport, and the photo shows the terminal still under construction as the glazing process was going on.

Source: www.foster+ partners.com

Figure 5.35: steel sections on the cantilever on the landside

Source: www.foster+ partners.com

Figure 5.36: steel sections of the roof of the Beijing international airport terminal 3 before it was raised to its actual location.

Source: www.foster+ partners.com
5.3.4 NEW AIRPLANE DESIGNS AND THE TERMINAL BUILDING

1. AIRPORT DESIGN CONCEPTS

The concept is as an interpretation from the traditional Chinese people’s culture, the roof of the airport was designed to have a dragon-like form. Norman Foster thinks this is a building borne of its context since it really conforms to the site and existing site features. The building communicates and displays a unique Chinese sense of place and is a true vision and a definite gateway to the nation. This form is expressed in its dragon-like form and the drama of the soaring roof that is a blaze of ‘traditional’ Chinese colors – imperial reds merge into golden yellows. As you proceed along the central axis, view of the red columns stretching ahead into the far distance evokes images of a Chinese temple.
5.3 FIELD WORK FINDINGS

1. The concept is as an interpretation from the traditional Chinese people’s culture, the roof of the airport is designed to have a dragon-like form. Norman Foster thinks this is a building borne of its context since it really conforms to the site and existing site features.

2. This form is expresses in its dragon-like form and the drama of the soaring roof that is a blaze of ‘traditional’ Chinese colors – imperial reds merge into golden yellows. As you proceed along the central axis, view of the red columns stretching ahead into the far distance evokes images of a Chinese temple.

3. The roof is a steel space frame with triangular roof lights and colored metal decking. It curves, rising at the midpoint to create a dramatic central cathedral-like space, and tapering towards the edges of the building to provide areas that are more intimate as passengers travel towards the gates and the aircraft piers.

4. The high transparency of the curtain walling is made possible by extra-large mullions, which are generously spaced to allow larger spans of suspended glazing.

5. The terminal building is one of the world’s most sustainable, incorporating a range of passive environmental design concepts, such as the southeast-orientated skylights, which maximize heat
gain from the early morning sun, and an integrated environment-control system that minimizes energy consumption.

6. In construction terms, its design optimized the performance of materials selected on the basis of local availability, functionality, application of local skills, and low cost procurement.

7. The length from north to south of the terminal 3 building is three and a quarter kilometers, the visual links between the three elements are maintained by strong sight lines as well as visual connections between the lower level and an open mezzanine level above.

8. On arrival to the terminal building, one has an embracing curved cantilever of the terminal, which greets passengers arriving by road. Departures and arrivals are on separate levels.

9. The single unifying roof canopy was perforated with skylights to aid orientation and bring daylight deep into the building.

10. Beijing was awarded to host the 2008 summer Olympics games it was estimated that the passenger peak per month would reach 5.6million. The first building on the terminal is used to break the one million square meter barrier; it will accommodate an estimated 50 million passengers per annum by 2020 and hence the massive building structure and massive spaces.

5.4 COMPLETE FIELD WORK FINDINGS

1. The terminal buildings image is considered as memorable or as an iconic building if the form, character, and how the final building would look like. Most of the airports act and are a symbol of the country’s image.

2. All airport buildings studied and analyzed act as a gateway to most countries and so the designs are very iconic and memorable to the passengers and final users.

3. All airports studied have a great image and character from a birds view, meaning they have a strong image from the skies this is because they are meant to even be appreciated from the air by passengers, since the airport experience starts from the air to when the passenger leaves the airport.

4. The terminal building are evolving and the materials and technology used is getting advanced and better. The terminal building are opting to use high quality light weight material in the designs to give the best result in terms of the final image, form and character.

5. Passenger volume is a major factor affecting nearly all elements in the airport industry this is because passenger volume is one constant that does not remain the same and that varies after a few years.

6. Passenger volume has made the terminal building to be flexible in such a way that the designers are considering expansion even when they are already designing because the building is not a static building.
7. Passenger volume goes hand in hand with terminal buildings expansion plans and the terminals expansions designed marry and blend with the existing structures.

8. The size of the terminal building solely depends on the passenger volume expected or focused at a terminal building, so the planning also relies on the amount of passengers expected.

9. New airplane design has affected the airport since with the coming of new airplane designs it has led to an evolution of the terminal build especially on the airside.

10. New airplane design has led to different boarding patterns due to massive plane like the airbus A380 and so this has boiled down to the design of the air bridges.

11. The management of the airport determines the final image and character of any terminal building since in private airports they mainly consider profits as their main driving force and on the other hand the public airports other than profit the image, form and character are some of the major considerations in the design.

12. The planning and the design of the terminal building affect the form, image since the airport building is just a large structure with columns, and so the planning is not different in arrangement. What set airport buildings apart are the form and the buildings character?

CHAPTER SIX

SITE ANALYSIS
6.1 Introduction

An understanding of the site and its environment is an integral part of a building program and is a prerequisite for good design. The building location on the site is basically established by one of two different viewpoints. In one, the building location is given by the client. In the second and most advantageous, the building site is revealed by a thorough site analysis. A site analysis is the gateway to energy conscious design and environmental responsive architecture.

6.1.2 Site climate:
It establishes the scale: whatever the size of the project, it implies the climate of the area available and is to be used for the given purpose, both in horizontal extent and in height.

6.1.3 Microclimate

Microclimatic factors refer to variations to the general climate such as might be created by topography, plants and vegetation, exposure to winds, elevation above sea level, and relationships to structural elements. These factors are important to design in terms of delineating the “opportunities and constraints” of a particular site for development. Slopes are analyzed in relation to solar orientation to determine “warm” and “cool” slopes, based on sun exposure. Shade and shadow patterns created by existing vegetation and structures are important to design in terms of potential positive or negative impacts for development.

Local factors: The factors which may cause local deviation are:

- Topography, i.e., slope, orientation, exposure, elevation, hills or valleys, at or near the site.
- Ground surface, whether natural or man-made, its reflectance, permeability and the soil temperature, as these affect vegetation and this in turn affects the climate (woods, shrubs, grass, paving, water, etc.)

Three – dimensional objects, such as trees, or tree – belts, fences, walls and buildings, as these may influence air movement, may cast a shadow and may sub-divide the area into smaller units with distinguishable climatic features.

6.2 Location:

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>Borama, Somaliland</th>
</tr>
</thead>
<tbody>
<tr>
<td>LONGITUDE</td>
<td>43.1833 (4310°59.880&quot;E)</td>
</tr>
<tr>
<td>LATITUDE</td>
<td>9.9333 (955°59.988&quot;N)</td>
</tr>
<tr>
<td>ALTITUDE</td>
<td>1408M</td>
</tr>
<tr>
<td>Population of Borama</td>
<td>38,075 people</td>
</tr>
</tbody>
</table>
6.2.1 Somaliland:

The modern day Republic of Somaliland declared its independence from Somalia on 18 May 1991, is the third incarnation of the territory established by the British in the Horn of Africa towards the end of the nineteenth century. It spans a land area of 137,600 square kilometers, or roughly 22 per cent of the territory of the Somali Republic (637,540 square kilometers), most of which receives less than 300 millimeters of rainfall annually. The population is currently estimated at between two and three million (the lower figure is probably more accurate) out of some seven million inhabitants of the whole Somali Republic.

In June 1960, after more than seven decades as a British protectorate, the territory received its independence from Queen Elizabeth II. Once one of five Somali entities that aimed to unite under a single flag,3 it was the only Somali territory actually to unite with Italian Somalia, which it did just five days after obtaining its own independence.

Following the collapse of the Somali government in 1991, Somaliland announced the dissolution of the 1960 union with Somalia, but its declaration of independence has yet to be recognized by a single member of the United Nations.
6.2.2 Borama.

- Brief history of Borama:

Borama also known as Borame is the capital of the northwestern Awdal region of Somalia. The commercial seat of the province, it is situated near the border with Djibouti and Ethiopia. During the middle Ages, Borama was ruled by the Adal Sultanate. It later formed a part of the British Somaliland protectorate in the first half of the 20th century.

As with several nearby towns such as Amud, numerous archaeological finds have been discovered in the Borama area that point to an eventful past. The latter include ancient remains of tombs, houses and mosques, in addition to shreds of Oriental wares, particularly Chinese porcelain. The artifacts and structures date from various historical periods, ranging from the 12th through to the 18th centuries. Most, however, are from the 15th and 16th centuries, a time of great commercial activity in the region that is associated with the medieval Adal Sultanate Hills and homes in the Sheikh Ali Jowhar section of Borama.

Excavations in the late 1800s and early 1900s at over fourteen sites in the vicinity of Borama unearthed, among other things, coins identified as having been derived from Kait Bey, the eighteenth Burji Mamluk Sultan of Egypt. Most of these finds were sent to the British Museum for preservation shortly after their discovery.

In the first half of the 20th century, Borama formed a part of the British Somaliland protectorate. It was later given district status in 1925.

In 1933, Sheikh Abdurrahman Sheikh Nuur, a Qur'anic teacher and son of Borama's qadi (judge), devised a new orthography for transcribing the Afro-Asiatic Somali language. A quite accurate phonetic writing system, this Borama script was principally used by Nuur and his circle of associates in the city. The alphabet is also generally known as the Gadabuursi script.

During the onset of World War II, the town was captured by the Italians. It was re-captured by the British the following year, in 1940. In the post-independence period; Borama was administered as part of the official Awdal administrative region of Somaliland.

Location and area of Borama:

Borama is the regional capital of Awdal and is located 120km west of Hargeisa. It is positioned 3km north of the Ethiopian Boundary and lies on latitude 9° and longitude 23°. Earthquakes are relatively frequent in Borama and its surrounding areas, although these earthquakes have never been beyond 5° in strength. The people of Borama reportedly experience at least two tremors every month.
Climate:

The prevailing climate in Borama is known as a local steppe climate. The warmest month of the year is June with an average temperature of 24.1 °C. In January, the average temperature is 17.1 °C. It is the lowest average temperature of the whole year and the difference in precipitation between the driest month and the wettest month is 110 mm. The average temperatures vary during the year by 7 °C.

### Climate data for Borama

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan °C</th>
<th>Feb °C</th>
<th>Mar °C</th>
<th>Apr °C</th>
<th>May °C</th>
<th>Jun °C</th>
<th>Jul °C</th>
<th>Aug °C</th>
<th>Sep °C</th>
<th>Oct °C</th>
<th>Nov °C</th>
<th>Dec °C</th>
<th>Year °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average high °C (°F)</td>
<td>24.6 (76.3)</td>
<td>25.4 (77.7)</td>
<td>27.5 (81.5)</td>
<td>27.8 (82)</td>
<td>29.3 (84.7)</td>
<td>30.0 (86)</td>
<td>28.8 (83.8)</td>
<td>28.8 (83.8)</td>
<td>29.0 (84.2)</td>
<td>27.4 (81.3)</td>
<td>25.8 (78.4)</td>
<td>24.4 (75.9)</td>
<td>27.4 (81.3)</td>
</tr>
<tr>
<td>Average low °C (°F)</td>
<td>9.7 (49.5)</td>
<td>11.7 (53.1)</td>
<td>13.8 (56.8)</td>
<td>15.7 (60.3)</td>
<td>17.0 (62.6)</td>
<td>18.3 (64.9)</td>
<td>17.8 (64)</td>
<td>17.6 (63.7)</td>
<td>17.3 (63.1)</td>
<td>13.7 (56.7)</td>
<td>11.3 (52.3)</td>
<td>10.4 (50.7)</td>
<td>14.53 (58.14)</td>
</tr>
<tr>
<td>Average rainfall mm (inches)</td>
<td>6 (0.24)</td>
<td>21 (0.83)</td>
<td>36 (1.42)</td>
<td>86 (3.39)</td>
<td>61 (2.4)</td>
<td>32 (1.26)</td>
<td>78 (3.07)</td>
<td>112 (4.41)</td>
<td>86 (3.39)</td>
<td>18 (0.71)</td>
<td>10 (0.39)</td>
<td>2 (0.08)</td>
<td>548 (21.59)</td>
</tr>
</tbody>
</table>

Source: [Climate-Data.org][1], altitude: 1454m

Education facilities:


Amoud University is also situated in the city. It is the first post-civil war institution of higher learning in Somalia. Other local tertiary academies include EELO American University and SAW Community College.

Additionally, Borama is home to the first school for deaf children in Somalia. Borama Deaf School trains and provides educational services for hearing impaired children that extends to high school. Using the Somali Sign Language, it has attracted deaf pupils from across the region and beyond.
**Geography:**
Borama is a mountainous and hilly city. It has green meadows and fields, and represents a key focal point for wildlife. The town's unusual fertility and greenery in largely arid Somalia has attracted many animals, such as gazelles, birds, and camels.

**Transportation facilities:**
For air transportation, Borama is served by the [Borama International Airport](#). It is the only airport in the Awdal region. The facility was named in honor of Aden Isaq, Somalia's first Minister of Education. The airport is not in use however, there are plans to rejuvenate it.

### 6.2.3 LOCATION OF THE SITE:
The site selected is located in the outskirts of the city, where the unused airport building and runway exist. It is isolated from the city.

The selection of a suitable site for an airport depends upon the class of airport under consideration. However if such factors as required for the selection of the largest facility are considered the development of the airport by stages will be made easier and economical.

The factors listed below have been considered for the selection of a suitable site for a major airport installation:

1. Regional plan
2. Airport use
3. Proximity to other airport
4. Ground accessibility
5. Topography
6. Obstructions
7. Visibility
8. Wind
9. Noise nuisance
10. Grading, drainage and soil characteristics
11. Future development
12. Availability of utilities from town
13. Economic consideration

**Regional plan:** The site selected fits well into the regional plan thereby forming it an integral part of the national network of airport.

**Airport use:** the selection of site depends upon the use of an airport, whether for civilian or for military operations. However during the emergency civilian airports are taken over by the defense. Therefore the airport site selected is such that it provides natural protection to the area from air roads. This consideration is of prime importance for the airfields to be located in combat zones.

**Proximity to other airport:** The site is selected at a considerable distance from the existing airports so that the aircraft landing in one airport does not interfere with the movement of aircraft at other airport. The required separation between the airports mainly depends upon the volume of air traffic.

**Ground accessibility:** The site is so selected that it is readily accessible to the users. The airline passenger is more concerned with his door to door time rather than the actual time in air travel. The time to reach the airport is therefore an important consideration especially for short haul operations.
**Topography:** This includes natural features like ground contours, trees, streams, etc. A raised ground a hilltop is usually considered to be an ideal site for an airport.

**Obstructions:** When aircraft is landing or taking off it loses or gains altitude very slowly as compared to the forward speed. For this reason long clearance areas are provided on either side of runway known as approach areas over which the aircraft can safely gain or lose altitude.

**Visibility:** Poor visibility lowers the traffic capacity of the airport. The site selected is therefore free from visibility reducing conditions such as fog, smoke, and haze.

**Wind:** Runway is so oriented that landing and takeoff is done by heading into the wind should be collected over a minimum period of about five years.

**Noise nuisance:** The extent of noise nuisance depends upon the climb out path of aircraft type of engine propulsion and the gross weight of aircraft. The problem becomes more acute with jet engine aircrafts. Therefore, the site is selected that the landing and takeoff paths of the aircrafts pass over the land which is free from residential or industrial developments.

**Grading, drainage and soil characteristics:** Grading and drainage play an important role in the construction and maintenance of airport which in turn influences the site selection. The original ground profile of a site together with any grading operations determines the shape of an airport area and the general pattern of the drainage system. The possibility of floods at the valley sites should be investigated. Sites with high water tables which may require costly subsoil drainage should be avoided.

**Future development:** Considering that the air traffic volume will continue to increase in future more member of runways may have to be provided for an increased traffic.

### 6.2.4 SHAPE OF SITE:

The site is irregular in shape.
6.3 SELECTED SITE:

Map of the selected site
Approximate area: 1,345,185.5 sq.m

Area of the selected site
CHAPTER SEVEN

PROJECT DESIGN


3. Mark fosters Gage, *Aesthetic theory*. Essential texts for architecture and design


7. Van uffelen, *Airport architecture*.


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3. Nyamai m.k, modal centre of airports (1998)
5. Kinyua s.m, space organization in airports (2005)

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