TAMALE INTERNATIONAL AIRPORT (TML)

BY

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DECLARATION

I hereby declare that this submissions is my own work towards the Master of architecture degree and that, to the best of my knowledge, it contains no material previously published by neither another person nor materials which has been accepted for the award of any other degree of the university, except where acknowledgement has been made in the text.

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DEDICATION

This project is dedicated to the Eduful Family

ACKNOWLEDGEMNT

'As His divine power has given to us all things that pertain to life and godliness, through the knowledge of Him who called us by glory and virtue,..........1 Peter 1:3(NKJV)

If the LORD does not build, the builders labour in-vain... God has been good in all things from the beginning of this project to the finish.

I also appreciate the prayer support, financial supports and moral support of my family. To my Dad, Mum and siblings I say thank you and God bless you. Also to Miss Rachel Thompson, I say thank You and God bless and increase you for you invaluable support.

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To all the workers of Ghana Civil Aviation and Ghana Airport Company who help in diverse ways with aviation information and the other relevant information to this study, I say I am grateful.

Finally to all the Post-graduate graduating class of 2009, thank you very much for your inspiration. My prayer for you all is that God should increase you in all fields of endeavor.

ABSTRACT

The aviation statistics of Ghana in terms of Passenger throughput capacity reveals an average growth of 10% for the past 5 years. Aviation statistical projection up to 2013 by GCAA Corporate Planning reveals the following data 2010 – 1 348 829, 2011 – 1 483 767, 2012 – 1 632 144, 2013 – 1 795 359.

With an annual growth of 10% Ghana is expected to be receiving about 3million passengers per annum by 2020 and about 6million passengers by 2030. Kotoka International airport stands as the only International airport for both short and long haul international flights. KIA currently has a capacity of 1 260 passengers per annum. Plans are underway to rehabilitate KIA to be able to handle 2million passengers by 2020. This implies beyond 2020 there will be passenger excess to be catered for and hence the need for a new international airport in Ghana.

Tamale was considered to be the next location for Ghana's next international airport. The idea is to create a catalyst that will help bridge the developmental gap between the down-south and up-north of Ghana.

After a careful consideration of the clients brief and intentions, case studies, site analysis and technical studies a brief was developed. The brief took into careful consideration Standards and Recommended Practices of ICAO Annexes, ICAN and FAA recommendations. A design proposal from master planning to detailed design was formulated based on the brief.

The project further details the services and construction technology and phasing of project and finally presets conclusions on the way forward in helping realize Ghana's aviation dreams.

TABLE OF CONTENTS

CHAPTER THREE

CHAPTER FOUR

LIST OF FIGURES

CHAPTER ONE

1.1 INTRODUCTION

The aircraft industry continues to evolve. This is as a result of the rapid technological developments in information technology, business and transportation. Airports must be able to adapt to these changing trends and be flexible enough to adapt to the evolving aviation industry. Airports today are a combination of transportation centers and malls, hence making Airports a new building type.

Airports were originally referred to as flying fields. This is because they were just fields. During the early days of aviation, a large field was needed for airplane operations. A long and equally as wide field was necessary because the airplanes needed to be oriented into the wind no matter which direction the wind was blowing. During the 1950's airplanes began to have variety of uses for transportation and business. As airplanes became larger and heavier it became imperative to have hard surface runways instead of the grass or gravel fields. This is because the later could no longer support the weight of heavier airplanes. For instance, a Boeing 747 can weigh more than 800,000 pounds at take off. Airplanes eventually began to offer more services than its traditional role of transportation.

Today, airports are not just transit points -where people embark and disembark for air transportation but have become intermodal transportation facilities -where several transportation systems meet. Airports today have shifted from its traditional role of transportation into a combination of transportation services and the convenience of a mall-centered culture where one meets people of all facets of life. In other words airports today constitute cities outside cities.

Airports are icons of cities; they give the first and last impression of a city, region or country. Airports must meet all its functional requirements, International Civil Aviation Organization's (ICAO) standards and recommended practices (SARP) and must effectively constitute operations where economic, social and now environmental systems need to functionally and effectively interact.

In conclusion, successful development in the aviation sector now requires solid and sustainable foundations. Airport planners, architects, engineers and airport authorities need to begin designing and managing these interacting systems, new trends and processes to produce positive result.

1.2 PROBLEM STATEMENT

'The latest known long-term forecast released by The International Civil Aviation Organization (ICAO) in April 2007 estimates that passenger traffic on scheduled airline services, measured in passenger kilometres performed, will grow at the average annual rate of 4.6 percent over 20 year period ending in 2025. International traffic is expected to increase at 5.3 percent per annum, outpacing domestic traffic growth of 3.4 percent annually. For a regional perspective, the airlines of the Middle East and Asia/Pacific regions are expected to experience the highest growth in passenger traffic, at 5.8 percent per annum through to 2025, following airlines in Africa and the Latin American/Caribbean regions, predicted to grow at 5.1 and 4.8 percent per year, respectively'.[1] A close look at Ghana's aviation statistics over the past ten years reveals an average of 9% growth per annum.[2]

The current political and economic stability the country is enjoying connotes a conducive environment where aviation activities flourish. Whiles there are political upheavals all over Africa and W/African Sub-region in particular, there has been relative peace in the country. Ghana is now being projected high in terms of the very few African Countries that have a stable political environment. This indicates a potential for Ghana to receive more travelers coming in and out of the country to do and promote trade and investments. This therefore puts Ghana into the position of becoming a hub, a connecting point to most African countries, especially the West African Sub-region. The growth of tourism in

[1] International Civil Aviation Organization journal, volume 62
[2] Corporate planning Department, Ghana Civil Aviation Authority (2008)

Ghana also depends largely on stable political environment. According to Ghana tourist board 80% of tourist arrivals in Ghana is 2007 arrived through KIA. It is anticipated that due to the stable political atmosphere in Ghana as against most African countries Ghana is likely to get more tourist coming into the country.

The government of Ghana under the vision 2020 program has a goal of transforming the country into a middle-level income country by 2020. One of the key sectors to realizing this vision is the aviation industry that is through a strong outward-orientation of economic activity which is facilitated to a larger extent by the aviation industry.

The above factors are indications to the fact that our average annual growth of 9% will move up and be projected in double digit. It therefore implies that more people will use our entry point. Kotoka International Airport (KIA) currently stands as the only international airport in the country. There will therefore be an increased pressure on KIA's infrastructure and limited services and resource. The Ghana Civil Aviation Authority and Ghana Airports Company have plans of rehabilitations KIA with upgraded facilities to cater for this anticipated traffic of 2 million passengers per year by 2020[3]. A critical study of this proposal indicates some lapses. Emphasis was placed on upgrading facilities to cater for increased passenger traffic with little emphasizes on issues relating to environmental hazards, traffic beyond the airport environment and the catalytic effect of aviation on development.

ICAO advocates that, due to hazards like noise, air pollution, airports should be situated outside the city. It again specifies a 40 minutes minimum range of travel time. A close look at some airports and their location gives a different picture from that of KIA which has been caught up with the city but yet still takes more than 40min to travel from the city centre to the airport which is just 9miles. For instance, London Heathrow airport is 20miles from the city of London, Gatwick airport is 30miles to the city, Moscow airport is 20miles to the city and Cairo airport is 15miles from the city.

The risk of an uncontrolled air-disaster will be very disastrous to the country. A closer look at the flight path calls for a critical assessment of the location of KIA. The flight

[3] Ghana Civil Aviation Authority (2008)

path falls directly on or close to sensitive areas in the country – The Castle, State House, Police Headquarters, El-Wak Sports Stadium, Golden Jubilee House and 37 Military Hospital. Areas like the castle, ring road estate, the police headquarters, state house and cantonments falls within the take off tunnel.

The proposal for KIA rehabilitation considered road network, parking and traffic situation within the airport with no consideration to traffic situation beyond the airport environment neither does it suggest an alternate means of transportation aside by the already congested roads. The impact the airport makes on the traffic situation beyond the airport and vice versa was not discussed. I believe this is unfair to the user (traveler) and must critically be looked at.

On the other hand, traffic projection with an average growth of 10% indicates that Ghana will receive 3million Passengers annually by 2020 and 6million passengers by 2030. KIA cannot support this increase in passenger thru-put capacity.

The above issues raised should not be overlooked, because any attempt to will be very costly to the economy –it will limit patronage, kill public confidence in air transport in Ghana and also jeopardize our dream of ever becoming a middle-income economy by 2020. There is therefore the need for the government of Ghana to invest in another international airport that by location, planning and facilities will be able to reduce all environmental hazards to the barest minimum, consider the issues of traffic in and beyond the airport vicinity, become an intermodal transport facility (interchange between different forms of transportation), become an aviation hub of West Africa and become a catalyst for developing the economy and helping in diverse ways to the realization of vision 2020.

There is therefore the need for another international airport in Ghana. This is because Kotoka International Airport (KIA) which stands as the only international airport will not be able to effectively support the nations projected and anticipated air passenger and freight volume by 2025.

1.3 PROJECT JUSTIFICATION

The focus of the project is to create an international airport that will become a catalyst for developing the northern part of the country and help to fully utilize the dormant resources of this part of the country.

By location and planning the projects focus is to make Ghana an aviation hub to West Africa. In other words the airport will become the main transit point for aviation activities in Ghana and West Africa as a whole. The project aims at developing an airport of international standard at Tamale which is capable of handling larger aircraft and will be capable of taking a greater percentage of Ghana's anticipated air traffic and freight volume by 2020. As an aviation hub and gateway to West Africa, the land use and master planning will not only focus on the airport environment but beyond the airport vicinity. The idea is to create an attractive environment for investment. In other words world class businesses centre around the airport area that will attract world class corporate businesses and light industries to invest in West Africa.

The justification of the project has been crystallized from the above discussion as follows:

- The project falls within the framework of government's aim to;

  i. Making Ghana the gateway to Africa with the aviation industry as a key player
  ii. Providing alternate systems of transportation and address the growing demand for mass aviation services.

- An international airport at Tamale will be a catalyst to spark up developments at the Northern part of the country and help utilize its vast untapped and dormant resources. It will make this region attractive for both foreign and domestic investors.
- Tamale is a strategic point to link the Sub-Saharan routes hence becoming an aviation hub. The first president of Ghana, Dr Kwame Nkrumah saw this potential and in his bid to unit the continent contracted the soviet experts to tilt it near a cosmodrome as possible.

- Tamale international airport will ignite and boost our domestic airport operations as it becomes one of the main transit point for the country. This will contribute immensely towards domestic travel revenue generation to transform GCAA and GAC from its current fragmented and unprofitable domestic aviation state into a focused and profitable commercial enterprise that is market driven and service oriented.

In conclusion, the completion of the entire phase of the project will put Ghana in the right position of realizing a middle-income status and become an aviation hub hence the Gateway to West Africa by the said year.

1.4 OBJECTIVES

To develop an:

- international airport that will effectively play the role of one of the main aviation transit point in the country and the rest of the West African Sub-region.
- an international airport that will be capable of handling anticipated and projected increase in traffic by 2030
- an airport that is capable of handling future aircraft with
- an airport that will become an icon of Ghanaian solidarity and unity.
- airport where travelers enter the property, meaning the airport site, and they are eased into the airport experience comfortably, gently and gradually

1.5 SCOPE OF PROJECT

Airports are divided into the landside and the air side, each with facilities that support air transport.

AIRSIDE

1. Apron Areas: consisting of runways, taxiways, exit taxiways and their shoulders clear-zones, loading bays and approach zones

LANDSIDE

2. Terminal Area, consisting of the point of exchange between the aircraft and the roadway (cars) with facilities to cater for the passengers and visitor's comfort.

3. Services and maintenance area which consists of Administration block, Air Traffic Control Rooms, Hangars, Workshops, air travel Catering ,Crush Rescue and Fire Service ,Cargo Terminal , Electrical Transmission Sub Station, water storage and Treatment facilities, Waste Treatment and disposals Fuel Farms, Apron Services.

ANCILLARY AND OTHER SUPPORTING FACILITIES

4. Ancillary facilities like lettable Office Blocks, Airport Hotel, Aviation Training School, and Outdoor Restaurant.

5. Other facilities such as Residential developments for very Sensitive staff, Commercial areas , Market, Civic Areas, Cultural, Light industrial area and Tourist Areas.

The scope of the design thesis is limited to a master planning of the various sectors. The Terminal Area (2) will be treated in sufficient detail. Areas such as Air-traffic Control tower under (3) will also be treated to an average level of detail. All other area will be treated schematically with graphically outlined impressions.

1.6 CLIENTS

The client for this project is the Ghana Civil Aviation Authority (GCAA) and The Ghana Airports Company (GAC) under the auspices of the Ministry of Transportation.

1.7 FINANCING THE PROJECT

Funding for the project is to be sourced both domestically and internationally

Domestically through GCAA and GAC under the auspices of the ministry of transportation and the government of Ghana

Internationally through financial institutions such as grants and loans to promote international trade and investment in the country

1.8 CLIENTELE

The project aims at varied user groups. These are

- GENERAL PUBLIC

Domestic and foreign travelers including transiting passengers both locally and internationally, traveling and visiting tourist, escorts

- AIRPORT WORKERS
- AIRLINES

Domestic and international airlines, commercial, chattered and private

- CARGO HANDLING AGENTS
- PETROLEUM ORGANIZATION AGENTS
- PRIVATE COMMERCIAL ENTERPRISE
- GOVERNMENT INSTITUTIONS

Ghana Civil Aviation, Ghana Airport Company, Customs and Immigration, Ghana Narcotic Board

- FINANCIAL INSTITUTIONS

Banks, International money exchange agencies

1.9 CLIENT BRIEF

AIRSIDE

- Loading Apron
- Runway
- Helipad
- Access roads
- Parking Apron
- Control Tower
- Navigational aids
- Taxiway

LANDSIDE

- Terminal building
- Hangars

- Civil Aviation Offices
- Fuel farm
- Presidential Lounge
- Car parks (public/staff, etc) commercial & private.
- Fire station/police station security
- Hotel (accommodation)
- Crew block
- Catering building (Ghana Airways)
- Meteorological station
- Waste Treatment area
- Service stations
- Workshop

1.10 METHODOLOGY

The methodology used can be categorized into four broad heading:

- Primary data collection sources such as site surveys, sketches, interview with stakeholders and etc
- Secondary data Collection sources were basically from GCAA library and KNUST main library and internet search
- Analysis and synthesis of data
- Design proposal
- Finally, recommendations and conclusions are drawn based on the studies, analysis and proposals

1.11 ORGANISATION OF REPORT

Chapter one comprise an introduction and definition of airports today, the problem statement, the project and its justification, the objectives of the study, scope of design clients and clientele, financing the project, client needs, methodology and chapter outline. Chapter two gives an overview of aviation and airport development history, Ghana's aviation history and statistical data. This chapter reviews other literature on airport planning, standards and requirements by ICAO and other relevant technical data. The chapter further presents the various special and technical studies that was undertaken to fully understand the dynamics of airport design.

Chapter Three talks about the research methodology and further expands the various case studies and precedent studies that were undertaken to understand airport design.

Chapter four discuses the site with aviation standards as presented in the literature review that is site location and selection. It also discusses the procedures and factors considered in the site selection and analysis. It finally details the site justification against others considered.

Chapter five details the design process, concepts and ideas. It continues with presentation of the conceptual site planning, design options considered and presents the design proposals. To effectively achieve the project target the following were recommended- Phasing plan for the project and costing, finishes, construction methods, infrastructure and services.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

To fully understand and appreciate the dynamics of airport design it is important to have a clear understanding of where airports started from, the various changes and developments it's undergone, the current state and finally future of airports.

2.2 HISTORICAL DEVELOPMENTS OF AIRPORTS

The relatively short but very rich history of civil aviation has made dramatic impacts on society. Airports have grown from simple grass-covered fields into some of the busiest transportation centers in the world, moving millions of passengers worldwide. As airline traffic increases, new airports are built to accommodate more passengers.

2.3 EARLY DEVELOPMENT

Early airplanes were light and had low operating speeds, so they could operate from any relatively level cleared field. Takeoff and landing fields in the 1910s and 1920s were generally built in any location that was convenient to the population being served. These airfields had no designated runways, because the airplanes did not require specially prepared or paved surfaces. Pilots simply positioned their aircraft into the wind and, after a short ground run of 300 to 900 m (1,000 to 3,000 ft), took off into the air.

Because airfields were relatively easy to create in the early days of aviation, many cities had more than one. Terminal buildings, if they existed at all, were often multipurpose buildings housing the offices of a few airlines, weather observers, and air traffic controllers, as well as ticket counters, snack bars, and passenger-waiting and baggage-pickup areas.

Multiengine airplanes, introduced in the 1930s, were heavier and needed longer paved runways to take off and land. As a new round of airport construction began, airport builders favored sites away from central downtown districts, such as outlying farm areas or unpopulated marshlands. These marginal sites were inexpensive, provided enough space for expansion, and were also clear of obstructions such as tall buildings. In most cities, government officials chose to designate only one airport in their region as a major airport. The other fields were closed, and their sites were subsequently used for shopping centers, industrial parks, and residential developments.

These second-generation commercial airports of the 1930s were designed to serve airplanes that usually carried up to 75 passengers. Because airplane capacity was still relatively small, all terminal functions were handled on a single floor. Terminal buildings were usually of the gate terminal design, with airplanes on one side of the building and automobile parking on the other.

With the introduction of jet airplanes into commercial service in 1959, facilities at many existing airports became outdated or obsolete. To correct this, another round of construction and expansion began. To allow long-range operations by the heavier and faster jet aircraft, runways now needed to be extended in length to about 3,000 m (about

10,000 ft). Terminals designed for the passenger volumes of earlier, smaller aircraft were no longer adequate for the new jet airplanes, which could seat more than 150 passengers on each flight.

New concepts in terminal design that were implemented in the 1960s featured much larger architecture than that of earlier terminals. Many new terminals were built by specific airlines to serve their own customers.

In the years following the deregulation of the U.S. domestic air-transport industry in 1978, airlines began converting their operations to hub-and-spoke systems. In this system, an airline's passengers are collected by flights from many spoke cities and are flown to a hub airport, which is normally located at a centralized point in the airline's route system. Passengers arrive at the hub in a wave of flights arriving at approximately the same time. During the time the airplanes are on the ground at the hub (about 1.5 hours), passengers transfer to other airplanes that are going to their ultimate destination. Then all flights in the wave depart to the spoke cities and the whole process begins again. This pattern is repeated throughout the day to provide service at convenient frequencies.

Prior to the establishment of hubs in the United States, long, nonstop domestic flights of 4,000 to 5,000 km (2,500 to 3,000 mi) were traditionally flown in large wide-body jets holding from 250 to 400 seats. These large jets flew usually once or twice per day for each airline in the market. With the advent of the hub-and-spoke system, nonstop flights have been largely replaced by shorter flights and smaller jets that fly as many as 12 connecting flights per day.

2.4 HISTORICAL OVERVIEW OF THE AIRPORT TERMINAL

2.4.1 INTRODUCTION

The airport terminal area, comprised of passenger and cargo terminal buildings, aircraft parking, loading, unloading, and service areas such as passenger service facilities, automobile parking, and public transit stations, is a vital component to the airport system. The primary goal of an airport is to provide passengers and cargo access to air transportation, and thus the terminal area achieves the goal of the airport by providing the vital link between the airside of the airport and the landside. The terminal area provides the facilities, procedures, and processes to efficiently move crew, passengers, and cargo onto, and off of, commercial and general aviation aircraft.

The term *terminal* is in fact somewhat of a misnomer. Terminal implies ending. Although aircraft itineraries begin and end at an airport's terminal area, the itineraries of passengers and baggage do not. It is vitally important to understand that the airport terminal is not an end point, but an area of transfer along the way. As will be discussed in this section, the building configurations, facilities and processes that comprise an airport terminal area require careful planning and management to ensure the efficient transfer of passengers and cargo through the airport and aviation system.

2.4.2 THE HISTORICAL DEVELOPMENT

Just as there were no runways or other airfield facilities during the very earliest days of aviation, there certainly were no terminals, at least the way they are recognized today. The first facilities that could be remotely considered airport terminal areas evolved in the early 1920s with the introduction of airmail service. Airmail operations required small depots in order to load and unload mail, fuel aircraft, and perform any required maintenance. Little in the way of formal passenger or cargo processing was required, and hence, airport terminal facilities were little more than single-room structures with the most basic of infrastructure.

The introduction of commercial passenger air service in the late 1920s resulted in the need to develop certain basic passenger processing policies. The earliest passenger processing strategies evolved from the major intercity transportation mode of the day, the railroads. Tickets and boarding passes were issued for passengers, and similar to policies set for rail transport, cargo rates were also charged, typically by the weight of the cargo being transported. (Sometimes passengers were weighed as well, primarily to ensure that the aircraft did not exceed its maximum takeoff weight). The facilities required for performing basic ticketing and weighing functions, as well as for aircraft boarding and alighting the relatively few passengers and little cargo that used civil air transportation could be, and were often, incorporated into one-room facilities, strikingly similar to the facilities that served the railroads.

2.4.3 UNIT TERMINAL CONCEPTS

These first terminals were the earliest **centralized facilities,** centralized meaning that all passenger processing facilities at the airport are housed in one building. These first centralized facilities became known as the earliest **simple unit terminals,** because they contained all required passenger processing facilities for a given air carrier in a single-unit building. In addition to passenger processing facilities, the airport's administrative offices, and even air traffic control facilities, were located within the unit terminal building.

As air service became more popular, particularly in the 1940s and 1950s, airport terminals expanded to accommodate increasing volumes of aircraft, passengers, and cargo. As multiple airlines began to serve single communities, airport terminals expanded in two ways. In smaller communities, two or more airlines would share a common building, slightly larger than a simple unit terminal, but have separate passenger and baggage processing facilities. This configuration became known as the **combined unit terminal.** In larger metropolitan areas, separate buildings were constructed for each airline, each building behaving as its own unit terminal. This terminal area configuration became known as the **multiple-unit terminal** concept. Even though the multiple-unit terminal area consisted of separate facilities for each airline, it is still considered an individual *centralized* facility because all passenger and cargo processing required for any given passenger or piece of cargo to board any given flight still exists in one facility. The early centralized terminals, including the simple-unit, combined-unit, and multiple-unit terminals, employed the **gate arrival concept.** The gate arrival concept is a centralized layout that is aimed at reducing the overall size of terminal areas by bringing automobile parking as close as possible to aircraft parking. The simple-unit terminal represents the most fundamental type of gate arrival facility, consisting of a single common waiting and ticketing area with exits onto a small aircraft parking apron. Even today, the gate arrival concept is adaptable to airports with low airline activity and is particularly applicable to general aviation operations whether a smaller general aviation terminal is located separately from a larger terminal for commercial air carriers or is the operational center for an airport used exclusively for general aviation.

Where the terminal serves airline operations, close-in parking is usually available for three to six commercial aircraft. Where the simple-unit terminal serves general aviation only, the facility is within convenient walking distance of aircraft parking areas and adjacent to an aircraft service apron. The simple-unit terminal facility normally consists of a single-level structure where access to aircraft is afforded by a walk across the aircraft parking apron.

2.4.4 LINEAR TERMINAL CONCEPTS

As airports expanded to meet the growing needs of the public, as well as the growing wingspans of aircraft, simple-unit terminals expanded outward in a rectangular or *linear* manner, with the goal of maintaining short distances between the vehicle curb and aircraft parking that existed with unit terminals. Within linear terminals, ticket counters serving individual airlines were introduced and loading bridges were deployed at aircraft gates to allow passengers to board aircraft without having to be outside on the apron, thereby improving convenience and safety for passengers. In some instances airports were extended in a **curvilinear** fashion, allowing even more aircraft to park "nose-in" to the terminal building while maintaining short walking distances from the airport entrance to the aircraft gate. In many respects, the linear and curvilinear terminal concepts are mere extensions of the simple-unit terminal concept. More sophisticated linear terminals, particularly those that serve high volumes of passengers, often feature two level structures where enplaning passengers are processed on one level and deplaning passengers on the other level. Passenger walking distances from the "curb to the gate" are typically short, on the order of 100 feet. The linear configuration also lends itself to the development of automobile parking that is close to the terminal building, and provides extended curb frontage for loading and unloading of ground transportation vehicles. One of the main disadvantages of linear terminals becomes evident as the length of the terminal building increases. Walking distances between facilities, particularly distantly separated gates, become excessive for the passenger whose itinerary requires a change in aircraft at the airport. Prior to airline deregulation the percentage of these transfer passengers was insignificant. After 1978, however, this percentage increased dramatically and the issue of long walking distances between gates became a major issue, particularly at the hub airports.

2.4.5 PIER FINGER TERMINALS

The **pier finger terminal** concept evolved in the 1950s when gate *concourses* were added to simple unit terminal buildings. Concourses, known as *piers* or *fingers*, offered the opportunity to maximize the number of aircraft parking spaces with fewer infrastructures. Aircraft parking was assigned to both sides of a pier extending from the original unit terminal structure. The pier finger terminal is the first of what are known as **decentralized facilities,** with some of the required processing performed in common-use main terminal areas, and other processes performed in and around individual concourses. Many airports today have pier finger terminals in use. Since the earliest pier finger designs, very sophisticated and often convoluted forms of the concept have been developed with the addition of hold rooms at gates, loading bridges, and vertical separation of enplaning and deplaning passengers in the main-unit terminal area.

As pier finger terminals expanded, concourse lengths at many terminal buildings became excessive, averaging 400 feet or more from the main terminal to the concourse end. In addition, as terminals expanded by adding additional piers, distances between gates and other facilities became not only excessive in distance, but also confusing in direction. Moreover, often the main-unit terminal facility and corridors connecting the individual fingers were not expanded along with the construction of additional concourses, leading to passenger crowding in these areas. Another of the disadvantages of pier finger terminals is that expansion of terminals by adding or lengthening concourses may significantly reduce the amount of apron space for aircraft parking and movement. Also, the addition of concourses to the terminal tends to put constraints on the mobility of aircraft, particularly those that are parked closer to the main terminal building.

2.4.6 PIER SATELLITE AND REMOTE SATELLITE TERMINALS

Similar to pier finger terminals, **pier satellite terminals** formed as concourses extended from main-unit terminal buildings with aircraft parked at the end of the concourse around a round atrium or *satellite* area. Satellite gates are usually served by a common passenger holding area. Satellite terminal concepts, developed in the 1960s and 1970s, took advantage of the ability to create either underground corridors or **Automated Passenger Movement Systems (APMs)** to connect main terminal buildings with concourses. Such terminals are said to be built on the **remote satellite concept.**

The main advantage of the remote satellite concept is that one or more satellite facilities may be constructed and expanded when necessary while providing sufficient space for aircraft taxi operations between the main terminal building and satellites. In addition, although distances from the main terminal to a satellite may be quite large, APMs or other people-mover systems such as moving walkways or shuttle buses are provided to reduce walking distances.

Another of the advantages of the satellite concept is that it lends itself to a relatively compact central terminal with common areas for processing passengers, because aircraft with large wingspans, which for all intents and purposes dictate the size of terminal gate areas and thus concourses and satellite, are parked at remote satellites rather than at the central facility. As with the pier finger concept, the expansion of pier satellite and remote satellite concept terminals tend to result in terminal facilities that not only have large distances between key points within the terminal, but also often become confusing for passengers in their attempts to find their way to their respective gates, baggage claim areas, or other desired facilities.

2.4.7 THE MOBILE LOUNGE OR TRANSPORTER CONCEPT

In 1962 the opening of Dulles International Airport west of Washington, D.C., designed as the first airport specifically for the new jet aircraft of the day, introduced the **mobile lounge** or *transporter concept* of airport terminals. Sometimes known also as the *remote aircraft parking concept,* the Washington Dulles terminal area attempted to maximize the number of aircraft that may be parked and maximize the number of passengers that may be processed, with minimal concourse infrastructure. In this concept, aircraft are parked at remote parking locations away from the main-unit terminal building. To travel between aircraft and the terminal building, passengers would board transporters, known as mobile lounges that would roam the airfield among ground vehicles and taxiing aircraft.

With the mobile lounge concept, walking distances were held to a minimum because the main, relatively compact, terminal building contains common passenger processing facilities, with automobile curbs and parking located in close proximity to the terminal building entrances. Theoretically, expansion to accommodate additional aircraft is facilitated by the fact that there is no need to physically expand concourses, piers, or satellites, just merely add additional mobile lounges, if necessary.

Despite its theoretical advantages, the mobile lounge concept did not on the whole win approval from passengers. Mobile lounge boarding areas in the main terminal often became excessively congested as passengers with carry-on baggage would crowd the area, often arriving early so as not to miss their assigned mobile lounge boarding time. Moreover, the relatively small mobile lounges offered far less room for passengers than the aircraft from or to which they are transitioning, especially in comparison to large "wide-body" aircraft introduced in the late 1960s, leaving passengers crowded and often uncomfortable while on the mobile lounge. In addition, mobile lounges require constant maintenance, which over time becomes an excessive cost element of operations.

In the mid-1990s Dulles in effect abandoned the mobile lounge concept by constructing satellite or *midfield* concourses on the airfield. Today, the remaining mobile lounges at Dulles still in service act as transporters merely between the main terminal building and the satellite concourses rather than directly to aircraft. Current plans at Dulles call for construction of an underground transporter between the main terminal and the remote concourses and removing the mobile lounges from the terminal area entirely.

In the United States, no other airports have relied entirely on the mobile lounge concept for their terminal areas, with the exception of providing shuttle bus services to aircraft that must be parked in remote parking spots because of lack of available gate space at the terminal building or concourses. In other countries, particularly in the Middle East, the mobile lounge concept has been met with higher levels of success.

2.4.8 HYBRID TERMINAL GEOMETRIES

With the volatile changes in the amount and behavior of civil aviation activity in the 1970s, with increasing numbers of large aircraft (with high seating capacities and large wingspans), volumes of passengers, and changes in route structures, particularly after airline deregulation in 1978, airport management has had to expand and modify terminal areas to accommodate almost constantly changing environments. As a result, many airport terminal geometries expanded in an ad-hoc manner, leading to ***hybrid terminal geometries*** incorporating features of two or more of the basic configurations. In addition, for airports that accommodate an airline's hub, airport terminal planning became necessary to accommodate up to 100 or more aircraft at one time and efficiently handle record volumes of passengers, particularly those passengers transferring between aircraft.

It's no coincidence that in the 1970s and 1980s public sentiment for the planning and management of many airport terminals in the United States was declining. Issues including congestion, long walking distances, confusing directions, as well as limited amenities and passenger services became popular issues of criticism. As a result, airport planners began to redevelop terminal area designs, focusing on strategic planning and design of terminals that can accommodate requirements of accessing ground vehicles, passengers, and aircraft, with sufficient flexibility to adapt to ever-changing levels of growth and system behavior.

2.4.9 THE AIRSIDE-LANDSIDE CONCEPT

The most significant terminal area concept to emerge involved a more physical separation between facilities that handle passengers and ground vehicles and those that deal primarily with aircraft handling. The **airside-landside concept** emerged with the opening of the Tampa International Airport in 1972, and has proliferated throughout the United States at airports such as Pittsburgh International Airport and Orlando International

Airport. The airside-landside concept relies heavily on automated pedestrian movement systems to quickly and efficiently shuttle passengers to and from two separate facilities. In the landside facility, all passenger and baggage processing can be performed without being physically close to an aircraft. In addition, sufficient ancillary facilities, such as concessions, atriums, and the like, are located in landside facilities to provide amenities to facilitate a pleasurable experience for the passenger. Airside facilities, which have been built in various shapes and sizes, from X shapes to long concourses, focus on the efficient servicing of aircraft, including fueling, loading, and unloading. Separating each of the two processes allows greater flexibility in adapting to changes in either environment, whether it be new aircraft or changes in passenger processing policies.

2.4.10 OFF-AIRPORT TERMINALS

In the 1980s the airside-landside concept formed the basis for a series of experimental concepts known as **off-airport terminals.** With the notion that certain passenger processes, such as ticketing and baggage check-in, and certainly automobile parking, did not need to be within any proximity of aircraft, such processes weren't necessarily required to be performed on airport property. As a result, facilities located miles away from the airport itself were introduced whereby passengers could park their personal vehicles, check themselves and their baggage in for their flights, and then take a shuttle bus to the airport. With the use of these off-airport terminals, passengers would avoid the often significantly more crowded passenger processing facilities at the main terminal. Also the passenger would ~~not be~~ required to find parking at the often more crowded and expensive parking facilities at the main terminal. Off-airport terminals serving the San Francisco Bay Area, Los Angeles, and Las Vegas were met with positive response, with increased passenger convenience being the prime characteristic of the systems. Because of increased security measures following the attacks of September 11, 2001, however, off-airport terminals have had to discontinue any passenger or baggage check-in processes, and are now primarily used merely as off-airport parking facilities. However, the off-airport terminal concept set the precedent for implementing the idea of passenger processing at sites away from the main airport terminal, setting the stage for the potential future of airport terminal planning.

2.5 PRESENT-DAY AIRPORT TERMINALS

With over 650 million passengers traveling annually, each with different agendas, itineraries, needs, and desires, airport terminals have become complex systems in their own rights, incorporating both necessary passenger and baggage processing services as well as a full spectrum of customer service, retail shopping, food and beverage, and other facilities to make the passengers' transition between the airside and landside components of the airport system as pleasant as possible.

It is clear that no single airport terminal configuration is best for all airports. The airfield, schedules of airlines, types of aircraft, volumes of passengers, and local considerations, such as local architecture, aesthetics, and civic pride, dictate different choices from airport to airport and from one time to another. The airport terminal planner has the dubious task of anticipating conditions up to 10 years in the future in an environment that seems to change by the day. To ensure that present-day airport terminal plans will be effective in the future, the airport planner must rely on the fundamental requirements of airport terminals and behaviors of passengers, and also must plan with the idea of flexibility in mind, such as considering facilities that can be expanded modularly or can provide the opportunity for relatively low-cost, simple modifications that future circumstances might demand.

For airport management, airport terminal areas, when properly planned and managed, have provided significant sources of revenue from airline leases to retail concessions. *Airport terminals have also become a sense of pride for communities in general, as they are typically the first impression that visitors get of their destination city and the last experience they get before leaving.* Several airport terminals today appear more to be shopping malls than passenger processing facilities, and other airport terminals are fully equipped with hotels and conference centers. These facilities have actually encouraged visitors to use the facilities at the airport without ever intending to board an aircraft. The size and shape of airport terminal configurations has both an uncertain yet exciting future. New security regulations imposed by the Transportation Security Administration have established the need to expand airport security facilities, whereas advances in information technologies have suggested the ability to reduce the size of other passenger processing facilities such as staffed ticket counters. No matter how policies, regulations, technologies, and behaviors change, however, the basic function of the airport terminal area, that of efficiently linking passengers and cargo to the airside and landside components of the civil aviation system, should always be understood by airport managers and planners alike.

2.6 HISTORY OF AVIATION ACTIVITIES IN GHANA

The history of Civil Aviation in Ghana might be taken to date back to October 22, 1918 when the first of two letters concerning the subject of aerial transportation in the colony was received by the then governor from Vickers Aviation limited of London.

In 1919, the governor of Gold Coast (now Ghana), invited a group of people to submit a report of the possibility of air transport service in Ghana. Based on this report a preliminary survey was conducted in 1920 on sitting aerodromes in the country. Areas recommended by the commission were Accra, Kumasi, Tamale, Akuse, Sekondi, Kete-Krachi, Takoradi, Kpong, and Winneba.

On April 15, 1928, the first aircraft flying boat was piloted to Ghana and landed at Takoradi. A final survey on the establishment of air-service in Ghana was conducted and a small aerodrome was constructed in Accra in 1937. A regular service between Accra and the U.K was inaugurated in 1937 by Imperial Airways Corporation (BOAC). The French Aeromaritine later followed with another air service linking Ghana with rest of French West Africa. Later the West African Airways Corporation (WAAC) was founded in 1946, jointly owned by the four colonies: - Ghana, Nigeria, Sierra Leone, and Gambia.

1949 the Kumasi Aerodrome was built. The Ghana Airways Corporation started operating Direct Flights to London in the same year. Due to the high volumes at the Accra Airport a new terminal was commissioned in 1969. Ten (10) new Airstrips were established in the country in 1977. The Kumasi Aerodrome had a passenger terminal commissioned in 1989. The Kotoka International Airport was renovated in 1991 and a new domestic terminal commissioned in 2001.

2.6.1 GHANA CIVIL AVIATION

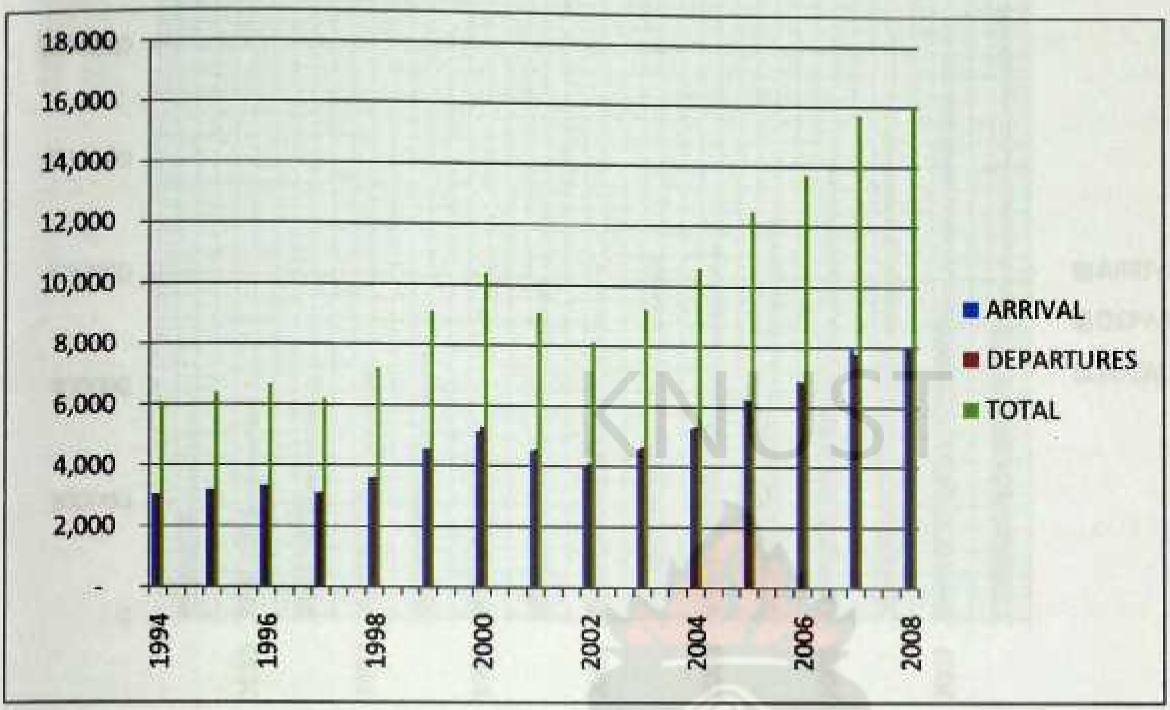
In 1930 Civil Aviation started as a unit within the Public Works Department (PWD) and was granted Departmental status in 1953 under the Ministry of Transport and Communications. It remained as such until 16th May 1986, when the Ghana Civil Aviation Authority (GCAA), was established by PNDC Law 151 and assumed the status of a corporate body under the present Ministry of Roads and Transport. This Law has been replaced with Ghana Civil Aviation Act 678 in the year 2004.

The Authority currently has under its control and management, Kotoka International Airport and the three domestic airports of Kumasi, Sunyani and Tamale. Ghana's Air Traffic Control serves as the coordination centre for the Accra Flight Information Region (FIR) which also has jurisdiction over the airspaces of the Republics of Benin and Togo.

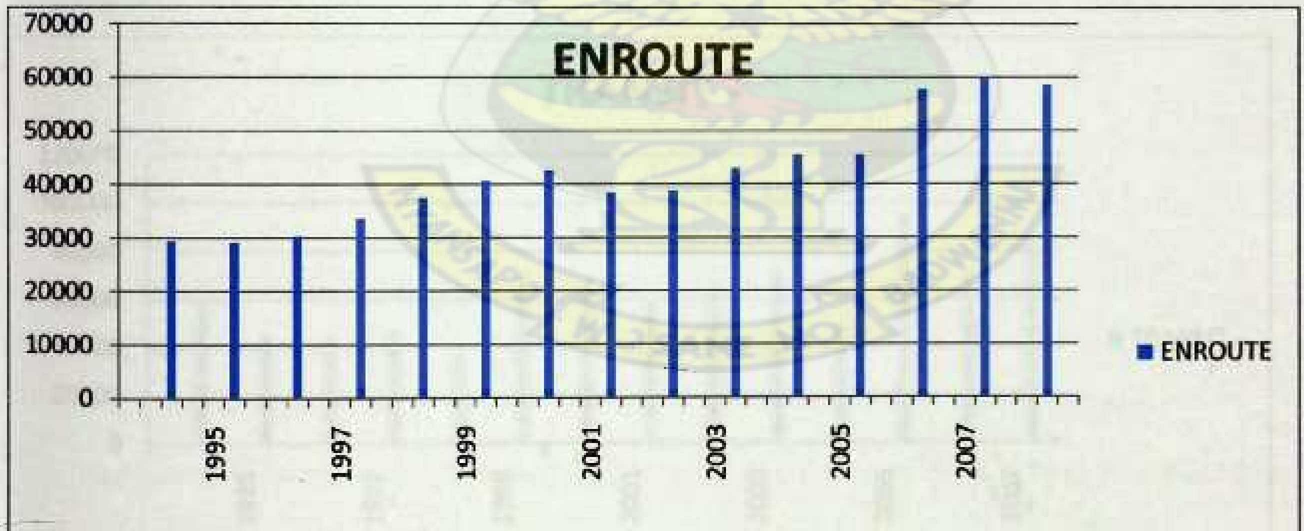
Civil Aviation in Ghana is handled principally by the following institutions, Ghana Civil Aviation Authority, Ghana Airport Company, Ghana meteorological Service, The Crash Rescue Fire Service and Airline Operators.

2.7 AVIATION STATISTICAL INFORMATION OF GHANA

2.7.1 AIRCRAFT MOVEMENT



2.7.2 ENROUTE



Source: Corporate Planning Department, GCAA(2008)

2.8. SPECIAL AND TECHNICAL STUDIES

2.8.1 THE AIRPORT AND ITS ENVIRONMENT

The compatibility of an airport with its environs is an ideal that can be achieved by proper planning of the area surrounding the airport. The aim is to provide the best possible conditions for the needs of the airport, the community in the surrounding area and the ecology of the environment.

Airport planning must be recognized as an integral part of an area-wide configuration of the airport need to be coordinated with patterns of residential, industrial, commercial, agricultural and other land uses of the area, taking into account the effects of the airport on people, flora, fauna, the atmosphere, water courses, air quality, soil pollution and other facets of environment.

Land-use planning or planning for compatible land use which takes into account the needs of airport development more adequately describes the process of achieving an optimum relationship between an airport and its environment.

2.8.2 THE NEED FOR ENVIRONMENTAL CONTROL

In recent year there has been increasing public concerns regarding the protection of the environment from the impact of transportation and consequently, growing emphasis on the need to employ effective measures to minimize such impacts. Since pollution may be generated within an airport as well as within the area surrounding it, environmental control should be applied at the airport and its environment.

Pollution occurring in and around the airport has the potential to affect not only the immediate area, but also the surrounding areas. Because it can have an effect on human health and the ecology of the surrounding area, efforts should therefore be made towards pollution prevention. Environmental control therefore provides a means of either decreasing pollution at the source or reducing the potential for negative environmental impact. Control such as air and water management plans, environmental emergency plans, and environmental management plans are necessary.

2.8.3 INTERNATIONAL AIRPORTS

According to Annex 9 of ICAO SARPS an international airport is an airport designated by the contracting states in whose territory it is situated as an airport of entry and departure for international air traffic, where the formalities incident to customs, immigration, public health, animal and plant quarantine and similar procedures are carried out.

2.8.4 AERODROME

Area of land or water (including any buildings installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft.

2.8.5 AIRPORT CLASSIFICATION

There are three main types of airport:

- Regional or domestic airports (civil or civil and airforce)
- Military airports (airforce base)
- National or International airport

2.8.6 AIRPORT DESIGNATION AND NAMING

Airports are represented by their IATA airport code and ICAO airport code. IATA airport codes are often, but not always, abbreviated forms of the common name of the airport, such as KIA, Kotoka International Airport. Exceptions to this rule often occur when an airport's name is changed. O'Hare International Airport in Chicago, Illinois retains the IATA code ORD, from its former name of Orchard Field.

In many countries airports are often named after prominent national celebrities, commonly politicians, e.g. John F. Kennedy International Airport, Indira Gandhi International Airport, Chiang Kai-Shek International Airport or Charles de Gaulle International Airport.

2.8.7 AIRPORT CONFIGUARATION

Airports are divided into two broad headings. They are the

LANDSIDE

Terminal building area

AIRSIDE

Runway and Apron areas

2.8.8 RUNWAY AND TAXIWAYS

Due to their physical characteristic and the land required and all the other factors which affect them and limit free choice of layout, runways and taxiways are the first to be considered. After determination of the dimensional criteria, pavement strength and airfield capacity and configuration, other elements of the airside of the airport, namely the apron navigation and traffic control aids are then considered. For the purposes of identifying standards for various sizes of airports and their functions, reference codes have been developed. The basis for the code is the runway basic length and wing span and wheel of aircrafts.

2.8.8.1 FACTORS DETERMINING SITTING, ORIENTATION AND NUMBER OF RUNWAYS

1. Weather, in particular the Runway/aerodrome usability factor, as determined by wind distribution and the occurrence of localized fogs'.

2. Topography of the aerodrome site and its surroundings.

3. Type and amount of air traffic to be served, including air traffic control aspects.

4. Airplane performance consideration

5. Environmental considerations particularly, Noise.

2.8.8.2 FACTORS DETERMINING LENGTH OF RUN-WAYS

1. Performance characteristics and operating masses of the airplanes to be served.

2. Weather, particularly surface wind and temperature.

3. Runway characteristics such as slope and surface condition

4. Aerodrome location factors example aerodrome elevation which affects the barometric pressure and topographical constraints.

2.8.8.3 RUNWAY UABILITY FACTOR

Airplanes take off and land into the wind. Runways should therefore be orientated in a way that approximately 95% of the year airplanes would be able to take off and land into the wind.

2.8.8.4 RUNWAY CONFIGURATION

The capacity of an airport depends upon its runway configuration; the pattern of the runway depends upon the volume of traffic, direction, duration and intensity of wind.

2.8.9 TAXIWAYS

Taxiways do not have stringent dimensional criteria since speeds of aircrafts on them are relatively less than on runways. The function of exit taxiways or turn-offs is to minimize runways occupancy time by landing aircrafts. Exit taxiways can be placed at right angles to the runways or at some other angle. It is important to provide a straight distance after the turning-off curve on a rapid exit taxiway (25° - 45°). The location of exit taxiways depends on the mix of aircrafts, the approach and touch-down speeds, the exit speed and rate of deceleration. The location of exit taxiways is also influenced by the location of the runway relative to the terminal area.

2.8.10 APRON

This is defined as an airside area on as airport intended to accommodate aircraft for purposes of loading and unloading passengers, mails, cargo, fuelling, and parking for maintenance. Besides the stands, the associated apron taxiway, apron service roads and parking for ground service equipment should all be included as part of apron systems.

2.8.11 AIRPORT TERMINAL

2.8.11.1 BASIC TERMINAL TYPES AND CONFIGURATION

- CENTRALISED

Where all passenger routes converge on and diverge from centralized passenger processing and amenity facility

- DECENTRALISED

Where passenger routes pass through a number of separate processing amenity facilities, therefore generally more applicable to domestic operations

- UNIT TERMINAL

Where two or more quite separate terminals of the centralized or decentralized type are provided to serve specific functions, e.g. individual airlines, international only, domestic only, etc

2.8.11.2 PASSENGER TERMINAL CONCEPTS

- PIER CONCEPT

Aircrafts park on both sides of a pier connected to the terminal building. Where there are two or more piers, the space in between have to be sufficient for taxiing in and out at the same time.

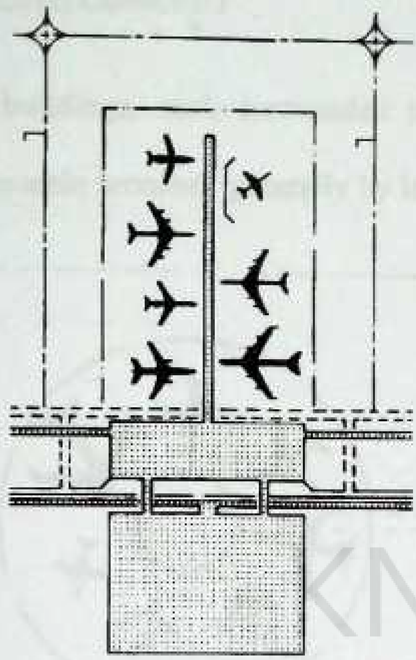


Fig 2.1

Source: Neufert (   )

➢ LINEAR CONCEPT

Aircraft are parked along the terminal building in a line next to each other in nose-in, parallel or diagonal positions. The parking position determines to a great extent the overall length of the terminal

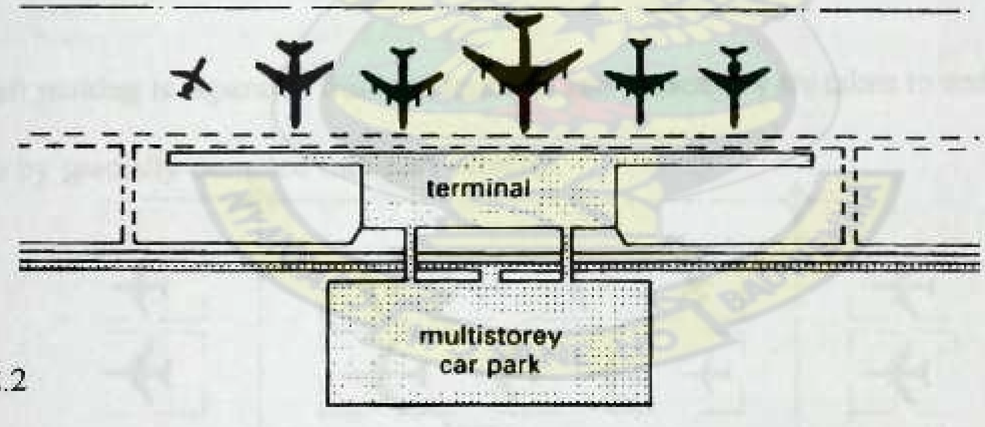


Fig. 2.2

Source: Neufert (   )

- SATELLITE CONCEPT

One or more buildings, each surrounded radially with aircraft parking places, are connected to the main terminal, generally by large underground corridors.

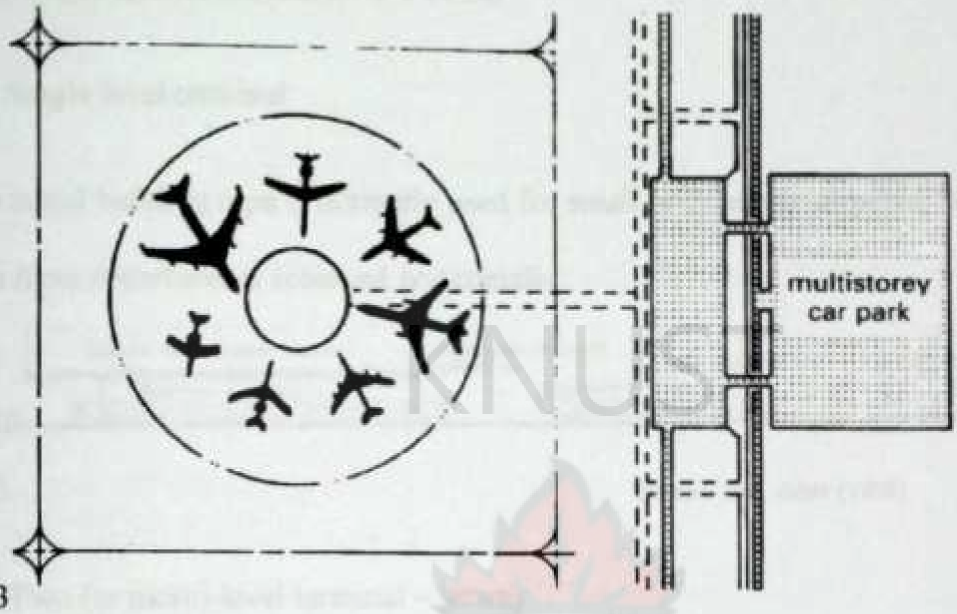


Fig. 2.3

Source: Neufert ( )

- TRANSPORTER

Aircraft parking is separated from the terminal and passengers are taken to and from their flights by specially designed transport vehicles.

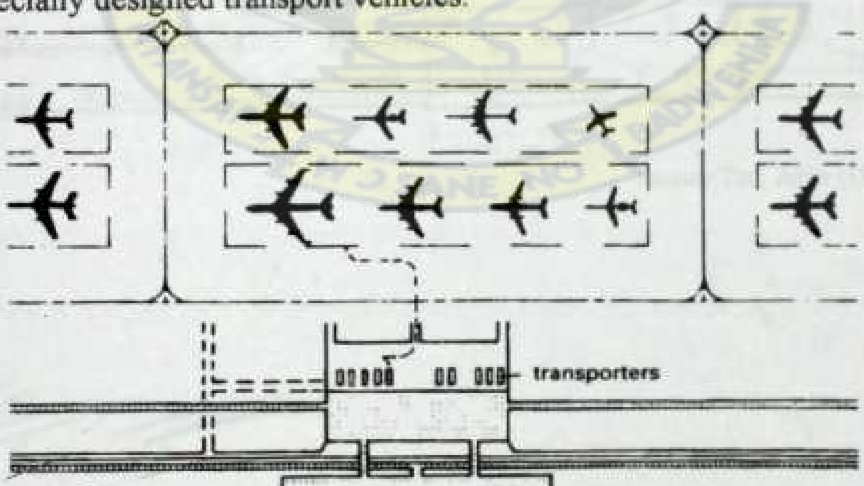


Fig. 2.4 Source: Neufert ( )

- HYBRID CONCEPTS

These are mixed variations developed from the basic layout mentioned above.

2.8.11.3 TERMINAL BUILDING TYPES

- Single level terminal

This terminal building type is normally used for small or domestic airports. Separation of arrivals from departures is achieved horizontally.

Fig. 2.5 Source: Tutt, Adler (1998)

- Two (or more)-level terminal – jetway

This terminal building type applies to larger international terminals. Separation of arriving and departing passengers is achieved vertically by floors whiles domestic and international routes are separated horizontally.

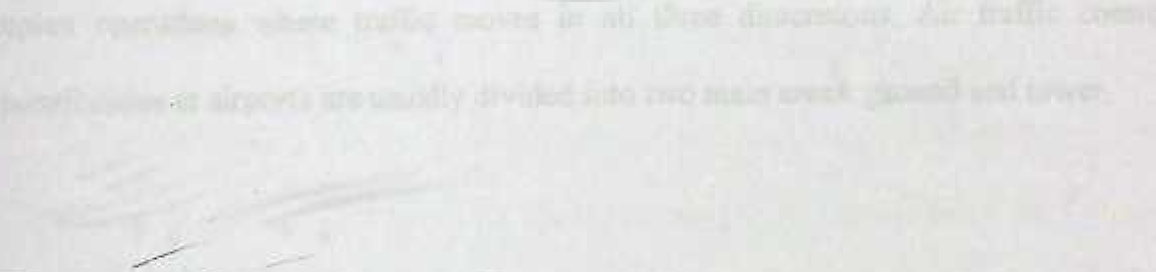


Fig. 2.6 Source: Tutt, Adler (1998)

- Two (or more)-level terminal – transporter type

This is also applicable to larger international terminal. Under this system domestic and international routes split horizontally while arrivals and departure routes split vertically.

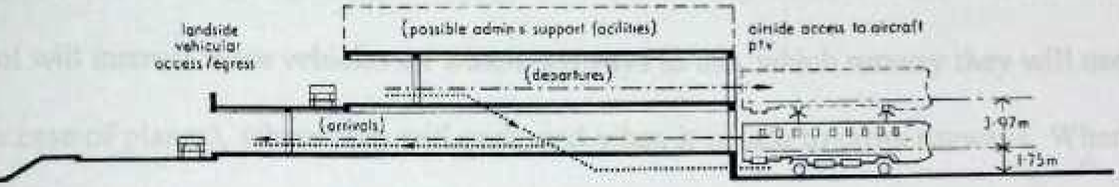


Fig 2.7 Source: Tutt, Adler (1998)

2.8.12 AIRPORT OPERATIONS

Outside the terminal, there is a large team of people who work in concert to ensure aircrafts can land, take off, and move around quickly and safely. This section gives an overview of these operations.

2.8.12.1 AIR TRAFFIC CONTROL

Air traffic control (or ATC) is system whereby ground-based controllers direct aircraft movements, usually via radio. This coordinated oversight facilitates safety and speed in complex operations where traffic moves in all three dimensions. Air traffic control responsibilities at airports are usually divided into two main areas: ground and tower.

- GROUND CONTROL

This section of airport operations is responsible for directing all ground traffic in designated "movement areas," except the traffic on runways. This includes planes, baggage trains, snow ploughs, fuel trucks, and a wide array of other vehicles. Ground Control will instruct these vehicles on which taxiways to use, which runway they will use (in the case of planes), where they will park, and when it is safe to cross runways. When a plane is ready to take off it will stop short of the runway, at which point it will be turned over to Tower Control. After a plane has landed, it will depart the runway and be returned to Ground Control.

- TOWER CONTROL

This section controls aircraft on the runway and in the controlled airspace immediately surrounding the airport. Tower controllers use radar to identify and accurately locate an aircraft's position in three-dimensional space. They coordinate the sequencing of aircraft in the traffic pattern and direct aircraft on how to safely join and leave the circuit. Aircraft which are only passing through the airspace must also contact Tower Control in order to be sure that they remain clear of other traffic and do not disrupt operations.

2.8.13 NAVIGATIONAL AIDS

When flying, there are a number of aids available to pilots, though not all airports are equipped with them. A Visual Approach Slope Indicator (VASI) helps pilots fly a perfect approach for landing once they have found the airport. Some airports are equipped with a

VHF Omni directional range (VOR) to help pilots find the direction to the airport. VORs are often accompanied by a Distance Measuring Equipment (DME) to determine the distance to the airport. In poor weather, pilots will use an Instrument Landing System to find the runway and fly the correct approach, even if they cannot.

2.8.14 GUIDANCE SIGNS

Airport guidance signs provide direction and information to taxiing aircraft and airport vehicles and assist in safe and expedient movement of aircraft. Smaller airports may have few or no signs, relying instead on airport diagrams and charts.

Operational Guidance Signs

- Location signs - yellow on black background. Identifies the runway or taxiway currently on or entering.
- Direction/Runway Exit signs - black on yellow. Identifies the intersecting taxiways the aircraft is approaching, with an arrow indicating the direction to turn.
- Other - Many airports use conventional traffic signs such as stop and yield signs throughout the airport.

Mandatory Instruction Signs

They are white on red. They show entrances to runways or critical areas. Vehicles and aircraft are required to stop at these signs until the control tower gives clearance to proceed.

2.8.15 LIGHTING

Many airports have lighting that help guide planes using the runways and taxiways at night or in rain or fog.

On runways, green lights indicate the beginning of the runway for landing, while red lights indicate the end of the runway. Runway edge lighting is white lights spaced out on both sides of the runway, indicating the edge. Some airports have more complicated lighting on the runways including lights that run down the centerline of the runway and lights that help indicate the approach. Low-traffic airports may use Pilot Controlled Lighting to save electricity and staffing costs.

2.8.16 WIND INDICATORS

Planes take-off and land into the wind in order to achieve maximum performance. Wind speed and direction information is available through the ATIS or ATC, but pilots need instantaneous information during landing. For this purpose, a windsock is kept in view of the runway.

2.8.17 SAFETY MANAGEMENT

Air safety is an important concern in the operation of an airport, and almost every airfield includes equipment and procedures for handling emergency situations. Commercial airfields include one or more emergency vehicles and their crew that are specially equipped for dealing with airfield accidents, crew and passenger extractions, and the hazards of highly flammable airplane fuel. The crews are also trained to deal with situations such as bomb threats, hijacking, and terrorist activities.

Depending on their configuration, an airport can have sections of their pavement where collisions between airplanes on the ground can tend to occur. Records are kept of any incursions where airplanes or vehicles are in an inappropriate location, allowing these "hot spots" to be identified. These locations then undergo special attention by the FAA and airport administrators in order to reduce accidents.

2.8.18 AIRCRAFT CONFIGURATION

The planning and designing of airports necessitates a proper understanding of present day aircrafts, their various types and sizes, and the probable future improvements in their design.

It is therefore essential to know the aircraft performance characteristics which will decide the landing and ground facilities required for their handling and servicing because aircraft design has not reached a static stage yet.

The likely improvements in their design in the future should be anticipated while deciding the airport master plan.

2.8.18.1 Air Craft Characteristics

To the airport planner and architect, aircraft characteristics are of primary importance. The characteristics are discussed below:

- **Type of Propulsion**

The size of the aircraft, its weight, circling radius, characteristics, load capacity, noise nuisance, etc depends upon the propulsion of the aircraft. The performance characteristics of the aircraft which determine the basic runway length also depend on the propulsion, which is either propeller engine or jet propulsion.

- **Size of Aircraft**

The sizes of aircrafts involve the following important dimensions:

Wing Span, Fuselage Length, Height, Distance between Main Gears, Wheels Base and Tail Width.

The wing span decides the width of taxiway, separation clearance between 2 parallel traffic ways size of apron and hangars, width of hangar gates, etc the length of the aircraft decides the widening of taxiways on curves, width of exit taxiways, size of aprons and hangars, etc. The Empennage Height, which is also the height of the aircraft, decides the height of the Hangar. The gears tread and wheel base affect the minimum turning of the aircraft.

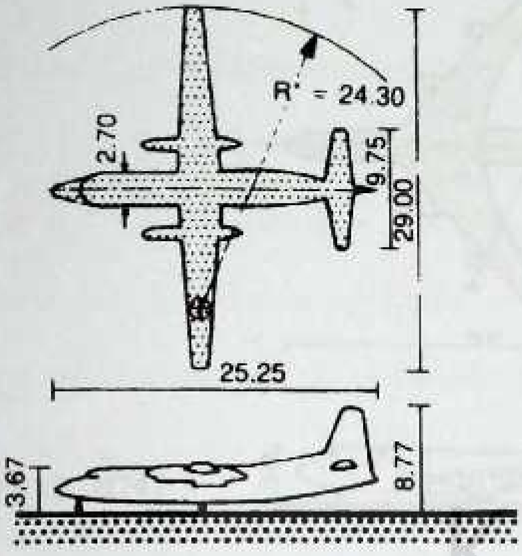


Fig 2.8 F50

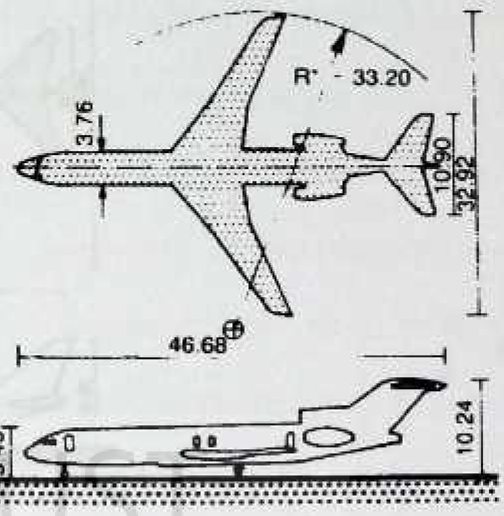


fig 2.9 B727

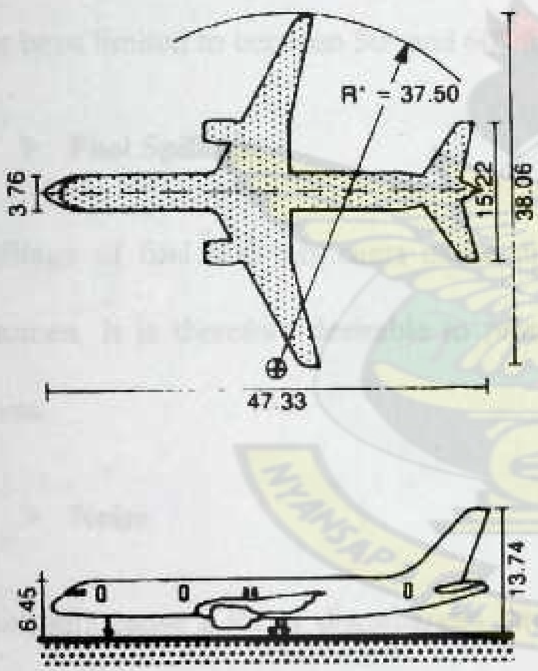


Fig. 2.10 B757

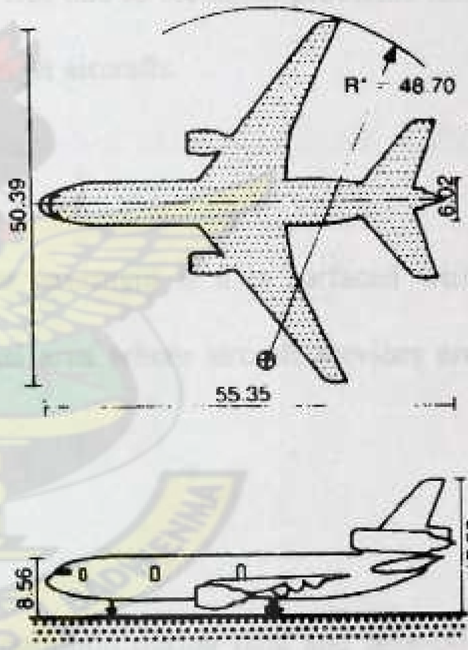


Fig. 2.11 DC10/30

Source: Neufert ( )

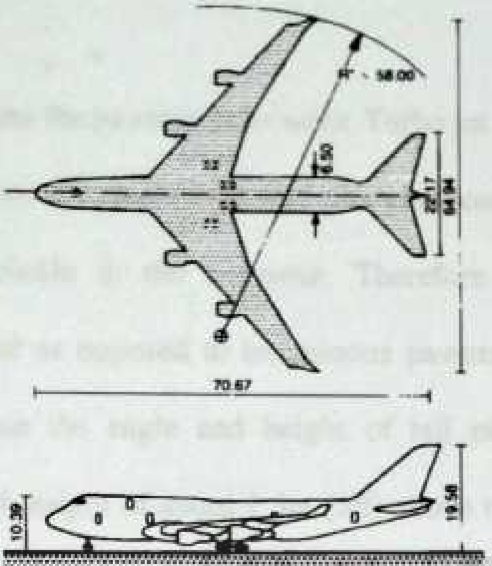


Fig 2.12 B747

- **Minimum Turning Radius**

Theoretically, the maximum angle of rotation is 90°. But due to technical problems this has been limited to between 50° and 60° for large turbo jet aircrafts.

- **Fuel Spillage**

Spillage of fuel and lubricants cause distress to the pavement if it is surfaced with bitumen. It is therefore desirable to protect the paved area where aircraft services are given.

- **Noise**

Aircrafts cause a lot of disturbances through noise pollution during land and take-off. More disturbances are caused during take-off than landing. Therefore orientation of the runway note should be taken of urban developments and their directions of growth.

➢ **Jet Blast**

Hot exhaust gases cause the pavements to wear. Turbo jet engines normally use kerosene as fuel (which does not evaporate as quickly as gasoline in conventional aircraft). The bitumen is partly soluble in the kerosene. Therefore the use of cement concrete pavements is preferred as opposed to bituminous pavements. The heat induced on the pavements depends on the angle and height of tail pipe included at 2° relative to pavement surface with height of about 1.5m (5ft) above the pavement surface hence the deteriorating effect of the commercial jet transport on the bituminous pavement.

2.8.18.2 Capacity of Aircraft

The numbers of passengers, baggage, cargo and fuel an aircraft can accommodate should be determined to help in deciding terminal facilities to be provided for their processing. Fuel storage and method of dispensing can be planned based on this information.

2.8.18.3 Aircraft Weight and Wheel Configuration

The length of a runway depends upon the weight of aircraft during landing and take-off. The runway and taxiway pavement's thickness also depends upon the gross weight of aircraft and wheel configuration.

2.8.19 AIRCRAFT AND APRON OPERATIONS

2.8.19.1 AIRCRAFT PARKING CONFIGURATION

This relates to how aircrafts enter and leave the aircraft stands. They use their own power (self-maneuvering) or are pushed out (tractor assisted).

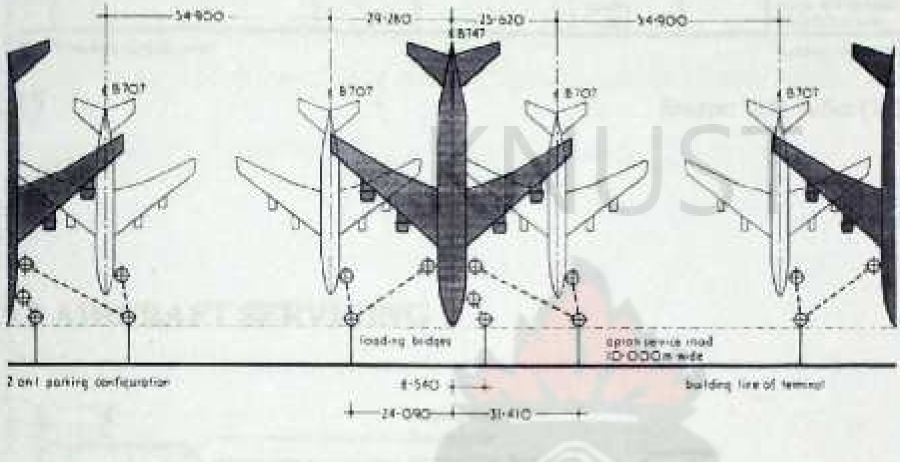


Fig 2.13 Two in One parking Configuration

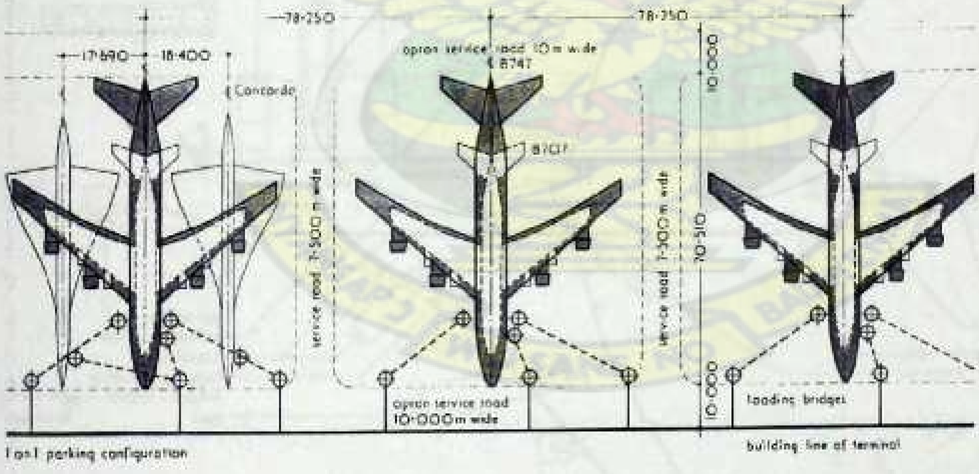


Fig. 2.14 One on One Parking Configuration

Source: Tutt, Adler (1998)

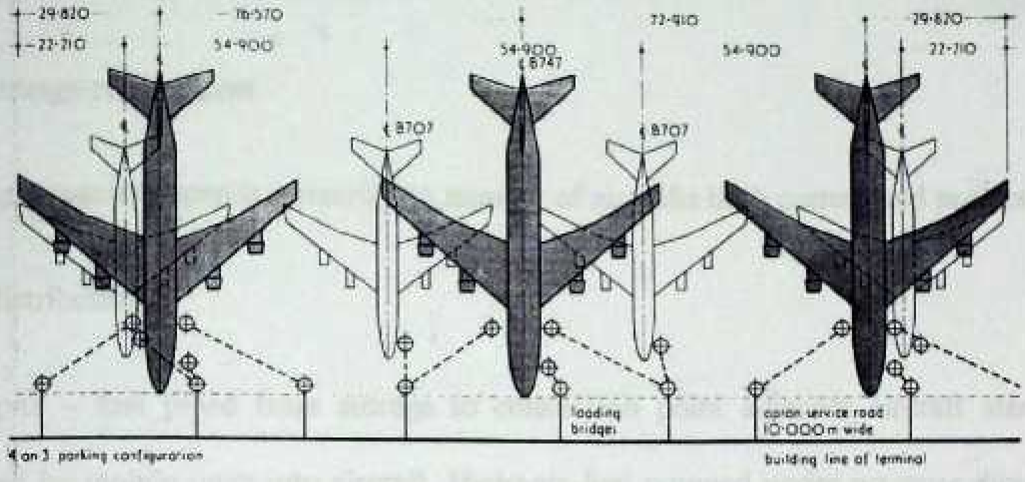


Fig 2.15 Source: Tutt, Adler (1998)

2.8.19.2 AIRCRAFT SERVICING

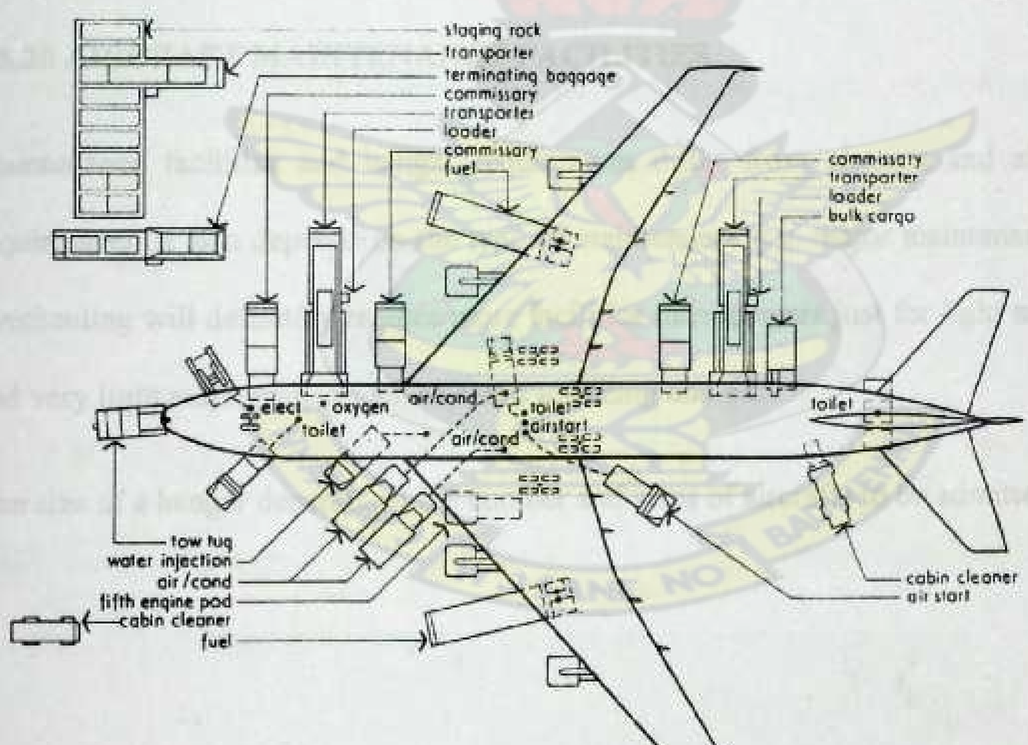


Fig 2.16 Servicing Arrangement Source: Tutt, Adler (1998)

2.8.19.3 AIRCRAFT FUELING

Fuel storage requirement

Storage capacity depends primarily on number of aircrafts both current and projected.

Fuel distribution

Fuel pits – fuel piped from storage to connection point adjacent aircraft stand then pumped by mobile units into aircraft. Hydrants-fuel pumped under pressure direct from storage to connection point adjacent aircraft stand then mitered by mobile unit into aircraft.

2.8.20 AIRCRAFT MAINTENANCE FACILITIES

Maintenance facilities and hangar requirement differ from airports and airline local requirement. It also depends on the type of maintenance e.g. major maintenance such as overhauling will definitely require more facilities than hangars just for light maintenance and very light maintenance such as cabin servicing and etc.

The size of a hangar depends on the number and sizes of aircrafts to be admitted.

2.8.21 AIR TRAFIC CONTROL (ATC) FACILITIES

Control tower

The aim of the control tower is to provide visual control of take offs, landing and part of aircraft movement on the ground

Size and facilities depends on local conditions and requirements

The height of the tower relates to the distance from the runways and angle of vision over local obstructions.

Its Location must be adjacent to the terminal but note constraint to terminal expansion.

2.8.22 FIRE FIGHTING AND RESCUE FACILITIES

Location: It must be located in such a way that has an unobstructed view and access to all areas of the airport. There must also be all weather rapid response times, that is 3minutes to crash site anywhere on airport

2.8.23 MISCELLANEOUS FACILITIES

These areas include custom facilities for aircrew and air control, vehicular maintenance facilities and apron staff facilities

2.8.24 CONNECTION OF PASSENGERS TO AIRCRAFT

Open apron approach – bus or walking across the apron

Passenger transport vehicle (PTV) – mobile lounge or transporter

Loading bridges – air-jetty, air bridge, jet way

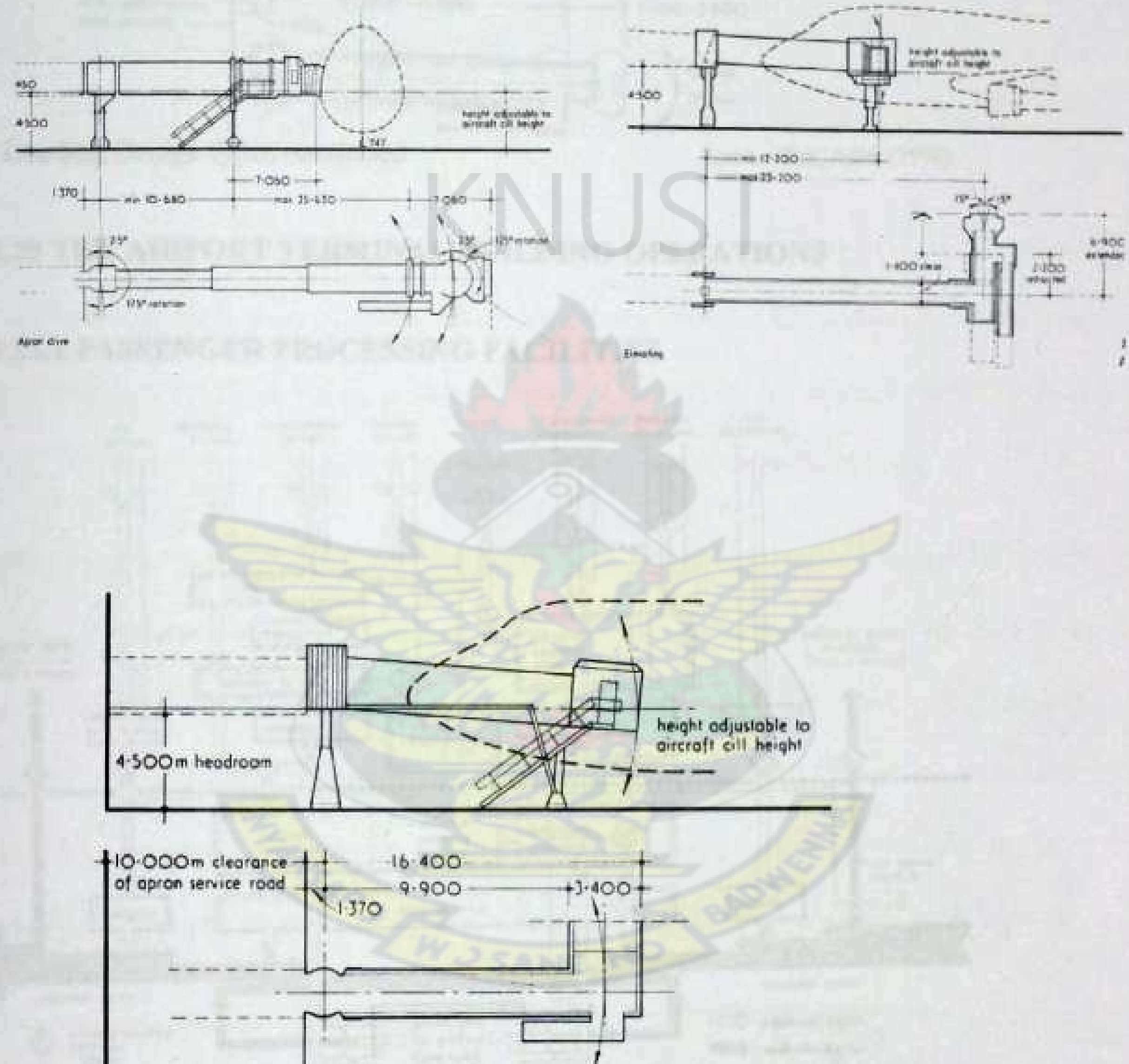


Fig 2.17 Loading Bridge types Source: Tutt, Adler (1998)

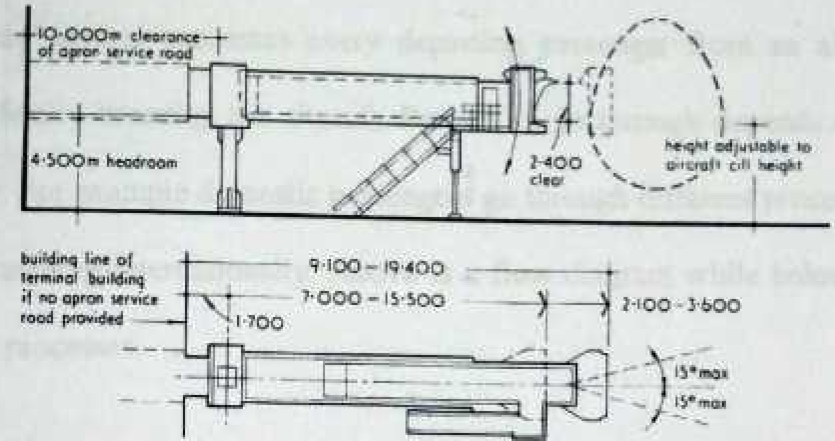


Fig 2.18 Loading Bridge types continued Source: Tutt, Adler (1998)

2.8.25 THE AIRPORT TERMINAL BUILDING OPERATIONS

2.8.25.1 PASSENGER PROCESSING FACILITIES

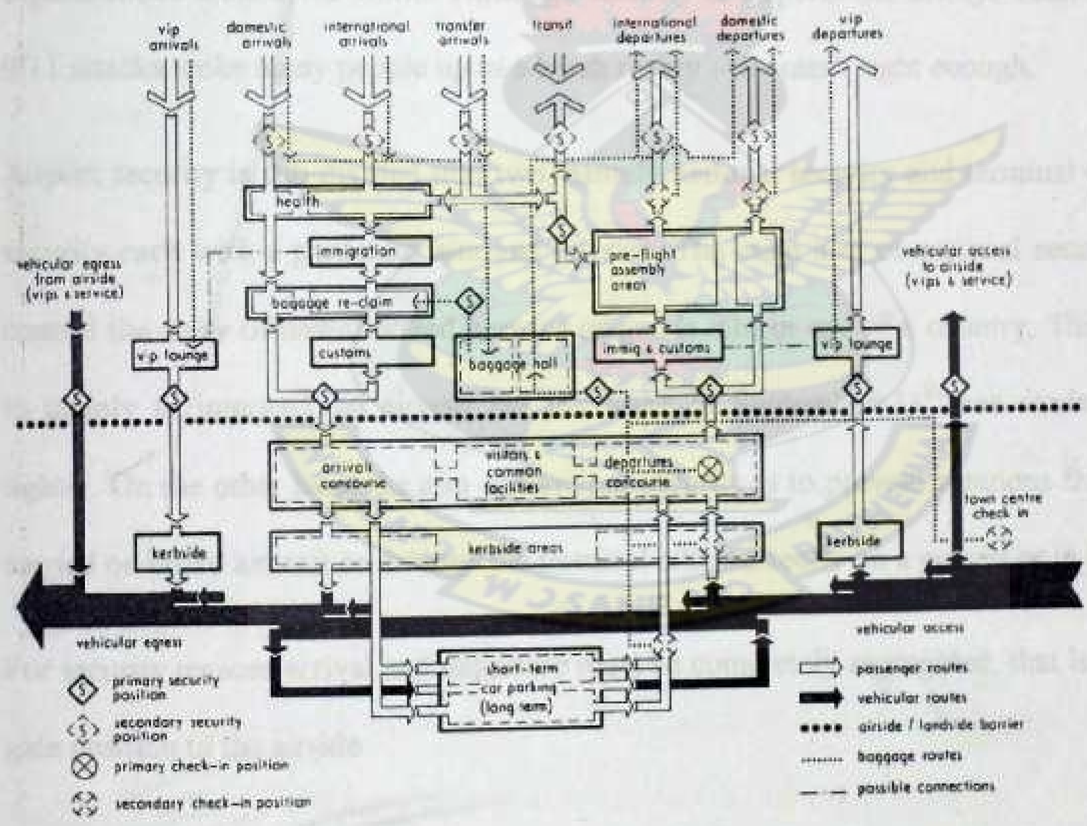


Fig 2.19 Flow plan diagram Source: Tutt, Adler (1998)

2.8.25.2 DEPARTING PASSENGERS

There are several processes every departing passenger from an airport goes through before finally boarding the aircraft. Process to go through depends on the status of the traveler. For example domestic passengers go through different processes as compared to those traveling internationally. Above is a flow diagram while below is a discussion of the key processes.

- **Airport security**

Terrorism has been a problem for airlines and air travelers since the 1970s, when hijackings and bombings became the method of choice for subversive, militant organizations around the world. Although security at airports has always been tight, the 9/11 attacks woke many people up to a harsh reality -- it wasn't tight enough.

Airport security is sub-divided into two, namely national security and terminal or airline security each with a particular aim and interest. The main aim of national security is to control the entry of unauthorized persons or goods into or out of a country. This applies to mainly to international airport but the wake of September 11th has made security tighter. On the other hand the aim of terminal security is to prevent weapons from being carried on board aircraft or through the terminal either directly on a person or in luggage.

For security reasons arrival and departure must be completely segregated, that is from the gate position to the airside.

1. **The First Line of Defense**

The first line of defense in airport security is the most obvious: fences, barriers and walls. Tall fences that would be difficult to climb enclose the entire airport property. Security patrols regularly scan the perimeter in case someone tries to cut through the fence. Especially sensitive areas, like fuel depots or the terminals and baggage handling facilities are even more secure, with more fences and security checkpoints. All access gates are monitored by either a guard station or surveillance cameras.

2. **Photo ID**

One of the most important security measures at an airport is confirming the identity of travelers. This is done by checking a photo ID. If you are traveling internationally, you need to present your passport.

The high-tech buzzword in airport security today is biometrics. Biometrics essentially means checking fingerprints, retinal scans, and facial patterns using complex computer systems to determine if someone is who they say they are - or if they match a list of people the government has determined might be potential terrorists.

3. **Metal Detector and ex-ray machines**

The next security check after the photo identification is stepping through the metal detector. All public access to an airport is channeled through the terminal, where every person must walk through a metal detector and all items must go through an x-ray machine. Almost all airport metal detectors are based on pulse induction (PI).

Fig 2.20 Metal detector

Fig 2.21 x-ray machine

4. **Checked-in Bags: X-ray Systems**

In addition to passenger baggage, most planes carry enormous amounts of cargo. All of this cargo has to be checked before it is loaded.

Most airports use one of three systems to do this:

- Medium X-ray systems - These are fixed systems that can scan an entire pallet of cargo for suspicious items.
- Mobile X-ray systems - A large truck carries a complete X-ray scanning system. The truck drives very slowly beside another, stopped truck to scan the entire contents of that truck for suspicious items.
- Fixed-site systems - This is an entire building that is basically one huge X-ray scanner. A tractor-trailer is pulled into the building and the entire truck is scanned at one time.

Fig 2.22 X-ray systems

5. **Checked in Bags: CT Scanners**

The first security check that your checked bags go through depends on the airport. In the United States, most major airports have a computer tomography (CT) scanner. A CT scanner is a hollow tube that surrounds your bag. The X-ray mechanism revolves slowly around it, bombarding it with X-rays and recording the resulting data. The CT scanner uses all of this data to create a very detailed tomogram (slice) of the bag. The scanner is able to calculate the mass and density of individual objects in your bag based on this tomogram. If an object's mass/density falls within the range of a dangerous material, the CT scanner warns the operator of a potential hazardous object.

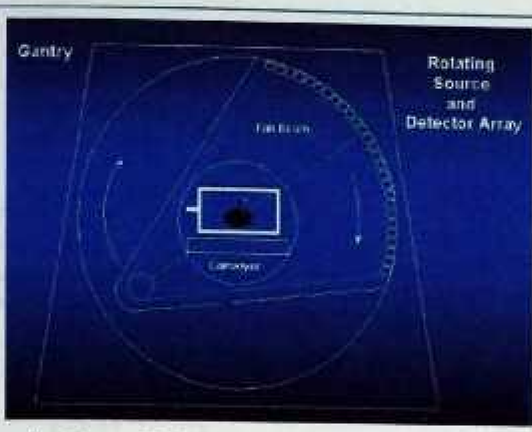


Fig 2.23 showing how a CT scanner works

CT scanners are slow compared to other types of baggage-scanning systems. Because of this, they are not used to check every bag. Instead, only bags that the computer flags as "suspicious" are checked. These flags are triggered by any anomaly that shows up in the reservation or check-in process. For example, if a person buys a one-way ticket and pays cash, this is considered atypical and could cause the computer to flag that person.

In most other countries, particularly in Europe, all baggage is run through a scanning system. These systems are basically larger versions of the X-ray system used for carry-on items. The main differences are that they are high-speed, automated machines integrated into the normal baggage-handling system and the KVP range of the X-rays is higher.

- **CHECK IN FACILITIES**

Departing passengers confirm their flight and seat, baggage are then weighed and distributed to aircraft.

Facilities for check in come in several configurations.

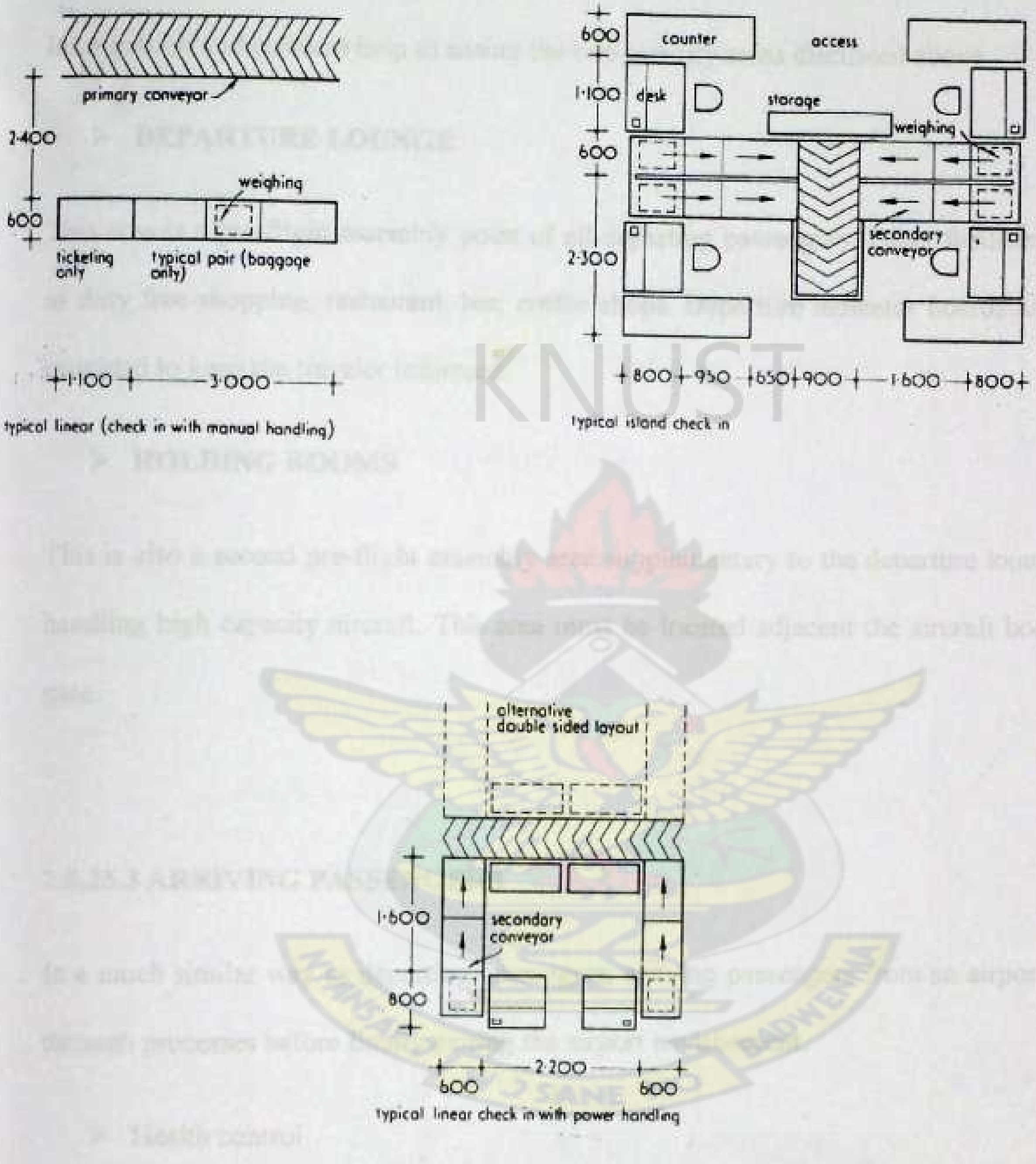


Fig 2.24 Various types of check in facilities Source: Tutt, Adler (1998)

- **IMMIGRATION AND CUSTOMS**

Immigration and customs help to ensure the two security areas discussed above.

- **DEPARTURE LOUNGE**

This area is a pre-flight assembly point of all departing passengers. Other facilities such as duty free shopping, restaurant, bar, coffee shops. Departure indicator boards are also provided to keep the traveler informed.

- **HOLDING ROOMS**

This is also a second pre-flight assembly area supplementary to the departure lounge for handling high capacity aircraft. This area must be located adjacent the aircraft boarding gate.

2.8.25.3 ARRIVING PASSENGERS

In a much similar way as departing passengers, arriving passengers from an airport goes through processes before finally exiting the airport environment.

- Health control

As part of the requirements for qualification as international airport is health control. This section works to prevent communicable diseases from entry a country. Facilities to provide are invariably affected by specific local requirement.

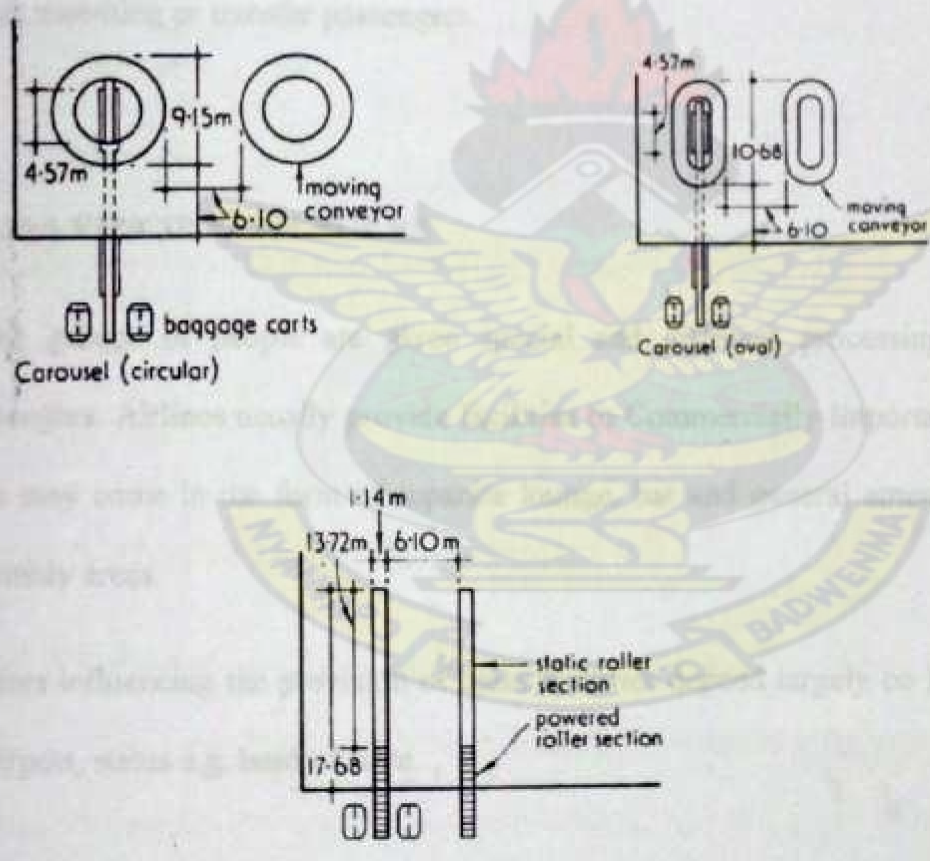
- **Immigration control**

This section controls entry of persons into a country. Passports and other travelling documents are checked and scrutinized to ensure that no unauthorized person enters the country.

- **Baggage reclaim**

From immigration control one is classified to have technically entered a country. The next section is the baggage reclaim where the traveler re-units with his baggage.

There are four main baggage reclaim installations.



linear track

Fig 2.25 Baggage reclaim installations

Source: Tutt, Adler (1998)

- Customs control

The last process arriving passengers go through before getting to the kerbside is customs control. Their work is to ensure no unauthorized good enters.

2.8.25.4 TRANSIT AND TRANSFER PASSENGERS

Transiting and transfer passengers go through a much different process. Bye-pass access at immigration must be provided to link transiting or transfer passengers to departure lounges. Note that transiting and transfer information points must be at arrival halls to direct transiting or transfer passengers.

2.8.25.5 VIP/CIP PASSENGERS

These groups of people are given special and different processing from all other passengers. Airlines usually provide facilities to Commercially Important Persons (CIP). This may come in the form of separate lounge, bar and general amenities in pre-flight assembly areas.

Factors influencing the provision of these facilities depend largely on local custom, size of airport, status e.g. head of state.

CHAPTER THREE

RESEARCH METHODOLOGY AND CASE STUDIES

This chapter details the research methods that were adopted for the purpose of the study. It gives a detail account on the data collection techniques, the techniques used in analyzing and presenting the data collected.

3.1 RESEARCH DESIGN

The research employs the use of both quantitative and qualitative data analysis methods. Quantitative data such as aviation statistics and response from questionnaires administered were analyzed through the use of charts and tables. Qualitative data from the literature and interviews conducted are also analyzed through inference and comparison of data.

3.2 DATA COLLECTION TECHNIQUES

The data collection techniques employed for the study can be categorized into two broad heading. These are Primary Sources- Visual Observations, Photographs, Interviews, Group discussions and structured questionnaires. On the other hand Library search, publications, thesis, plans and layout maps and internet search forms data collected from Secondary sources.

3.2.1 PRIMARY SOURCES OF DATA COLLECTION

- VISUAL OBSERVATIONS

A full understanding of the architecture and design of the study sites were aided through visual observations. Several surveys at the study areas aided the collection this data.

- PHOTOGRAPHY

Documentary proofs of data collected through visual observations were through the use of photographs taken during the site surveys. Photographs were used to give a better understanding of architectural elements that were documented during the various surveys of the sites under study.

- INTERVIEWS AND GROUP DISCUSSIONS

A better understanding of aviation systems and processes in Ghana were gathered through interview with selected heads of department and the management of Ghana Airport Company. The need or otherwise for a new international airport in Ghana were discussed with the management of Ghana Airport Company and Aerodrome Planning and Safety Department of The Ghana Civil Aviation Authority.

- STRUCTURED QUESTIONNAIRES

In order to give direction and quantify findings from discussions and interview a structured questionnaire was prepared and administered to various heads of departments. The perception of travelers and visitors to Kotoka International Airport was also measured through the use of questionnaires administered on site.

3.2.2 SECONDARY SOURCES OF DATA COLLECTION

- LIBRARY SEARCH

Most of the information for the literature review was got through readings made at the Ghana Airport Company Library and KNUST Library. Others were also from friend's library and my personal library.

- INTERNATIONAL ORGANISATION PUBLICATIONS

Publications made by International Organisations such as International Civil Aviation Organisation (ICAO), International Air Transport Authority(IATA) were a good source of literature for the study.

- REVIEW OF STUDENTS THESIS AND OTHER ACCADEMIC PAPERS

To help write a complete Literature Review student's research or thesis and other academic papers written in the past both published and unpublished were reviewed.

- INTERNET SEARCH

The internet was also a very good source of gathering information relevant to the subject matter. The search engines – GOOGLE and SEARCH among other specific sites were all relevant.

3.3 SAMPLING TECHN IQUES

The study employed the use of Random, Targeted and Cluster sampling techniques to get relevant data for the study.

- TARGETED AND CLUSTER SAMPLING

The first sampling method used was to divide the population into two major clusters. These were Workers (or Departments of Ghana Civil Aviation an Airport Company) and the general public (users of our airport). Interviews, group discussions and questionnaires were prepared and served to each cluster.

- RANDOM SAMPLING

This sampling technique was used through the administration of questionnaires and interviews conducted with travelers. This was done to sample views of the general public that use our entry point. This method was used because it helped to get the general idea of all users of Ghana's entry point. This was employed because it was impossible to interview the whole population in this cluster.

3.4 DATA ANALYSIS TECHNIQUES

Data gathered for the study from both primary and secondary sources were studied and carefully analyzed. Data collected from Kotoka International Airport through site survey was discussed and analyzed with standards by international bodies such as ICAO as presented in the Literature review. Selected site for the new international airport in Ghana was also analyzed by standards of these bodies. Quantitative data collected for the study such as passenger traffic at KIA were analyzed through the use of tables and charts.

3.5 CASE STUDIES

3.5.1 KOTOKA INTERNATIONAL AIRPORT, ACCRA, GHANA

Fig. 3.1, 3.2 Source: Site Survey (2009)

3.5.1.1 AIRPORT CODE

KIA

3.5.1.2 LOCATION

Kotoka International airport (KIA) is located in Accra the Capital city of Ghana and it's about 9km from the city centre. KIA is located on longitude 05° 35' 47" N and latitude 000° 10' 12" W with an elevation of 63 m above sea level.

3.5.1.3 AIRPORT USES

Kotoka is primarily used for Commercial airline on both scheduled and charter service. The airport also serves a military base.

3.5.1.4 AIRPORT CLASSIFICATION

KIA has a runway of length and width 3167m X 60m respectively. Other factors such as taxiways, commercial aircraft parking apron, aircraft size and other criteria are considered in determining airport classification. KIA is classified as ICAO Code 4E airport.

3.5.1.5 RUNWAY AND TAXIWAYS

The runway has an orientation of 21/03 and is 3167m in length and 60m in width, with paved shoulders 7.5m wide on both sides of the runway. The runway is constructed of flexible pavement. The runway has a parallel taxiway 2700m long by 23m wide. There are 4 connectors; two 45-degree rapid runway exits located respectively at 900m and 1600m from runway threshold 03 leading straight from the runway to aprons.

3.5.1.6 APRON

The passenger terminal apron area covers an area of $112500m^2$ with a capacity to accommodate 11 aircraft of type B-747, DC -10, A-310, B-727, B737, F28 and F27.Recently it was extended by $6300m^2$ with a capacity of 3 additional wide-body aircraft or 4 narrow-body aircraft. A parallel taxiway connects the passenger apron to the cargo apron, which has an area $6285m^2$ (78 X 87.5m) and is able to handle up to 3 wide body cargo aircraft.

3.5.1.7 VISUAL AIDS

The visual aids include a complete Cat II airfield lighting system consisting of the following:

- High intensity bi-directional runway end and threshold inset lights.
- High intensity bi-directional centerline inset lights
- High intensity unidirectional touchdown inset lights at runway 21
- High intensity unidirectional runway threshold inset lights
- High intensity bi-directional elevated runway edge lights
- CAT II high intensity unidirectional elevated approach lights on approach 21
- Simple configuration low intensity Omni directional elevated approach light on approach 03
- Omni directional portable-type elevated taxiway edge lights
- Omni directional elevated aircraft turnaround edge lights
- Precision approach path indicator path indicator (PAP I) on both sides of the runways

3.5.1.8 TERMINAL BUILDING FACILITIES

Check-in areas

Fig. 3.3 Source: Site Survey (2009)

The floor area is approximately 281m2. This area is able to accommodate 34 check-in desks. It has male and female toilets and offices for GCAA and airline staff. The check-in area is accessible either via a ramp or lift. The check-in area has offices for customs, surveillance and security personnel.

Departures lounge

The departures lounge is located above the check-in area on level +1. From the check-in area, passengers assess the departures area through a lift, a staircase or as escalator. There are 2 entrances into the passport control area, which has 4 double-bank booths. On this level there are offices for airline personnel, passenger services and supervisors. The total floor area from the departures lounge excluding toilets and offices is 220m2.

Arrival/baggage claim hall

Fig. 3.4 Source: Site Survey (2009)

There is an arrivals hall and immigration area. The customs area has a large 'red channel' of about 80m^2 and an accountant and manager's office. There is a customer services, crew examination, stores, and detention and offices for customs officers.

Airport square

Located at level-1 where meters and greeters assemble to receive the arriving passengers or bid farewell to departing passengers. This area has toilet facilities and fast food outlets. It consists of a canopy structure with a concrete roof, open on the sides. Meters and greeters hall: the hall is also located at level-1 and is an air-conditioned space. This meters area will have offices for hotel booking, car rentals, foreign exchange bureau and other services oriented around the needs of arriving passengers. It is partitioned from the greeters' area, which is planed for a cafeteria and shops. Both areas have access to the arrivals hall at the ground floor at level 0 of the terminal building via an inclined ramp and lifts.

3.5.1.9 AIR TRAFFIC CONTROL (ATC) TOWER

Fig. 3.5

The air traffic control tower is a single continuous structure equipped with an elevator that reaches the lower floor of the control tower cab. It is located in the technical building next to the passenger terminal and is operated and maintained by the GCAA. The ATC cab floor is 52.5m above ground level, with good visibility to both runway thresholds. The distance from threshold 21 is 920 and 825m from threshold.

3.5.1.10 AIRPORT RESCUE AND FIRE FIGHTING (AFFR)

This facility is classified as category 8 according to ICAO standards and occupies the southwest corner of the airport complex, behind the GCAA offices. It is made up of 2 separate single level buildings. The main building is a high-roof structure with 4 parking bays. The following equipment is in use:

- 2 full capacity fire trucks, each loaded with 15001 of foam and 110001 of water
- 1 full capacity fire truck loaded with 11001. Foam and 95001 of water
- 1 mobile generator for emergency lighting

- 1 ambulance
- 1 utility vehicle

3.5.1.11 HANGARS AND WORKSHOPS

There are 3 hangars of which hangar No.1 and No.2 cover an area of about 173m2 each. The hangars are approximately 20m high and have 2-story offices at the sides. One is used by Ghana airways and the other is shared between Ghana airways and, Ashanti Goldfields and GNPC. Hangar No. 3 measures approximately 48 X 36 X 20m for the main hangar area and 48 X 8m for the office space on the airside and landside, respectively. The hangar is made of structural steel and trusses.

3.5.1.12 FUEL FARMS

The fuel farm is located approximately 110m to the north of the passenger terminal building. There are 2 interconnected fuel storage tanks available having capacities of 724500l. The storage facility has its own fire safety system for water distribution in case of fire for all the fuel tanks, in accordance with international safety standards for this type of airport.

3.5.1.13 METEOLOGICAL DEPARTMENT

The meteorological station is located on the technical building. The meteorological farm is located next to the glide path antenna and a fence encloses all the meteorological equipment.

3.5.1.14 UTILITIES

Electricity power supply

The electricity company of Ghana is the electrical service provider for the airport. A new electrical power station has been constructed at the airport with 4 new generators, each with a capacity of 800KVA and 2 transformers with a capacity of 1000KVA each.

The airport receives a three-phase of 11KV form 2 separate source, which is stepped down by 2 separate transformers to 415V before distribution. Other source is the Achimota substation and the other source is from station L at Burma Camp.

The airport has 2 generators in use with a capacity of 800KVA and a third generator with a capacity 800KVA which not in use. The domestic terminal has a standby generator with a capacity of 150KVA.

Potable water supply

The service provider of portable water to the airport is the Ghana water company Limited (GWCL). There is a large concrete elevated tank near the fuel farm, which supplies water to the entire airport.

Sewage system

A new sewage treatment plant has been built at the airport. This facility is designed to treat all sewage discharged from the airport premises.

3.5.1.15 GROUND ACCESS

The main access road to the airport is a four-lane dual carriageway with a median strip and asphalted concrete surfacing. This main road meets another road from the cargo village area at the airport roundabout. The main access road continues to the GCAA tower building area, the GCAA Annex, the landside faced of the terminal building, the airline office area, the car parks and the fuel farm and also inside the perimeter fence through a gate.

3.5.2 SUVERNABHUMI AIRPORT, BANKOK, THAILAND

3.5.2.1 INTRODUCTION

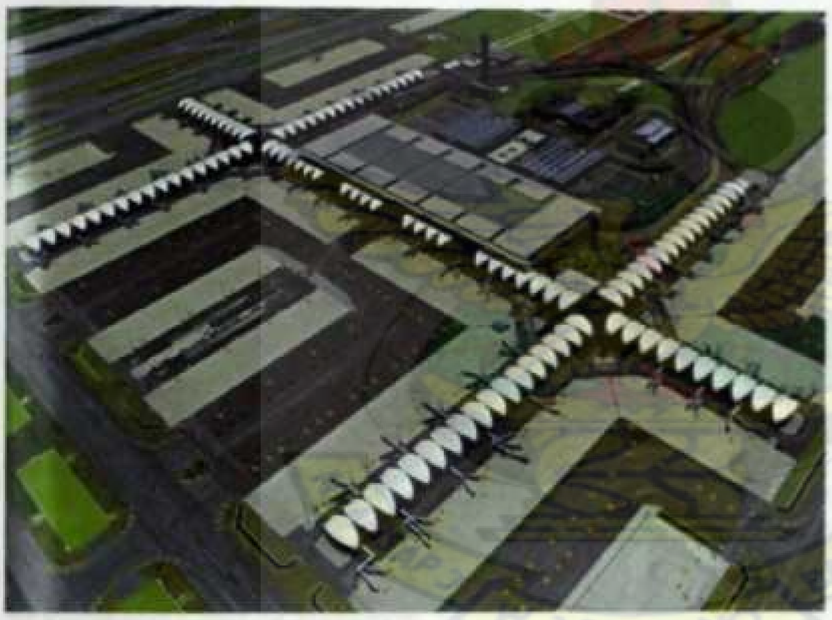


Fig. 3.6 Aerial view of Suvernabhumi Airport Source: Jahn(2007)

The airport represents the goal to construct buildings where nothing must be added and nothing can be taken away. The airport identity became associated with Bangkok and Thailand and considered one of its new icons

3.5.2.3 Climatic Data

No significant clouds

Temperature: 23°C

Wind: Southeast, 5.6 km/h

Pressure 1008hPa

RH: 83%

Visibility: 9 km

3.5.2.4 Airport Code

Suvarnabhumi Airport inherited its IATA airport code **BKK** from Bangkok Don Muang International Airport.

3.5.2.5 Location

The airport is located in Racha Thewa in the Bang Phli district of Samut Prakan province, 30 kilometers east of Bangkok.

3.5.2.6 Hours of operation

24 hours

3.5.2.7 Facilities

- 130 passport control checkpoints for arrivals, 72 for departures.
- 26 customs control checkpoints for arrivals, 8 for departures.
- 22 baggage conveyor belts.
- 360 check-in counters. There are 100 additional counters for passengers without luggage.
- 107 moving walkways.
- 102 elevators.
- 83 escalators.

3.5.2.8 Capacity

- The airport has 2 parallel runways (60 m. wide, 4,000 m. and 3700 m. long)
- 2 parallel taxiways to accommodate simultaneous departures and arrivals.
- It has a total of 120 parking bays (51 with contact gates and 69 remote gates)
- 5 of the gates are capable of accommodating the Airbus A380 aircraft.
- With a capacity of handling 76 flight operations per hour, both international and domestic flights will share the airport terminal but will be assigned to different parts of the concourse.
- In the initial phase of construction, it will be capable of handling 45 million passengers and
- 3 million tonnes of cargo per year.
- Between the airport hotel and the terminal building are the two 5-storey car park buildings with a combined capacity of 5,000 cars.

.5.2.9 Airport Hotel

The airport has a 600-room hotel operated by Accor Group under the Novotel Suvarnabhumi

3.5.2.10 Long-term plans

- Long-term plans for four runways flanking two main terminals
- Two satellite buildings with a combined capacity capable of handling up to 100 million passengers and 6.4 million tonnes of cargo a year
- The second phase of airport expansion involving the construction of a satellite building south of the main terminal is expected to begin 3 to 5 years after the completion of the first main terminal.

3.5.2.11 Focus of design

- Create a new gateway to Thailand
- Tropical climate
- Strive for transparency and elevate systems and material in their construction to a level of art hence making the airport an icon.

3.5.2.12 Project duration

11 years from planning to construction of first phase

3.5.2.13 Architecture

- Openness, comprehension and experience of the open spaces
- Roof gesture as a memorable image
- Blurring of boundaries between public and private spaces
- The design integrates technology and design. That is break down the barriers between architecture and engineering - Archi-Neering
- Advanced long span
- Lightweight steel structures
- Exposed pre-cast concrete structures
- Clear or low e-coated glass
- A three layer translucent glass mediates with exterior and interior conditions, dealing with heat and noise transmission but allows natural daylight into building.
- Integrated cooling, using water as low-energy carrier and thermal mass concrete and a displacement ventilation system with minimal air changes
- Components maximize daylight and comfort, yet minimize the use of energy with significant life cycle cost savings
- Installed cooling power is reduced close to 50% compared to a conventional system.
- The façade modulates the climate of a building and deals with daylight, natural ventilation, solar energy and their interaction with the buildings technical systems

3.5.2.14 FACADE

Light weight engineering and consequent architectural approach

1100m long in plan, 30m high

Supported by under slung vertical steel pipes acting as posts, each 25m high

Post are connected by pre-stressed cable trusses

Glass panes – 2.25 X 2.25m (skin of the terminal)

3.5.2.15 STRUCTURE

Goal – natural light, openness, easy orientation

Concept – structural logic, reduction of deadweight, perfection to least detail

Roof – 570m X 210m supported by 16 columns only

Main girders connect two columns each bringing a clear span of 126m cantilevering at each end by 42m

The main girder spacing is 81m

3.5.2.16 TRUSS CONFIGURATION

- Secondary and main girders are steel trusses being as light as possible
- The 3 chords of the main girder have been arranged with 2 chords where compression forces have to be transferred but a single chord where the tension forces are to be taken
- The Top chord of the truss is composed of 2 chords at mid span

3.5.2.17 CLIMATIC CONCEPT

Focus – highest possible comfort for occupants with lowest possible impact on environment. The idea was to achieve a 24 air temperature with 50-60 Relative Humidity.

- **Challenge**

Heat load from anticipated users, electrical equipments and lighting

- **Floor Cooling and Displacement Ventilation**

Building partitioned into zones of unconditioned spaces and cooled occupied zones

Cooling system – Radiant Floor Cooling directly removes radiation striking the floor. The floor stays cool, increasing thermal comfort

Air displacement system controllable air stream supplying cool air to the space T floor level and at low velocity

- **Thermal Air Stratification**

Thermal stratification is induced in the building through the radiant floor cooling. This occurs as a result of warm air within the space being forced up by cold air which is heavier

The zone which is air conditioned extends only 2.5m above floor level

Due to thermal stratification inhabited spaces achieves the required thermal comfort.

3.5.2.18 Culture

- Shaded gardens flaking the terminal represent Thai landscapes as seen in the regions cities and its rural areas
- Jungle garden between the terminal and concourse reflects the texture and nuance unique to Thailand
- Traditional artistic patterns colors on glazed surfaces and floors
- Their artifact at the airside centers and concourses shows a connection to the local cultural traditions.

References

- Jahn Helmut, Sobek Werner and Schular Matthias (2007), Suvarnabhumi Airport, Bankok, Thailand
- Patrick Osei Owusu(2006), Design Thesis Report on Kwame Nkrumah Airport, Takoradi (Unpublished)

CHAPTER FOUR

SITE SELECTION, ANALYSIS AND INVENTORY

4.0 INTRODUCTION

The focus of the project is to open up the northern sector of the country for developments and to the rest of the world. For this reason several sites within the northern part of the country were considered.

4.1 FACTORS CONSIDERED FOR SITE SELECTION

Though the above reason is one of the main reason for the project being situated within the northern part of the country, other reasons considered before the final selection was made includes:

- **TOPOGRAPHY**

Sites for airport location should ideally be relatively flat with a gentle slope not exceeding 1:2.5. The Slope character affects the location of the runway. This is because a runway located along a slope will definitely affect the acceleration and deceleration of the aircraft. On the other hand a runway oriented across the slope will also affect the stability of the aircraft when landing or taking off.

Sites for airport should ideally not be located between hills. This is as a result of the presence of rotor waves at the leeward side of mountains which causes hazardous turbulence to aircraft flying through them.

> **OBSTRUCTIONS**

Natural and artificial obstructions on airport sites must be avoided as much as possible. Natural obstructions may be in the form of mountains or vegetation whiles artificial or man-made obstacles may be in the form of multi-storey high rises, bridges and etc. all these influence the location and effective and safe use of the runway by aircraft.

> **LOCAL CLIMATIC AND ATMOSPHERIC CONDITIONS**

Local climatic or weather and atmospheric conditions impact the selection of a suitable site for an airport. The weather pattern of an area especially the prevailing wind direction is a major factor in determining runway heading. ICAO recommends a 95% usability factor of runways. This implies the wind direction should be able to support 95% of aircraft taking off and landing on the runway within a given year. Wind speed within airport areas should not be too low to cause fog and must not also be high to cause aircraft disasters. Sites with occasional strong winds reaching up to about 20knots must be avoided.

Atmospheric conditions such as fog, haze and smoke (from industrial areas) reduces visibility. This may go a long way to reduce the traffic capacity of the airport in question. Choosing a site with these conditions must be carefully considered if not completely avoided.

- **SURROUNDING LANDUSE**

Airports affect the quality of the environment and the surrounding communities in regard to airport expansion, use and development. One of the most severe problems is that of aircraft noise and its impact on surrounding communities. ICAO therefore recommends that airports should considerably be located outside the city or heavily populated areas. Sites for airports located in the heart of the city due to hazards to residence must hence be avoided.

- **ACCESSIBILITY**

Before a site for an airport is selected careful consideration must be given to passenger's origin and means of reaching the airport environment. The site must be accessible through ground transportation. Inaccessible sites through ground transportation should be avoided as much as possible. Ground Accessibility options such as road or rail may be considered.

- **FUTURE DEVELOPMENT CAPABILITY**

Air transport is a very dynamic and faster growing industry. Site chosen for an airport should be able to support a master plan development of up to at least 20 years. The site must have available land for expansion with little or no impact to airport operations, surrounding community and the environment.

- **OTHER AIRPORTS IN CLOSE PROXIMITY**

Airports located in close proximity to each other may cause interference to each other through its air traffic operations. ICAO therefore recommends a minimum of 3km between airports.

4.2 SITES CONSIDERED

Among the numerous sites scouted as possible locations – Sunyani, Kintampo and Tamale were considered and studied much closely.

4.2.1 SUNYANI

Sunyani was considered because of its strategic location in linking up the southern part to the northern part of the country.

The main site considered at Sunyani is the current Sunyani domestic airport. This site was not suitable because of some steep valleys that are located at the ends of the current runway. This implies extension of the runway is not economically reasonable in that it will involve very costly engineering works. Considering Sunyani for an airport of international standard will therefore mean a new virgin site which is also economically unwise.

4.2.2 KINTAMPO

Kintampo was considered because of its endowment in numerous eco-tourism sites. An international airport will therefore help to a larger extent to boost tourism within and around the area.

There are no sites that have been selected by GCAA and GCA as suitable for an aerodrome. This therefore implies the selection of a virgin site with no infrastructure such as roads, electricity and water. Kintampo have an undulating landscape with numerous rock outcrops. The topography and geology of Kintampo therefore make the area unsuitable to support an airport.

4.2.3 TAMALE

Tamale was also considered because of its vast available land resource and its position as the country's third largest populous city. Tamale was chosen because of its good aviation future prospects due to its location.

REASONS WHY NKRUMAH DECIDED TO MAKE TAMALE AN INTERNATINAL AIRPORT

Strategic point to link the sub-Saharan routes in his bid to unit the continent and therefore contracted the soviet expects to tilt it towards a cosmodrome as possible. Started 1965 halted at 1966 coup.

Resumes 1970, but reduced in scale.

4.3 SITES SELECTION AND JUSTIFICATION – TAMALE

- **TAMALE TOWN SITE (OPTION 1)**

This site satisfies the following considerations: topography, easy accessibility to groung transportation, no airport in close proximity, no natural or artificial obstruction. On the other hand the site is located less than a half a kilometer to the city centre. Hazards like noise to surrounding residential and commercial areas are inevitable. Future expansion of airport facilities will only be possible through resettlement of people who live close to the airport vicinity. Possible obstruction and glare from future developments around the airport environment.

- **TAMALE AIRPORT SITE (OPTION 2)**

The site under consideration satisfies topographical considerations, accessible by ground transportation, no airport close to it, and adequate land for future development. The site is about 13km NW of the town of Tamale hence less noise impact Tamale community. The site is currently being used as a domestic airport hence has improved set of visual and navigational aids. The site also has an existing runway which can be improved to meet international standards.

On the other hand the site is currently being used as a civil and military airport, access to site is therefore restrictive. The site is poorly planned with no segregation between its dual use as a civil and military airport. The site is also far from the city centre hence devoid of activity. The site also has a very poor ground transportation system to the city centre.

4.4 CONCLUSION

After considering the merits and demerits of both sites, the tamale airport site (option B) was selected. This is because the demerits of option A can never be compensated for without jeopardizing the life of residents in surrounding communities or the future operation and development of the airport. On the other hand option B has some demerits but with careful planning and zoning these demerits could be mitigated with comparatively less cost on lives, communities, future airport operations and investment.

4.5 SITE LOCATION

The site is located at Tamale about 13km northward from the city centre. It is located on latitude 00.5200west and longitude 09.3400north.

Fig. 4.1 Site Layout of Tamale Airport Source: Site Survey (2009)

4.6 AREA

The focus of the project is to transform the area into a world's first class business and tourist destination. The current airport covers an area of approximately 761 acres whiles the military barracks covers an area of approximately 244 acres. The area zoned for the proposed project covers an area of approximately 12500acres.

4.7 SITE ANALYSIS

4.7.1 GEOLOGY

The site is underlain by sandstone, mudstone and shale, which over time, have been weathered to different degrees. The main soil types that have resulted from the above natural phenomenon include sand, clay and laterite ochrosols. The soil has a bearing capacity of more than 4500KN/m2. This offers a solid base to hold foundations of proposed structures.

4.7.2 HYDROLOGY

There is no water body or water course within the vicinity of the airport site. The possible flood area that is the low lying areas are located about 5kilometre north of the current airport site.

4.7.3 CLIMATIC CONDITION

- The mean day temperatures range from 33°C to 39°C while mean night temperature range from 20°C to 22°C.
- The mean annual day sunshine is approximately 7.5 hours.
- The site experiences one rainy season starting from April/May to September/October with a peak season in July/August. The site experiences a mean annual rainfall of 1100mm within 95 days of intense rainfall.
- The dry season is usually from November to March. It is influenced by the dry North-Easterly (Harmattan) winds while the rainy season is influenced by the moist South Westerly winds. These are the two basic wind directions.
- Wind speed range between 2 to 3knots.

4.7.4 TOPOGRAPHY

The site is located approximately 180m above sea level. The site is fairly flat and has a negligible slope of 0.25 towards the north eastern part.

4.7.5 VEGETATION

The vegetation is at the site is basically savanna grass land with interspersed drought resistant trees such as neem, sheanut, dawadawa and mahogany. The height of the trees ranges between 500mm to 3m high. The existing airport terminal vicinity has interspersed mango trees at an average distance of 15 to 25m.

4.7.6 ACCESSIBILITY

Ground accessibility is by road network which reaches the site. There are currently three roads which reach the site. All the two easily accessible roads pass through military barrack gates. These are all branch roads from the mail Tamale to Bolgatanga road. The last road is a bush road that is not easily accessible and reaches the site at the north western part of the site.

4.7.7 SURROUNDING LANDUSE

The site is about 13km from Tamale city centre. The site has a military barrack at the southern part of the site. Aside the barracks the closest settlement is located within a radius of 10km.

4.8 SERVICES AND EXISTING FACILITIES

4.8.1 ELECTRICITY

Electricity reaches the site through overhead cables along the street. The cables are carried on timber poles places at a minimum interval of 20m. Power supply to the existing facility is supplemented by automatic change over generators. Larger and smaller ups regulates the power fluctuation to vital facilities e.g. the radar and other surveillance facilities.

4.8.2 WATER

Water reaches the site through a 6inch underground water pipe main from Tamale water supply system.

4.8.3 WASTE MANAGEMENT – SEWAGE

The site has its own sewage system. It has a septic tank located at the eastern part of the site. There is no sewage treatment plant in place at the site.

4.8.4 SURVEILLANCE EQUIPMENTS – RADAR, DME AND VOR

There is a radar station located at the North West part of the site. The radar used at the site is secondary radar. (*Secondary radar is a radar system used in air traffic control (ATC), which not only detects and measures the position of aircraft but also requests additional information from the aircraft itself such as its identity and altitude.*)

There is also a DME and a VOR located at about 500m off runway heading at 05.

4.8.5 FIRE HYDRANTS

The site currently has about 10 fire hydrant locations.

4.8.6 EXISTING RUNWAY FACTS

- ELEVATION 552ft (168m)
- RUNWAY DIRECTION 05/23

- LENGTH 2438m (8000ft)
- WIDE 150ft (45m)
- RUNWAY SLOPE Varies (up from both ends to middle at about 0.25% slope)
- SURFACE Asphalt .5 to 1.5 inch thick
- DRAINAGE Adequate
- SMOOTHNESS Satisfactory
- STOPWAYS 600ft (183m) sealed surface at both ends.
- CLEARWAYS Available at end 05 but limited on End 23
- AIRFIELD WIDTH Over 500ft
- OBSTRUCTION

None at end 05, but a hill about 4000ft (1200m) from end 23 at 1.2% slope up from threshold may be an obstacle.

- LIGHTING

None working, but all fixtures in place for edge end, Taxiway Apron lights and 2 bar vasis

- MARKINGS installed but barely visible
- PARKING RAMP

Adequate in size for 4 737 aircraft

4.9 SITE INVENTORY

Fig.4.2 Terminal Building

Fig.4.3Control tower

Fig.4.3 Fuel farms

Fig.4.4Secondary Radar Station

Source: Site Survey (2008)

Fig.4.5 Military hangar

Fig.4.6 Air force base

Fig.4.7 VIP/Presidential lounge

Fig.5.8 Air force hostel

Source: Site Survey (2008)

4.10 SERVICES AND EXISTING FACILITIES

4.10.1 SURVEILLANCE EQUIPMENTS – RADAR, DME AND VOR

There is a radar station located at the North West part of the site. The radar used at the site is secondary radar. (Secondary radar is a radar system used in air traffic control (ATC), which not only detects and measures the position of aircraft but also request additional information from the aircraft itself such as its identity and altitude). There is also a Distance measuring Equipment (DME) and VOR located at about 500m off runway heading 05.

4.10.2 CRASH RESCUE AND FIRE SERVICE

The following are available facilities currently in use at the existing airport site.

- Foam tender (eagle foam tender) – 405l

Scamel foam tender – 1500l

- Water tender (eagle water tender) – 3825l

Scamel foam tender – 11000l

- One ambulance with four stretchers
- One rapid intervention vehicle

CHAPTER FIVE

DESIGN CONCLUSIONS AND RECOMMENDATIONS

5.1 BRIEF DEVELOPMENT

After a careful consideration of the clients brief and intentions, case studies, site analysis and technical studies a brief was developed. The brief took into careful consideration Standards and Recommended Practices of ICAO Annexes, ICAN and FAA recommendations.

5.1.2 BRIEF

Car parking for 1680cars - 25 200m^2

Departure

Departure Hall

Check-in concourse (Airline check-in desks and Group check-in desk) - 1440m^2

Airline ticketing and information office – 160m^2

Airport information desk – 16m^2

Baggage storage rooms – 100m ^{2}

Customs and immigration control – 240m^2

Security check point

Detention rooms

Interview rooms

Departure lounge – 840m ^{2}

Main lounge

VIP lounge

Commercially Important Persons Lounge

Transfer desks – $3m^2$

Duty free shopping – $264m^2$

Restaurants – $200m^2$

Bank/Universal currency exchange – $24m^2$

Historic exhibition spaces – $150m^2$

Virtual museum – $100m^2$

Holding Rooms – $400m^2$

Boarding gates

Internet access booths (20) – $30m^2$

Telephone booths (20) – $30m^2$

Arrival hall

Transfer passenger's desk – $3m^2$

Passport control and immigration – $720m^2$

Detention rooms

Interview rooms

Dark rooms

Security offices

Staff common room and sanitary

Health Control– $96m^2$

Waiting and hold rooms

Health desk and examination room

Doctors room

Baggage reclaim – 360m^2

Unclaimed baggage store

Bonded store

Staff common room and sanitary

International currency exchange – 24m^2

Hotel reservation – 6m^2

Airport information desk – 6m^2

Car rental – 6m^2

Restaurants - 300m^2

Customs – 600m^2

Airline facilities

Telex, tax reclaim

Processing and ticketing offices

Engineer's common room

Airline departure briefing rooms

Security

Records and Documentation Offices

Terminal Service facilities

Electrical switch rooms

Telecommunication rooms

CC-TV and security room

Centralized air-conditioning room

Water storage and pump room

Automatic change-over generator plant room

Terminal Public Areas

Restaurants

Shopping areas

Visual and virtual museum

Public viewing areas

Bank and international currency exchange

Internet and telephone booths

Sanitary areas

Airside and landside worker's facilities

Conveyor belt attendant's common room

Driver's common room

Crew briefing room

Changing rooms

Airfield Marshallers common room

Cleaner's common room

Workers Canteen

Ground Engineers office

Apron Operations Supervisor

Baggage Handlers room

Restaurants and Canteen Facilities

Kitchen (Yard)

Storage areas

Matron's room

Pantry

Sluice room

Server

Cold rooms

Changing room

Worker's common room

Military/Presidential Terminal

Arrival Facilities

Departure Facilities

Parade grounds

Press room

Conference rooms

Resting lounge (living, Bedroom)

Kitchen and Bar Facilities

Cargo Terminal Facility

Reception

Deposit

Radioactive material

Deliveries (exports)

Arrivals (imports hall)

Warehouse (cages)

Special purpose warehouses

Customs

Vetenaries

Cold rooms

Refrigeration plant rooms

Transit goods

Security check gates

Cargo terminal office Facilities

Warehouse Manager

General supervisor

Directors' offices

Secretariat

Airline offices

Civil aviation offices

Ghana airport company offices

File and records room

Locker room

Care and Maintenance Building

Offices (Engineers)

Engine diagnoses and Repair

Workshops

Warehouses

Mechanic Yard

Workers common room facilities

Changing room

Cleaners

Fuel Farms

Reception

Offices

Fuel Storage Tanks

Parking for equipments

Fire Equipment Room

Changing Room

Worker's Common Room

Hangar facilities

Offices

Parking area

Fuel loading bay

Waste treatment and recycling plant

Reception

Offices

Chemical stores

Treatment and Recycling area

Car parking

Resident Airline block

Reception

General Offices

Administration Facilities

Service rooms

Flight Catering Facilities

Power plant Facilities

Office

Workshop and maintenance rooms

Storage

Generator Room

Transformer

Radar Station

Radar pole area

Radar control room

Universal Power Saver Room

Generator Room

Crash Rescue and Fire

First aid rooms

Fire trucks area

Ambulance area

Firemen dormitory

Forman

Repair and Maintenance

Equipment storage

Sanitary facilities

Workers common room facilities

Kitchenette

Ghana Civil Aviation Office block

Reception

General Manager

Human resource manager

Personnel manager

Finance department

Air-traffic service department

Aeronautical Information service

Aeronautical communication centre

Flight safety department

Engineering department

Meteorological service department

Air-Traffic Control tower

Services facilities (air-condition plant room, electrical switch room, CC-TV room)

Ghana Airport Company Office Block

Reception

General Manager

Deputy Managing Director

Human Resource Manager

Personnel Manager

Finance and Accounts Department

Projects and Quantities department

Drawing Office

Corporate Planning department

Economic Regulation and Commercial section

5.2 DESIGN PHILOSOPHY AND CONCEPTS

The idea of the airport is to create an icon that will in itself become a symbol of Ghanain Unity and Solidarity. This will therefore create the airport experience for users to appreciate Ghanaian history and culture.

In summary the design philosophy is *The transit experience.*

- The target is to create loud and strong impressions with form and elements to let the traveler have an unforgettable and comfortable experience.
- Creation of green interior environments that sooths the spirit and suspends anxiety, nervousness and fear associated with air travel.
- Creation of free open spaces with greeneries, museum collections, duty free shopping, restaurants where travelers awaiting boarding can wait.

5.3 AIRPORT MASTER PLANNING

Airport master plan is simply a document that charts the proposed evolution of the airport to meet future needs. A typical airport master plan has a planning horizon of 20years. The federal Aviation Administration notes that for a master plan to be considered valid it must be updated every 20 years.

5.3.1 OBJECTIVES OF THE AIRPORT MASTER PLAN

The airport master plan must provide guidance for future development that will

- Satisfy aviation demands
- Compatible with environment, community development, other modes of transportation and other airports

5.4 CONCEPTUAL MASTER PLANNING

Fig. 5.1 Initial Site Planning and Land-use

Source: Process drawings(2009)

5.5 TERMINAL BUILDING DESIGN CONCEPT

5.5.1 STRUCTURAL EXPRESSIONISM

The architectural concept employed in the design of the terminal building is a post-modernist concept of high-tech architecture or in other words structural expressionism.

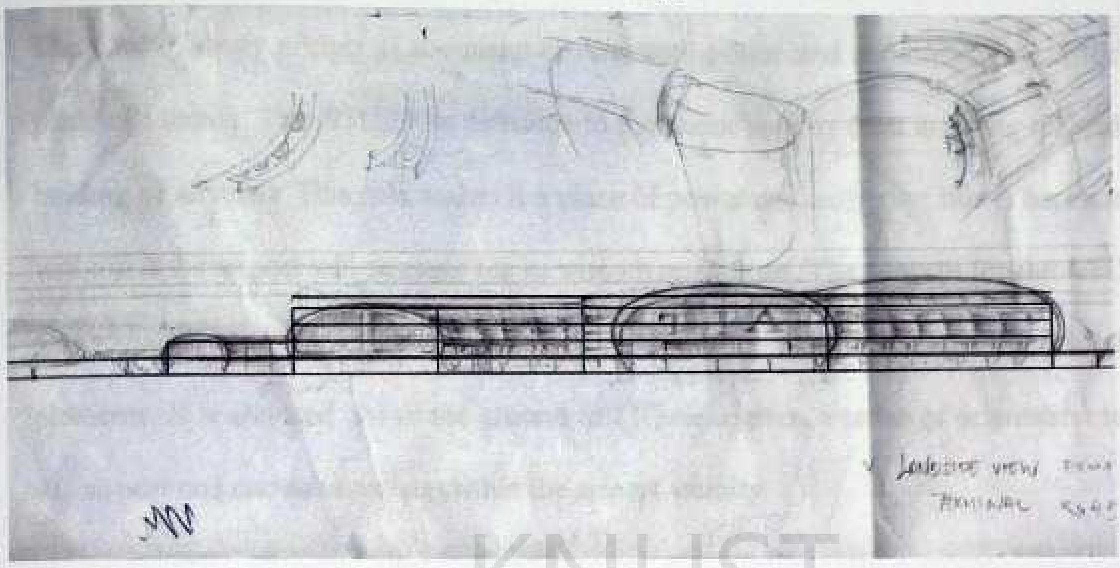
High-tech architecture, also known as Late Modernism or Structural Expressionism, is an architectural style that emerged in the 1970s, incorporating elements of high-tech industry and technology into building design. High-tech architecture appeared as a revamped modernism, an extension of those previous ideas aided by even more advances in technological achievements. This category serves as a bridge between modernism and post-modernism, however there remain gray areas as to where one category ends and the other begins. In the 1980s, high-tech architecture became more difficult to distinguish from post-modern architecture.

Like Brutalism, Structural Expressionist buildings reveal their structure on the outside as well as the inside, but with visual emphasis placed on the internal steel and/or concrete skeletal structure as opposed to exterior concrete walls. Buildings designed in this style usually consist of a clear glass facade, with the building's network of support beams exposed behind it.

5.5.2 WHY THE CONCEPT

It is anticipated that by 2030 Ghana should be able to make a bold statement to Africa and the rest of the world that our aviation industry has reach higher heights and hence the terminal's structural expressiveness.

5.5.3 TERMINAL BUILDING INITIAL IDEAS



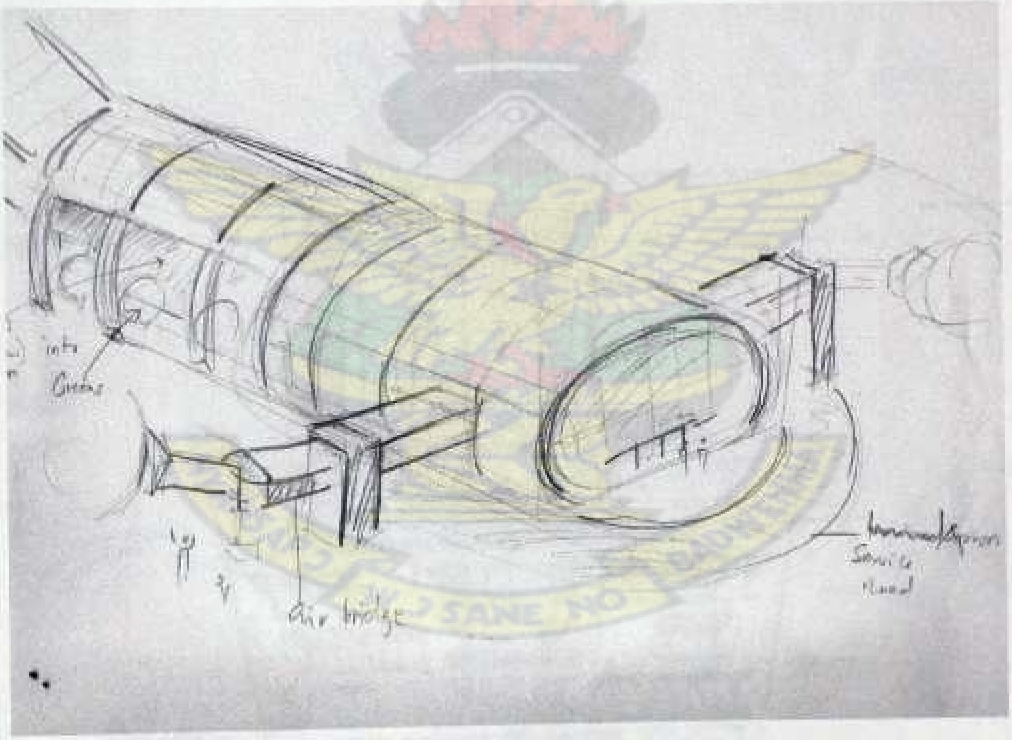


Fig 5.2 Initial Sketches Source: Process drawings (2009)

5.6 AIR TRAFFIC CONTROL TOWER DESIGN

The soul of every society is the place of direction, power and authority. This is the place of identity. The ATC gives direction to the major activity (that is taking off and landing of aircraft). This role makes it a place of power and authority; this is because without it the airport will struggle for its smooth operations. The concept for the ATC was to capture the idea of a place of power and authority with the use of architectural elements. It is elevated above the ground to 11 levels given a sense of orientation to the airport and serves as a vista within the airport vicinity.

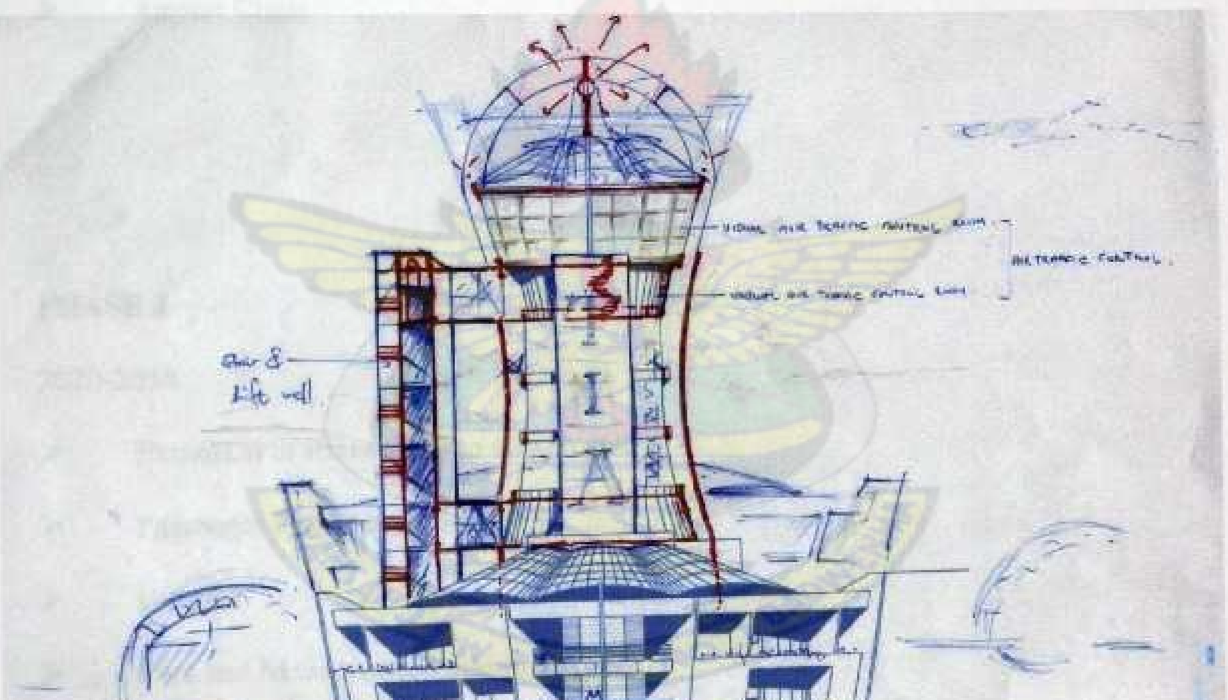


Fig 5.3 Air Traffic Control Tower Process sketches

Source: Process Drawings (2009)

5.7 CONSTRUCTION TECHNOLOGY AND SERVICES

5.7.1 PHASES

PHASE 1

2012 – 2020

- **Supporting Facilities such as aeronautical systems – Radar stations**
- **Air Traffic Control Tower and Offices**
- Airport and Surrounding Roadways
- Transit Hotels and Conferencing Facilities
- Airport Clinic

PHASE 2

2020-2030

- Extension of Runway up to 4000 meter
- Passenger Terminal Building
- Hangars
- Care and Maintenance buildings

Anticipated Cost – $300 million

PHASE 3

2025-2030

- Underground ways and mono rail network
- Aviation Training Schools
- Transport inter-change Center (Train and Bus Terminal)
- Airport Workers Residential Area
- Flight Catering Block and Landing Restaurants
- Fire service and crash rescue block
- Security block

PHASE 4

2030-2032

- Development of First Class Airport Residential Area
- Development of Recreational and Civic Hubs
- Redevelopment of old terminal into a presidential and Military Terminal

The completion of the entire phase is scheduled to be open for the celebration of Ghana's silver Jubilee that is Ghana at 75. The idea of the project is to project Ghana as the new eye of West Africa and Africa as a whole that is the gateway to Africa. This will put Ghana into the position of an aviation hub to West Africa and Africa as a whole.

5.7.2 FINISHES

The functional territories of a terminal tend to be defined by the choice of finishes, the method of lighting and the level of sound insulation. Although there is a trend towards the homogenized interior, design should help the passenger to distinguish the main sequence of spaces and intended use.

FLOORS

High Traffic Areas – Polished granite

Less Traffic Areas – Carpeted

Plant room areas – Isocrete K-Screed

WALLS

INTERNAL WALL - Industrial Finish of material – Paroc Panel

EXTERNAL WALL – Industrial Finish of material – Paroc Panels

All internal walls especially highly traffic areas such as airside corridors must be protected by stainless steel handrail and trolley guard rails

5.7.3 SERVICES

- **WATER STORAGE AND SUPPLY**

Water supply to the site is from Ghana Water Company. The first point of access of water is to the water reservoir located within the service core area of the site through an 8 inch diameter service pipes. From this point water reach the various facilities at their water storage tanks located at the ground floor through a 6 inch diameter pipe.

➤ **ELECTRICITY**

Electric Power reach the site at a sub-station located within the service core area at 11000v. Power from here is stepped down to 240v/415v and then carried through underground cables which reaches the various facilities distribution points through a three-phase wiring system in both loop and parallel order. Columns and ducts act as dry risers which carry cables vertically up whiles ceiling gaps carry them horizontally. The site is planned to have 8 automatic change over generators each with capacity of 1200KVA. Additional to this are solar powered generators located at every gate within the terminal building.

➤ **VENTILLATION**

To ensure the highest possible comfort for the occupants with the lowest possible impact on the environment and limited energy consumption several systems of ventilation was adopted. There is a conscious effort to cut down on the heat load of the building through the buildings envelope in the choice of material. The use of insulated aluminum and steel roofing insulated steel panels (Paroc Panels) and double layered e-coated glazing material helps to cut down on the heat gained through the buildings envelope.

AIR-CONDITIONING SYSTEM

The terminal building is zoned into two main parts and each is served by a different air centralized air conditioning unit. Cooling systems of the various spaces used include radiant floor cooling which directly removes radiations directly hitting the floor . The floor stays cool with increased thermal comfort. Another system adopted is through the admission of conditioned air at a lower level with a lower velocity. The systems employed for conditioned air admission induces thermal stratification which ensures that habitable zones receives the necessary conditioned air for its thermal comfort.

- **WASTE MANAGEMENT**

SEWAGE DISPOSAL

Sewage is taking from facilities through soil pipes into man-holes then to booster pump station points where the effluence is pumped to the treatment Plant area.

REFFUSE COLLECTION

Several bins serve as the primary collection points within facilities. Secondary collection points are also located on level one (ground floor level) at vantage points. From the secondary points refuse is sent to the waste treatment plant area for recycling.

BIBLIOGRAPHY

Airport Operations Association (2001) Environmental Management at Airports: Best Practice Manual. Airport Operations Association, London

Ashford, N (1992) Airport Engineering, Third Edition, Awiley-Interscience Publication Inc.

British Airways plc (2001) From the Ground Up: Social and Environmental Report 2001

Coleman, R. J. (1999). Environmental Sustainable Capacity: Airport Capacity – Challenges for the Future, Salzburg 15-16 April 1999 (ECAC Conference Proceedings document)

Dempsey, P. S. (2000). Airport Planning & Development Handbook. McGraw-Hill

DeNeufville, R and Odoni Amedeo (2003) Airport Systems: Planning Design and Management

Ghana Airports, Kotoka International Airport Travel and Flight Information Guide (2008), winter 2008 edition October 2008-March 2009

ICAO Publication (2005), International Standards and Recommended Practices, Annex 9 for Facilitation, ICAO

ICAO Publication (2001), International Standards and Recommended Practices, Annex 11 for Air Traffic Services, ICAO

ICAO Publication (2004), International Standards and Recommended Practices, Annex 14 for Aerodromes and Airport Master Planning, ICAO

ICAO Publication (2006), International Standards and Recommended Practices, Annex 17 for Security, ICAO

ICAO (2001) Balanced Approached to Aircraft Noise Management (Appendix C of Assembly Resolution A33-7)

ICAO Journal, Volume 62(2007), China's growth strategy, Safety improvements play a vital role.

ICAO Journal, Volume 63,N 3(2008), Airport Evolution, Safety remains the guiding priority as technology forges new tools to help 21st century facilities meet emerging environmental and capacity challenges

Jahn H., W. Sobek and M. Schular (2007), Suvarnabhumi Airport, Bankok, Thailand

Janic, M. (2001) Airport Sustainable Capacity: An Analysis of Concepts and Influencing Factors. Paper presented to the 1st International Conference on Environmental Capacity at Airports. Manchester Metropolitan University, 2nd- 3rd April 2001

Lever, M. & Dimitriu, D. (2001) Increasing Capacity at Airport in the Face of Noise Nuisance Perception. London: British Airways plc

Osei Owusu Patrick (2006), Design Thesis Report on Kwame Nkrumah Airport, Takoradi (Unpublished)

Ott, J. 'Tight security compels airport design shakeup'. Aviation week & space technology, v.156, no.7 (Feb. 18, 2002)

Tyson, Jeff. 'How Airport Security Works'. December 2008. http://www.howstuffworks.com/airport-security.htm

UNEP/T&E (2002) Final Boarding Call: Air Transport, Airports and Sustainable Development. Proceeds and reports of a conference held on 1st – 2nd July 2002, Paris

Wells, A (1996) Airport Planning and Management, Third Edition, McGraw-Hill International Enterprises Inc.

KNUST

APPENDICES

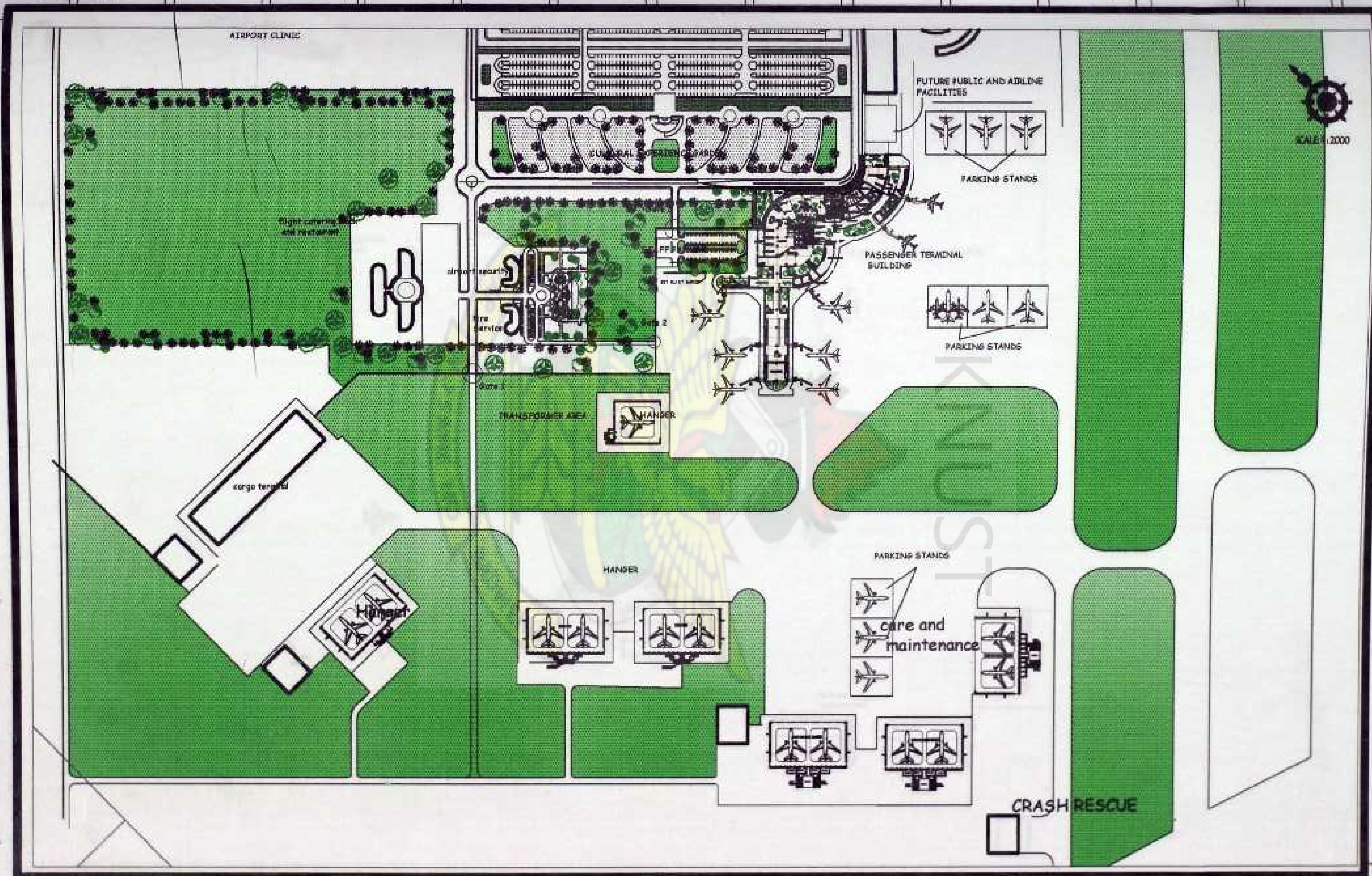
MASTER PLAN

TAMALE INTERNATIONAL AIRPORT

dept. of arch KNUST

james eduful
m.arch
design thesis
may 2009

SITE LAYOUT



TAMALE INTERNATIONAL AIRPORT

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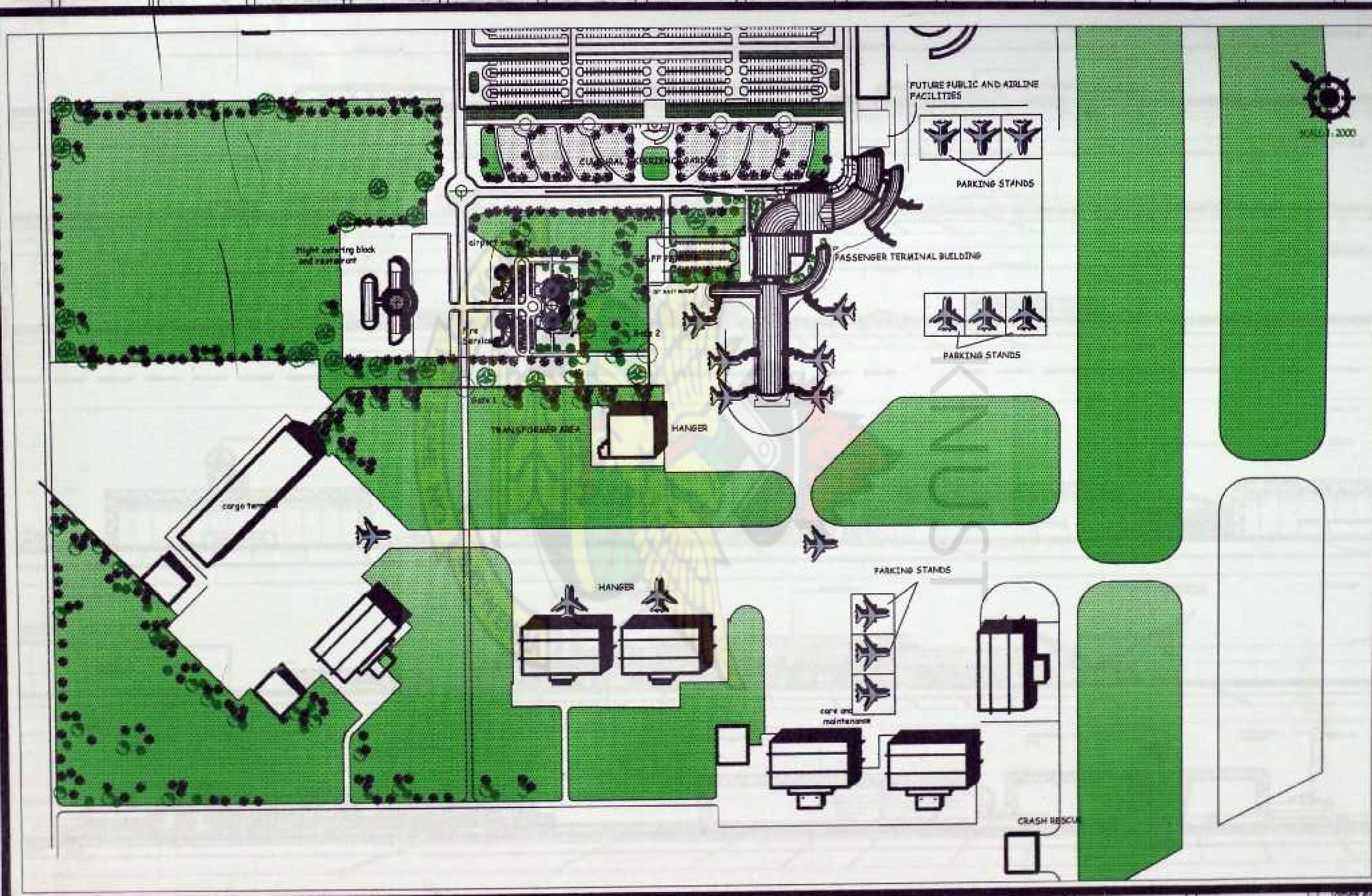
BLOCK PLAN



TAMALE INTERNATIONAL AIRPORT

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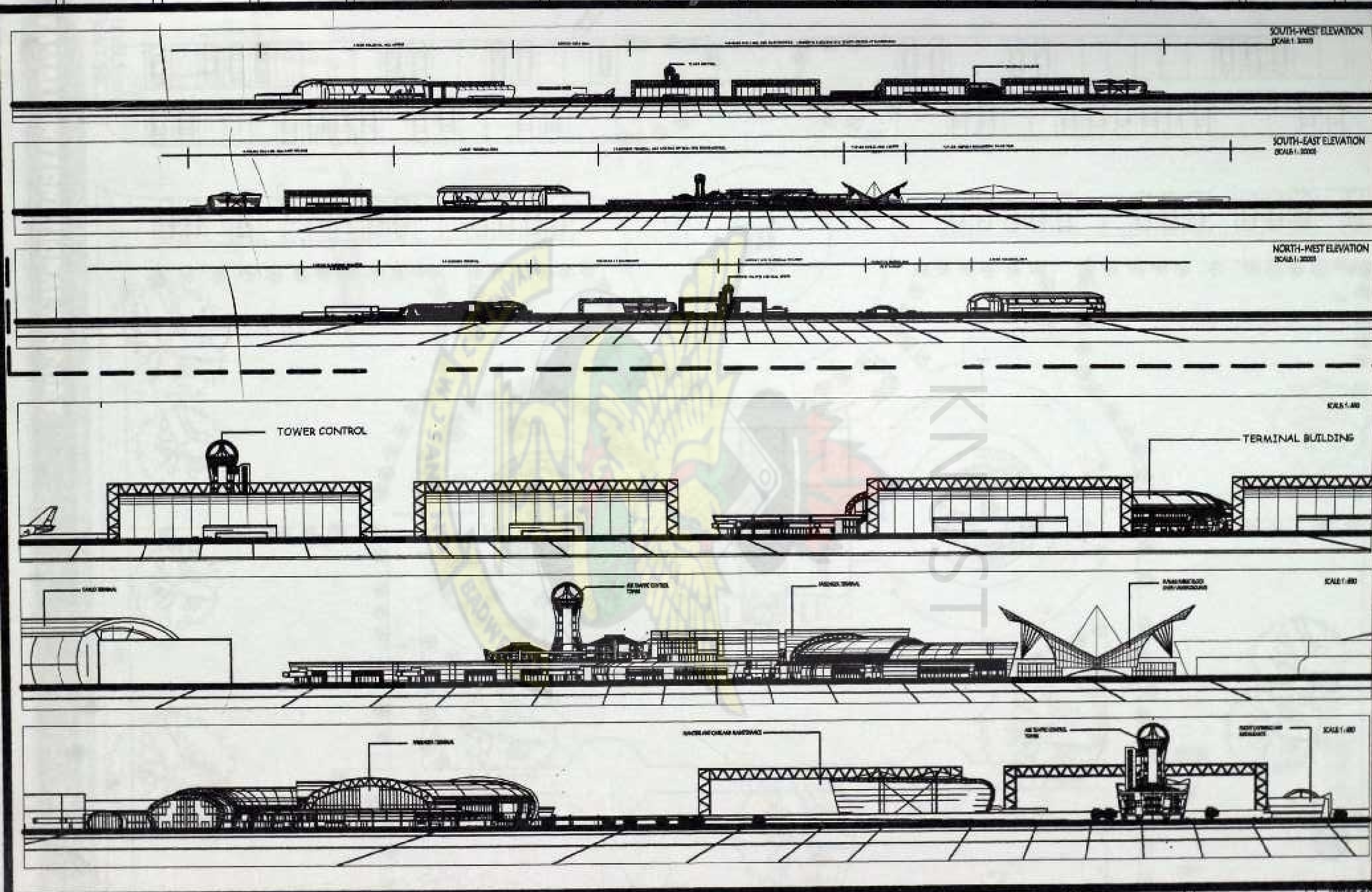
SITE ELEVATIONS



TAMALE INTERNATIONAL AIRPORT

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design thesis
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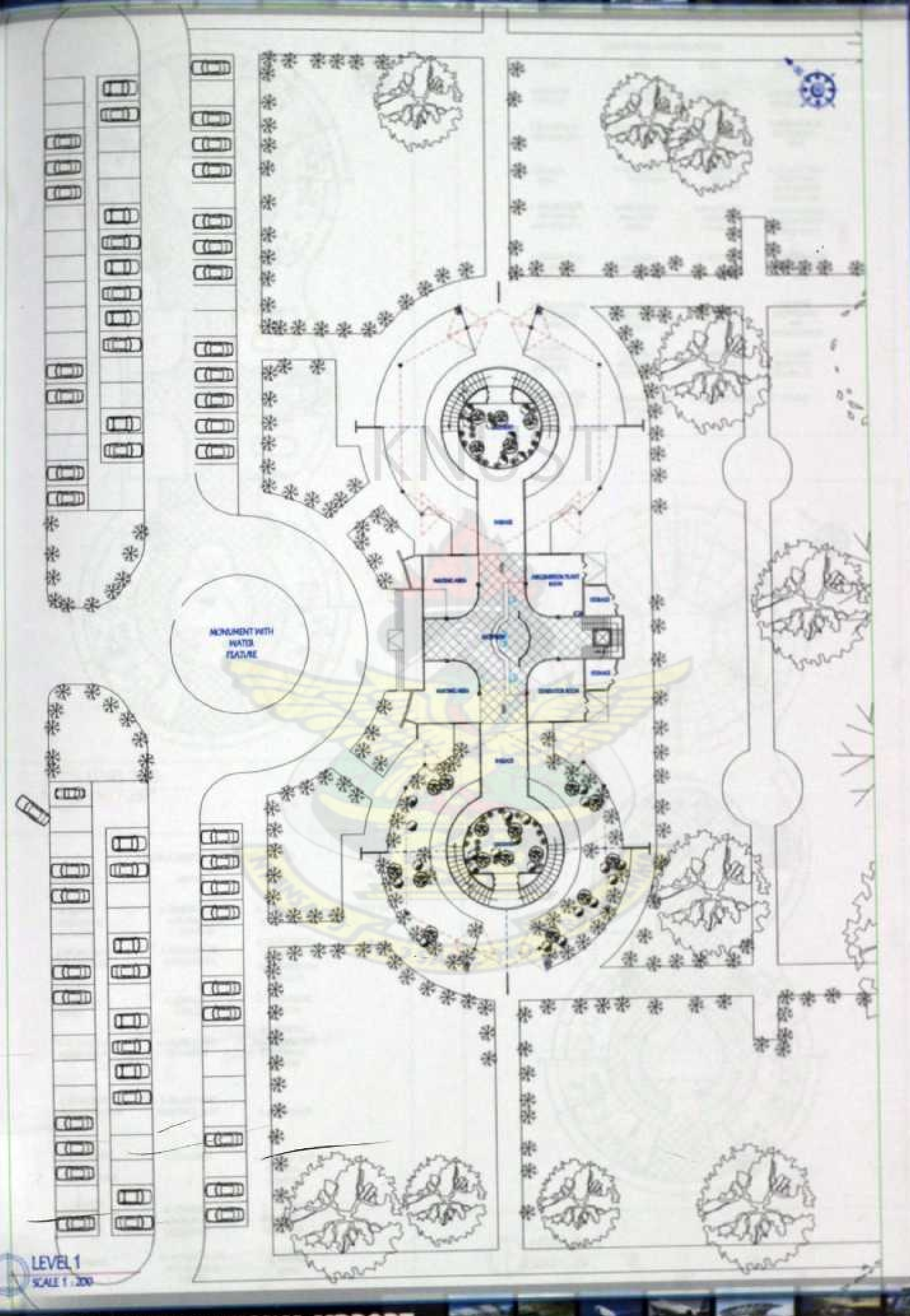
MONUMENT WITH WATER FEATURE
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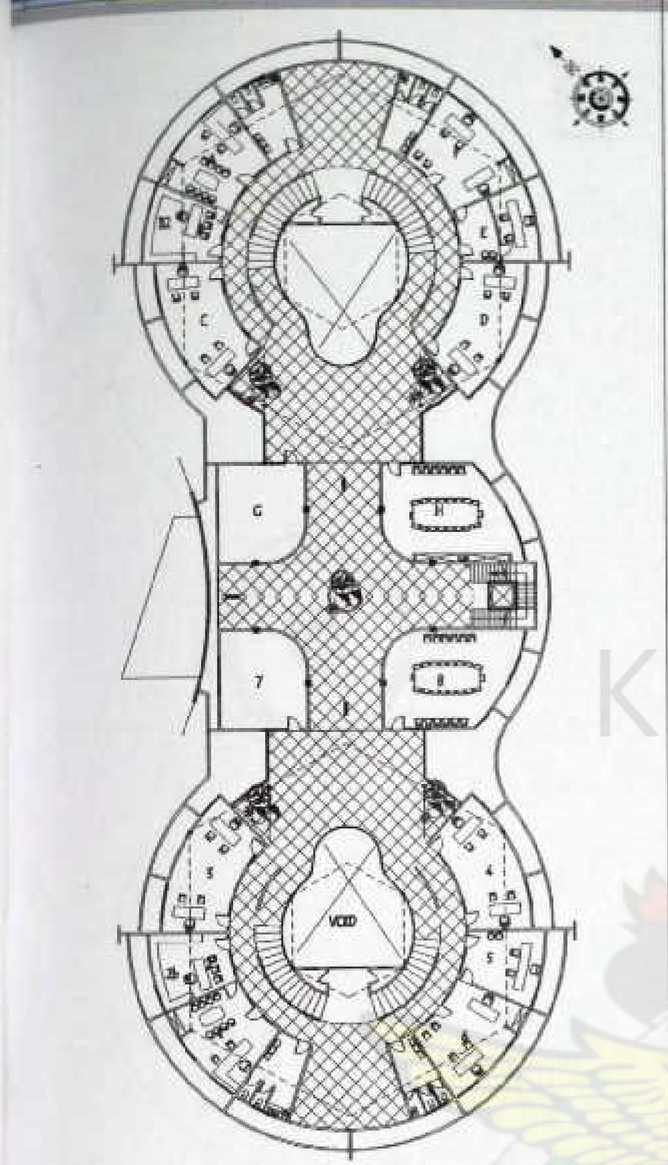
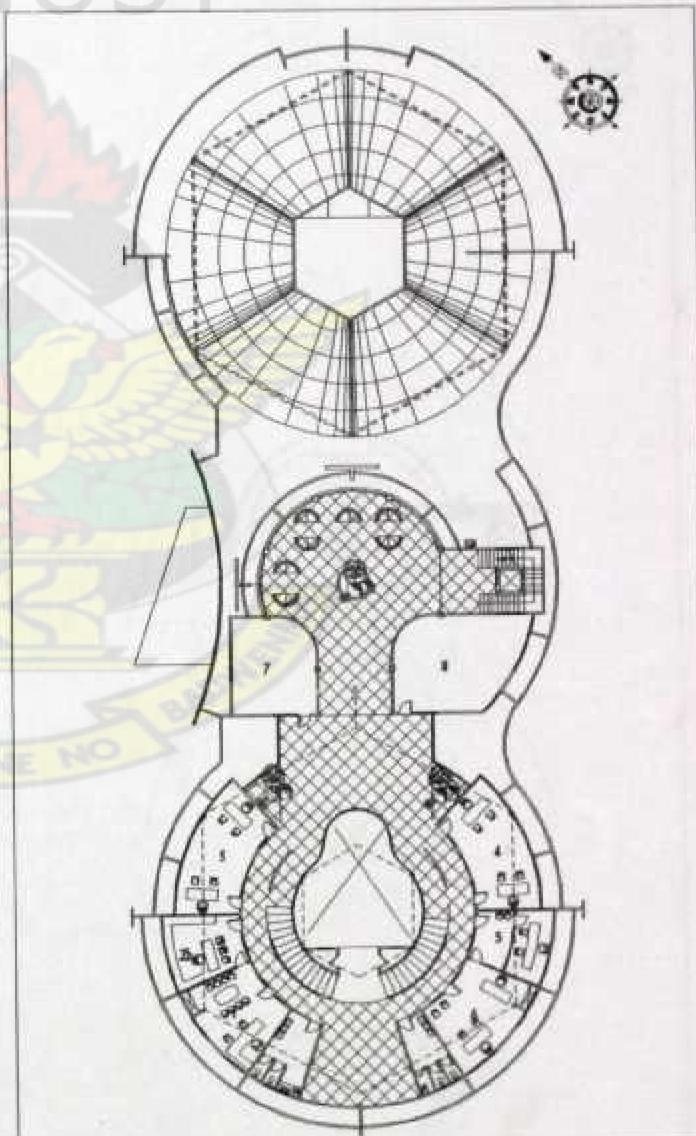


LEVEL 2 - 5
SCALE 1 : 200

GHANA CIVIL AVIATION OFFICES

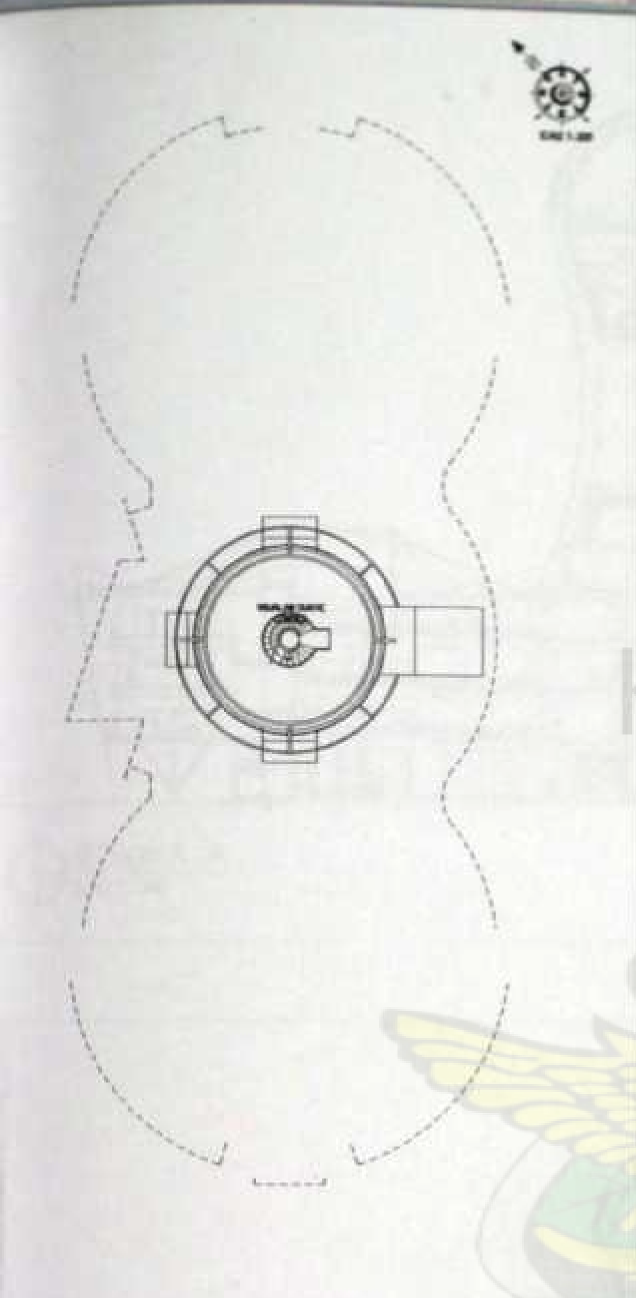
LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
1. PERSONNEL MANAGER	1. HUMAN RESOURCE MANAGER	1. GENERAL MANAGER	1. METROLOGICAL DEPARTMENT - 1
2. SECRETARY TO THE MANAGER	2. SECRETARY TO THE MANAGER	2. SECRETARY TO THE MANAGER 2b. RECORDS AND ARCHIVES	2. METROLOGICAL DEPARTMENT - HEAD
3. GENERAL OFFICE	3. ELECTRICAL SERVICES DEPARTMENT	3. ELECTRONICS SERVICE DEPARTMENT	3. METROLOGICAL DEPARTMENT - MEASUREMENTS AND REST ROOM
4. AERONAUTICAL INFORMATION DEPARTMENT - 1	4. AERODROME AND FLIGHT SAFETY1	4. ACCOUNTS AND FINANCE - GENERAL	4. AERONAUTICAL COMMUNICATION DEPARTMENT 1
5. AERONAUTICAL INFORMATION SERVICES - HEAD	5. AERODROME SAFETY HEAD	5. ACCOUNTANT	5. AERONAUTICAL COMMUNICATIONS - HEAD
6. AERONAUTICAL INFORMATION SERVICE - 2	6. AERODROME AND FLIGHT SAFETY 2	6. ACCOUNTS - AUDITING	6. AIRPORT INFORMATION AND COMMUNICATION
7. COMMON ROOM WITH KITCHNETTE	7. COMMON ROOM WITH KITCHNETTE	7. COMMON ROOM WITH KITCHNETTE	7. COMMON ROOM WITH KITCHNETTE
8. READING ROOM AND REFRENCE LIBRARY	8. READING ROOM AND REFRENCE LIBRARY	8. MEETING ROOM	8. STORAGE



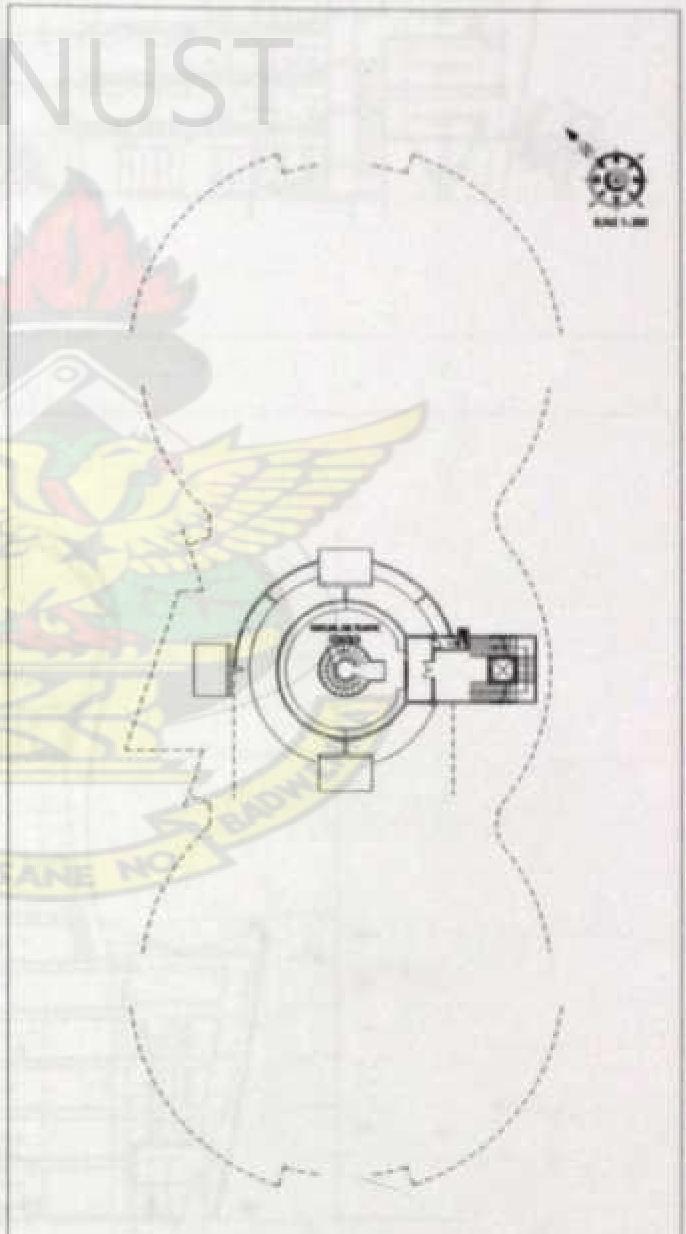
LEVEL 2 - 5
SCALE 1 : 200

GHANA AIRPORT COMPANY OFFICES

LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
A. AIRPRT OPERATIONS MANAGER	A. HUMAN RESOURCE AND PERSONNEL MANAGER	A. GENERAL MANAGER	1. ROOF TOP
B. SECRETARY TO THE MANAGER	B. SECRETARY TO THE MANAGER	B. SECRETARY TO THE MANAGER B2. RECORDS AND ARCHIVES	
C. GENERAL OFFICE	C. GENERAL OFFICE	C. COMMERCIAL SECTION	
D. CORPORATE PLANNING - 1	D. PROJECTS AND QUANTITIES	D. ECONOMIC REGULATION AND COMMERCIAL SECTION	
E. CORPORATE PLANNING- HEAD	E. PROJECT AND QUANTITIES HEAD	E. ACOUNTANT	
F. CORPORATE PLANNING - COMPUTATIONS	F. QUANTITIES	F. ACCOUNTS AND FINANCE - GENERAL	
G. COMMON ROOM WITH KITCHNETTE	G. COMMON ROOM WITH KITCHNETTE	G. COMMON ROOM WITH KITCHNETTE	
H. DRAWING OFFICE	H. READING ROOM AND REFRENCE LIBRARY	H. MEETING ROOM	

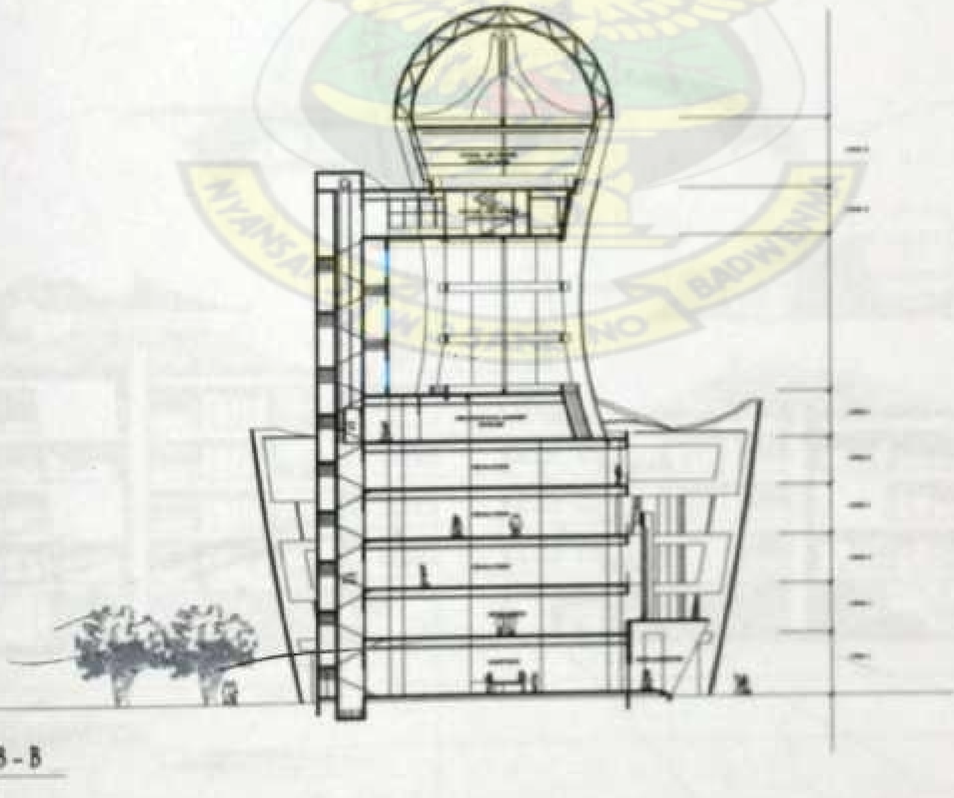


LEVEL 10
SCALE 1 : 200

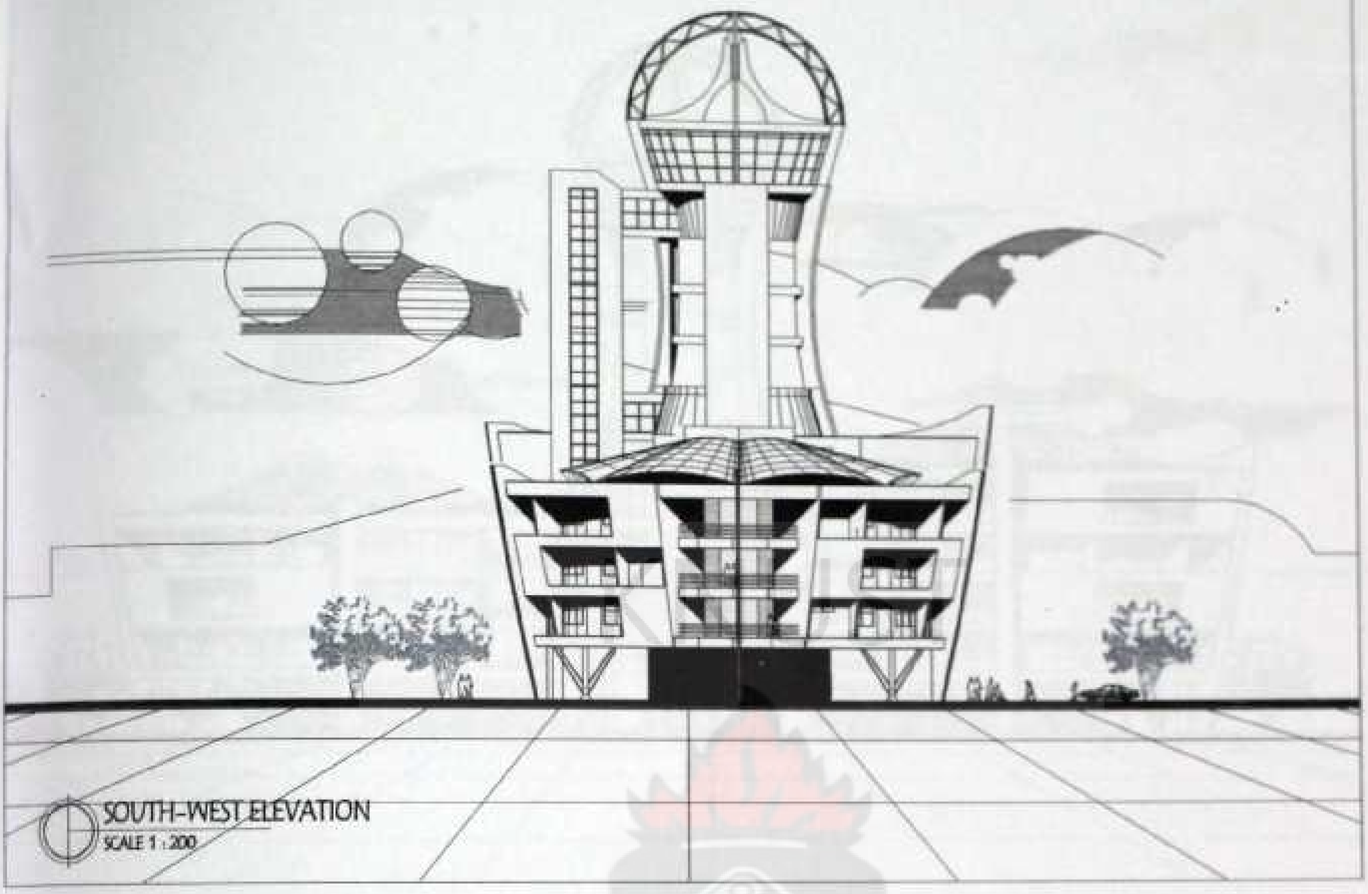


LEVEL 11
SCALE 1 : 200

SECTION A - A
SCALE 1 : 200



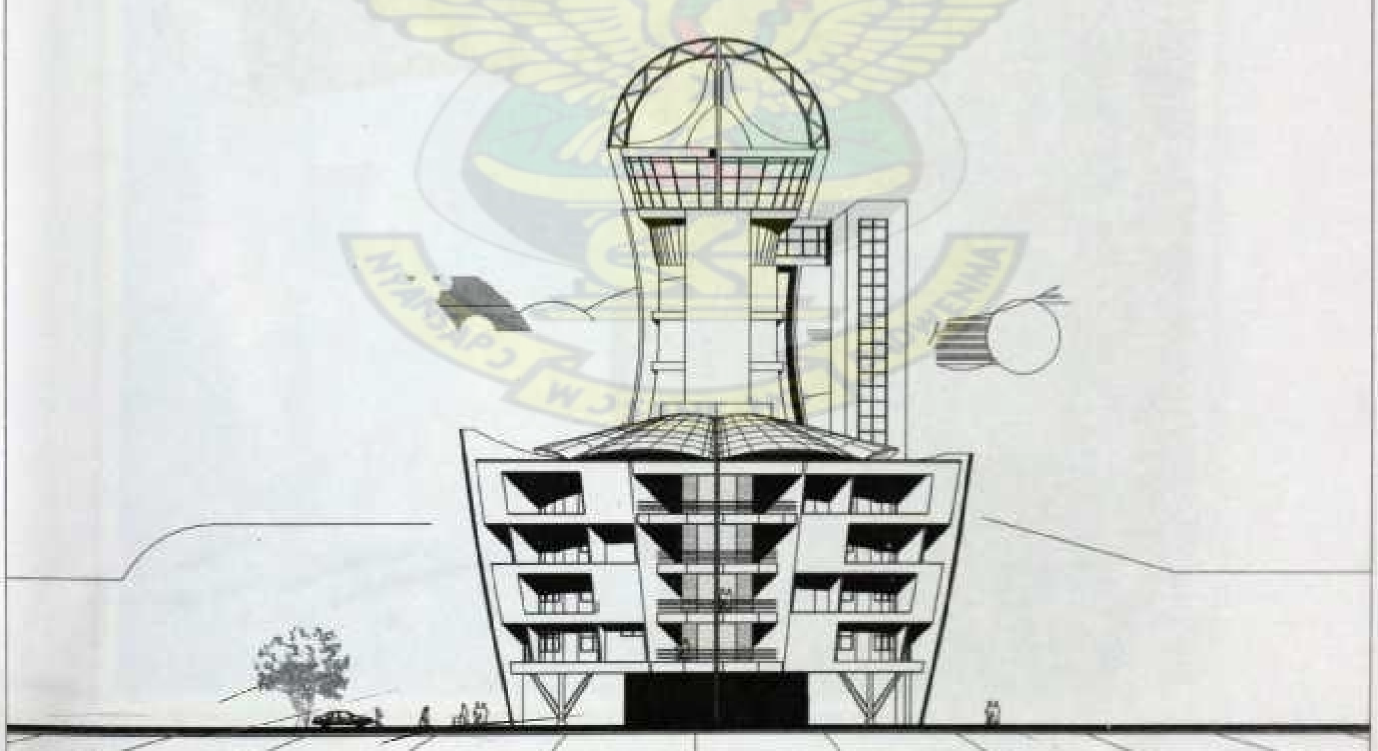
SECTION B - B
SCALE 1 : 200



SOUTH-WEST ELEVATION
SCALE 1 : 200

SOTH-EAST ELEVATION
SCALE 1 : 200

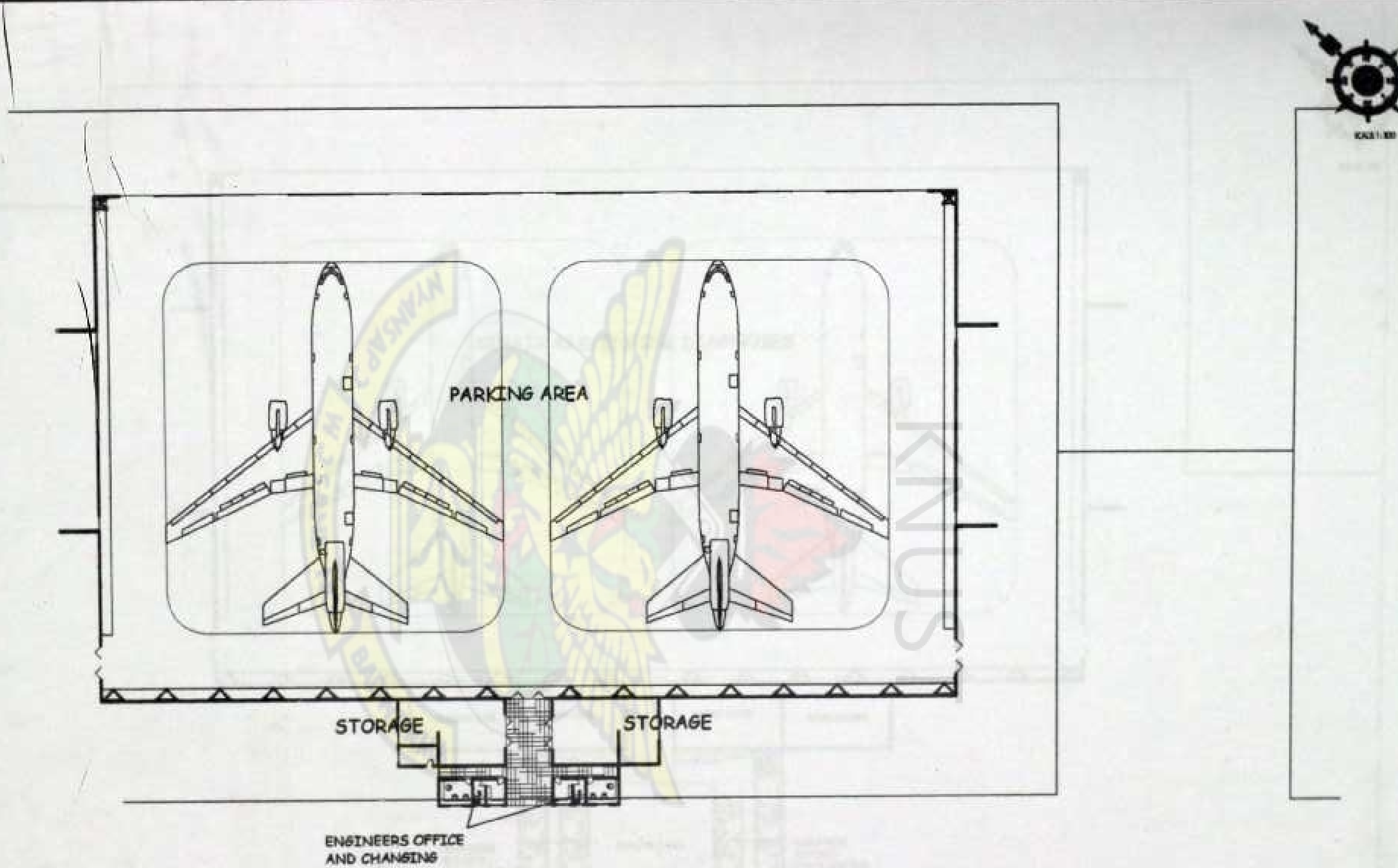
NORTH WEST ELEVATION
SCALE 1 : 200



NORTH-EAST ELEVATION
SCALE 1 : 200


AIR TRAFFIC CONTROL TOWER - TML

HANGAR - PLAN



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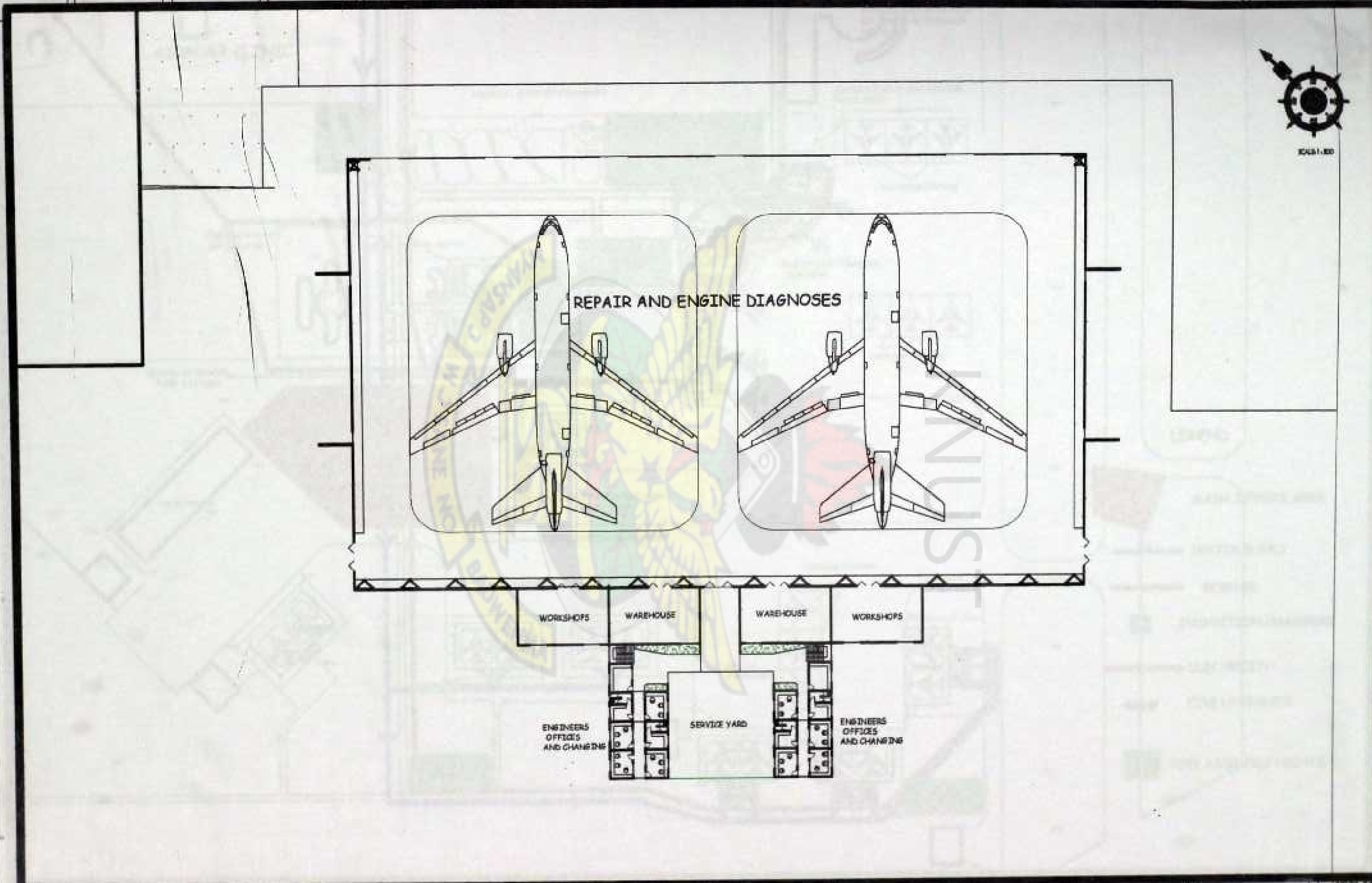

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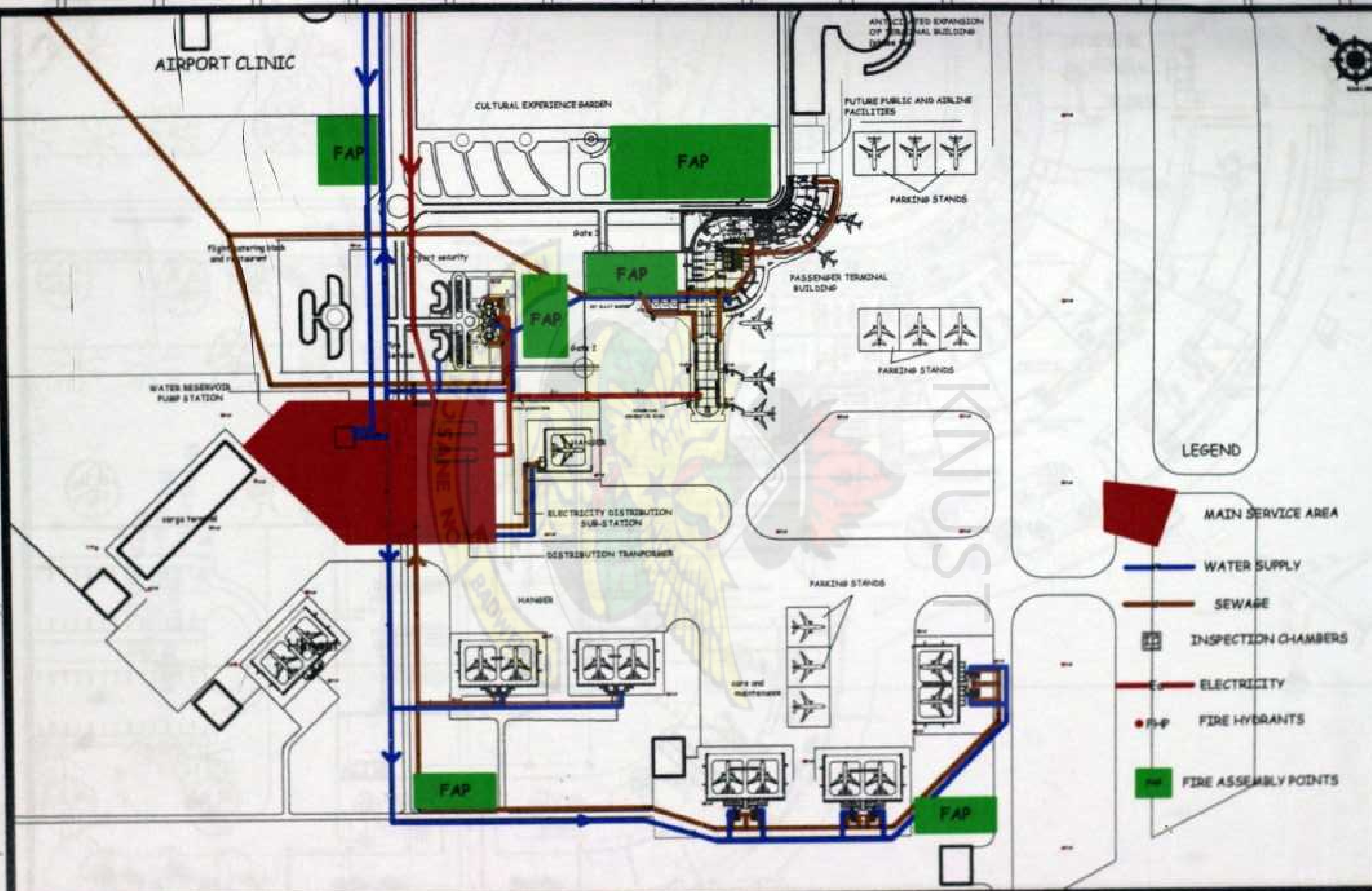
SERVICE LAYOUT PLAN



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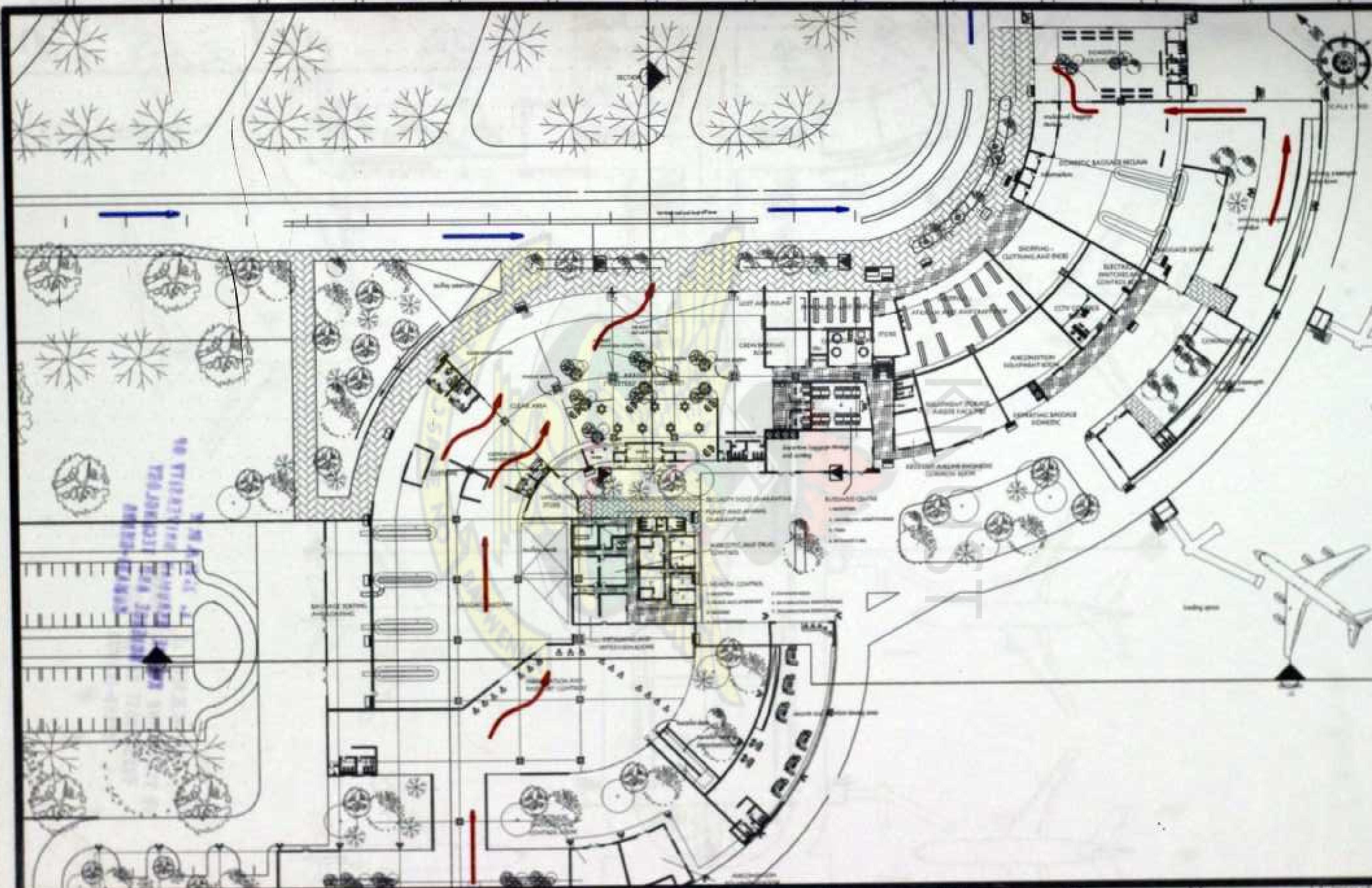
LEVEL 1 - ARRIVAL FLOOR - BAGGAGE CLAIM AND ARRIVAL HALL



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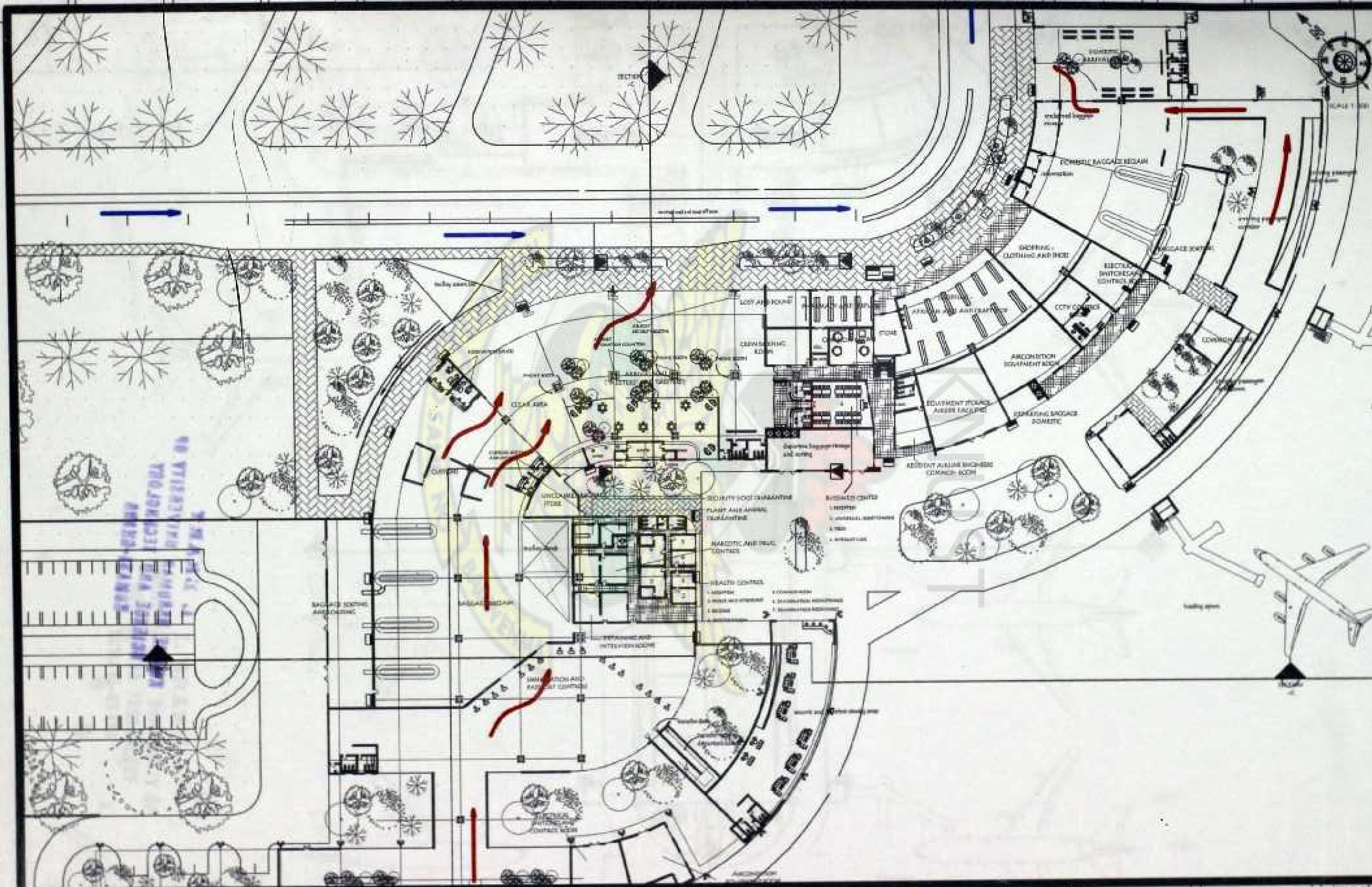
LEVEL 1 - ARRIVAL FLOOR - BAGGAGE CLAIM AND ARRIVAL HALL



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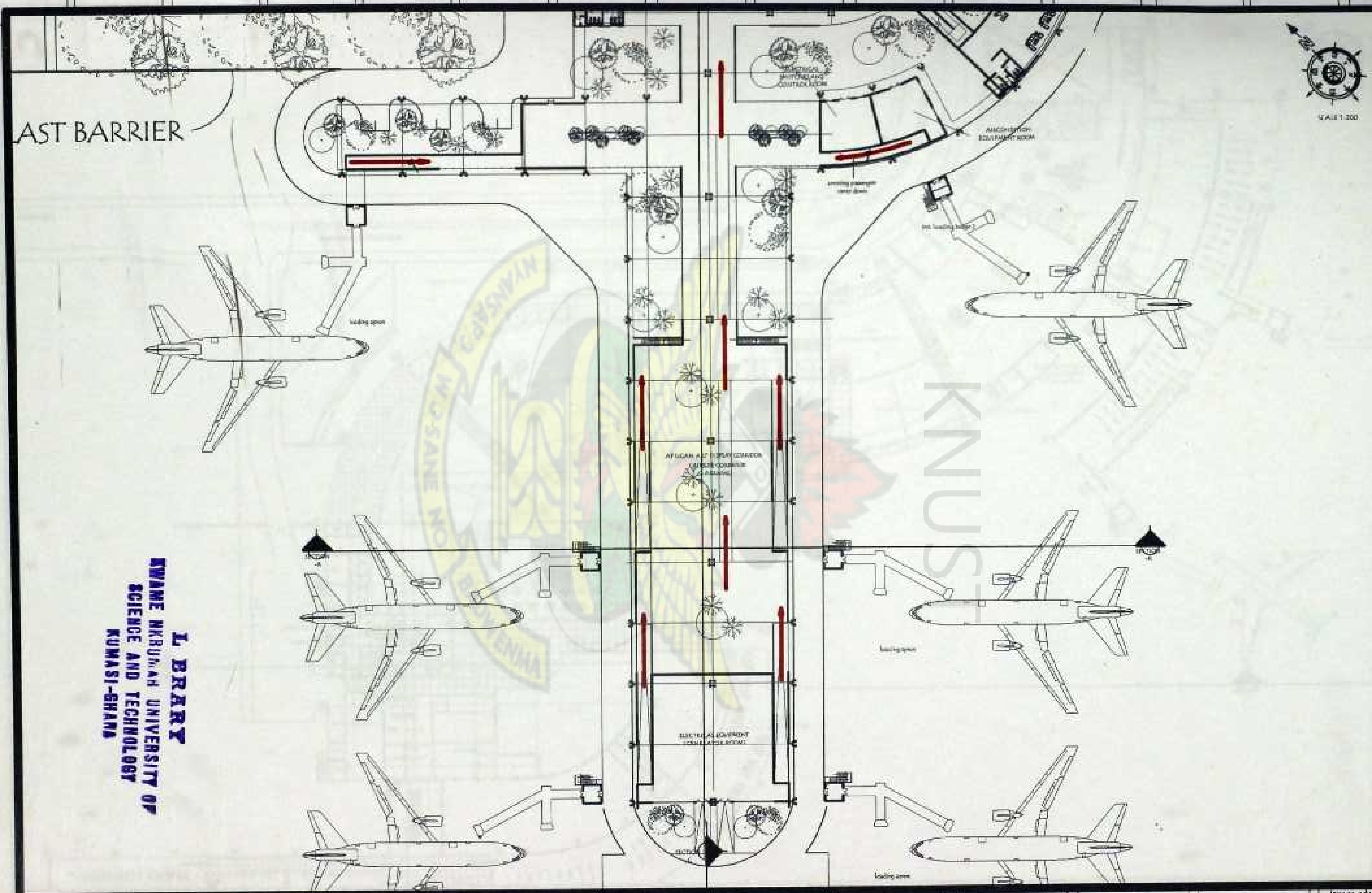
LEVEL 1 - ARRIVAL FLOOR - B



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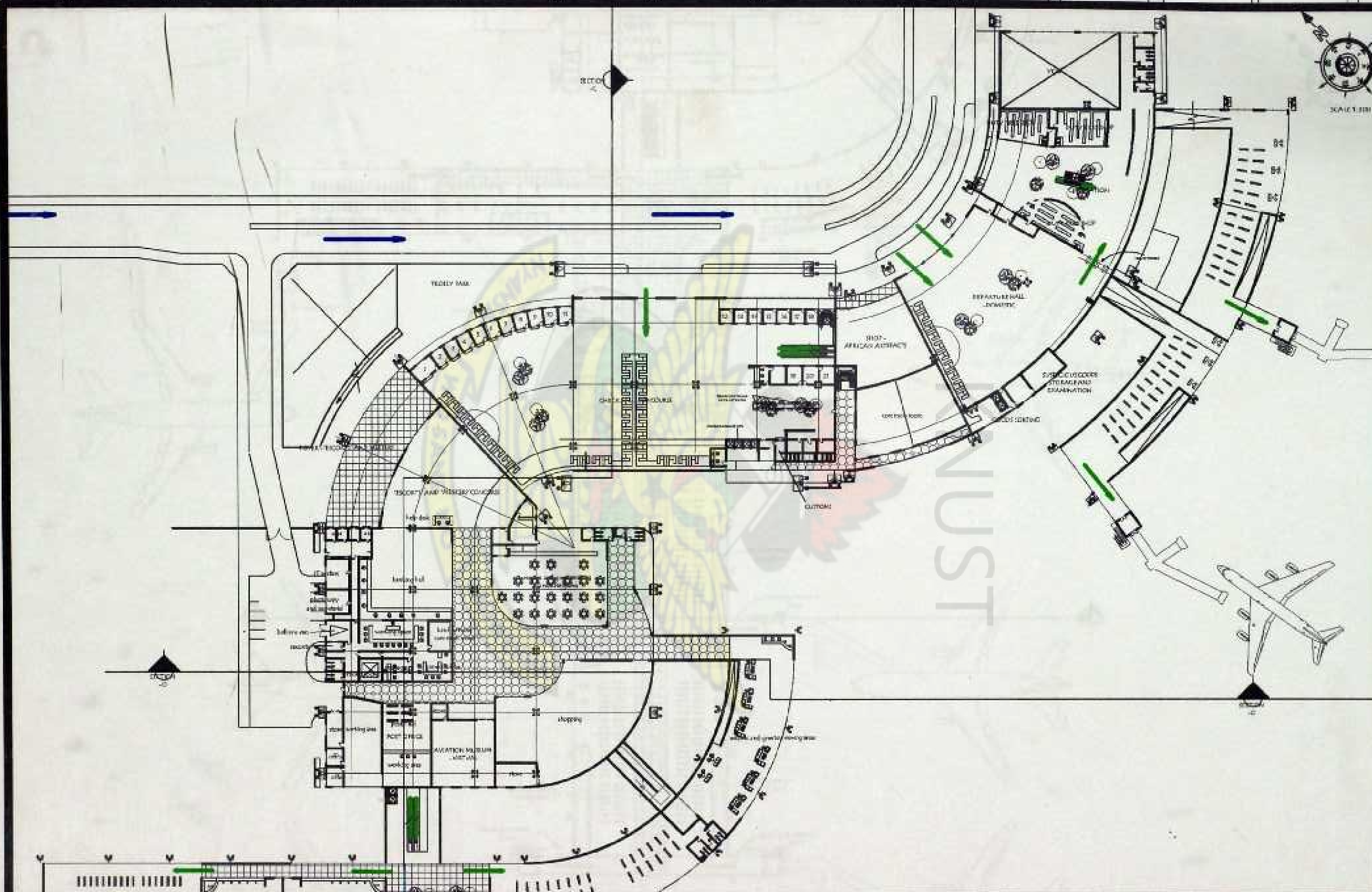
LEVEL 2 - DEPARTURE FLOOR - A



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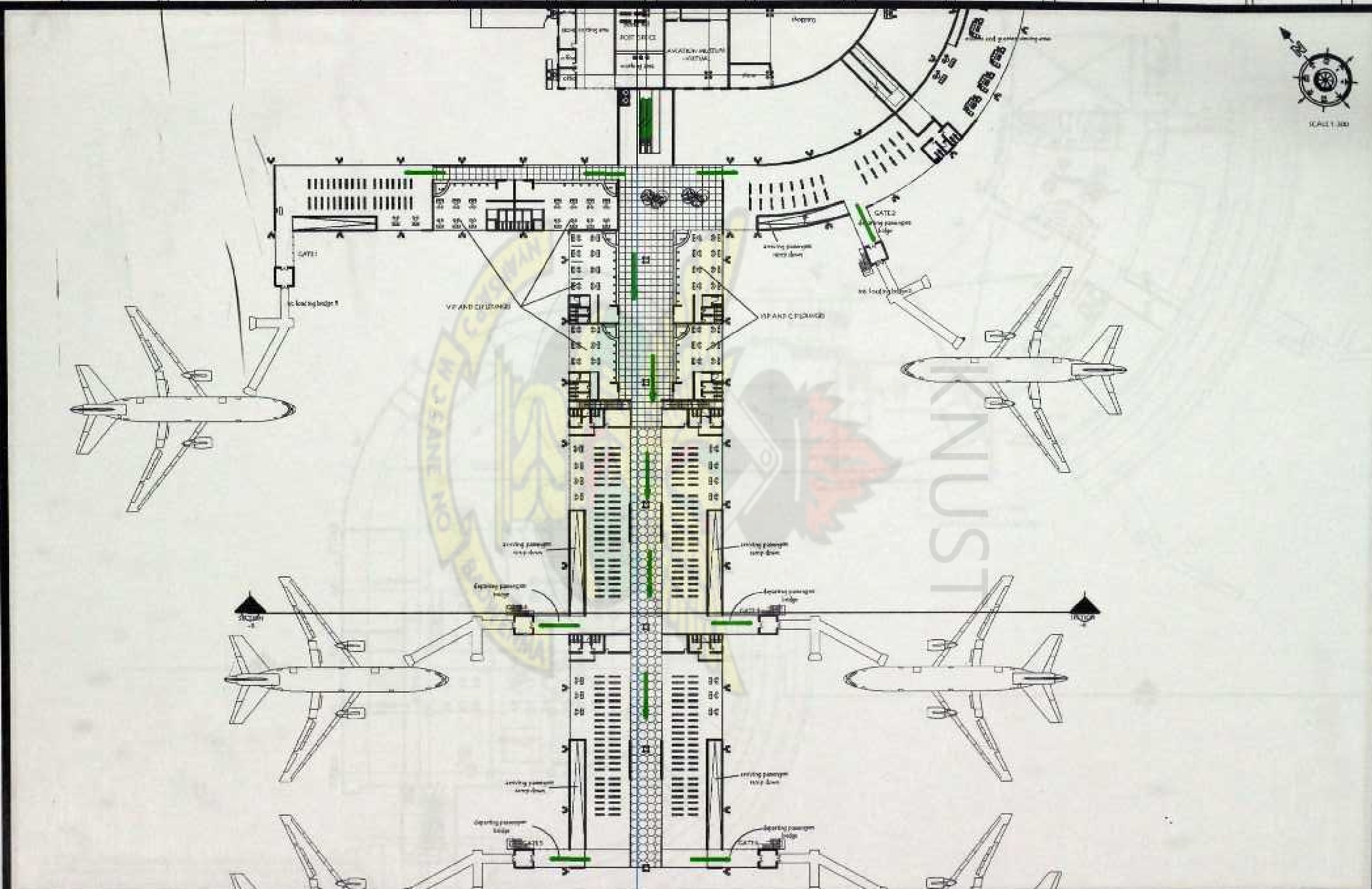
LEVEL 2 - DEPARTURE FLOOR - HOLD ROOMS AND VIP LOUNGES



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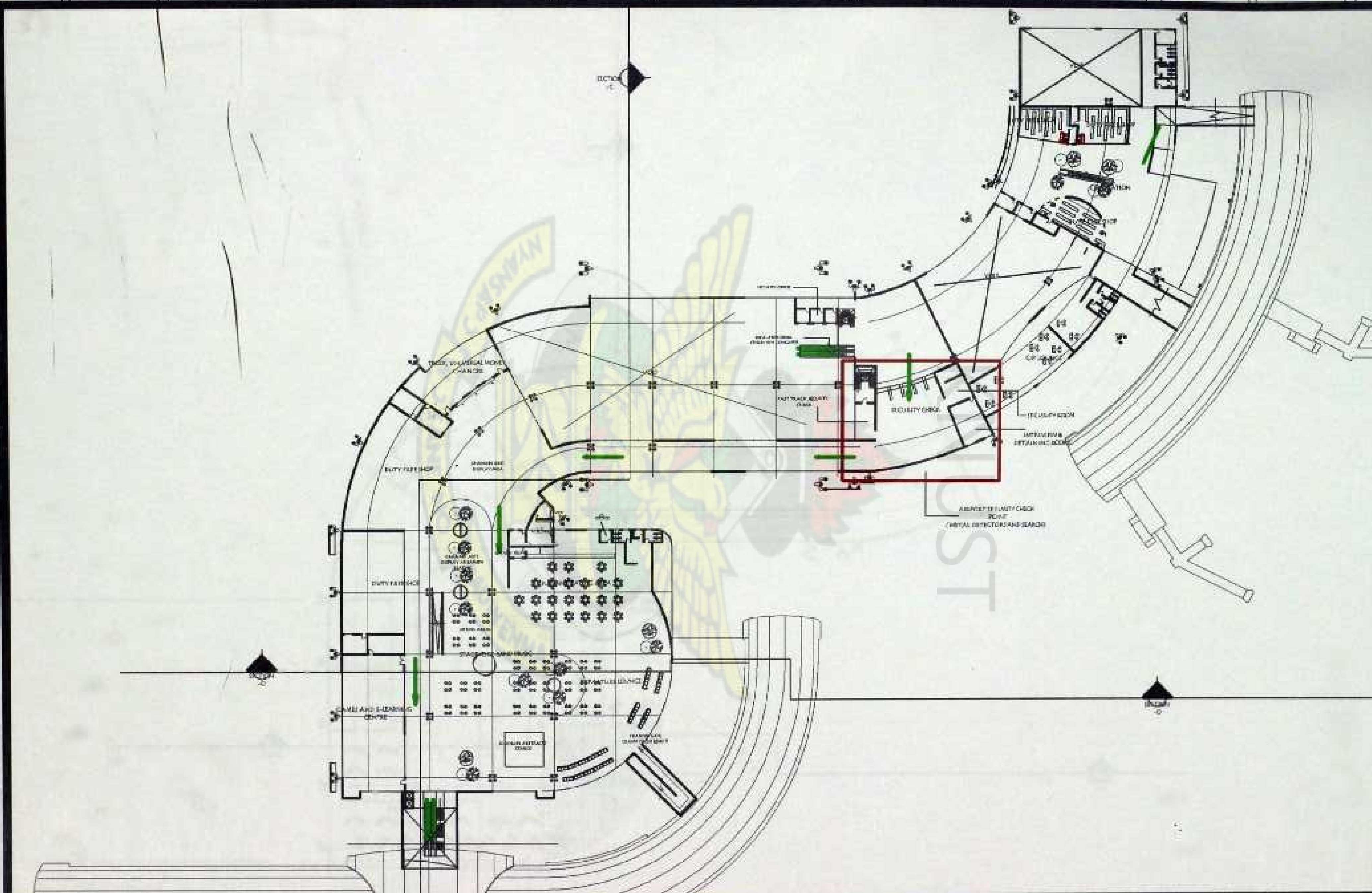
LEVEL 3 - DUTY FREE SHOPPING AND DEPARTURE LOUNGE



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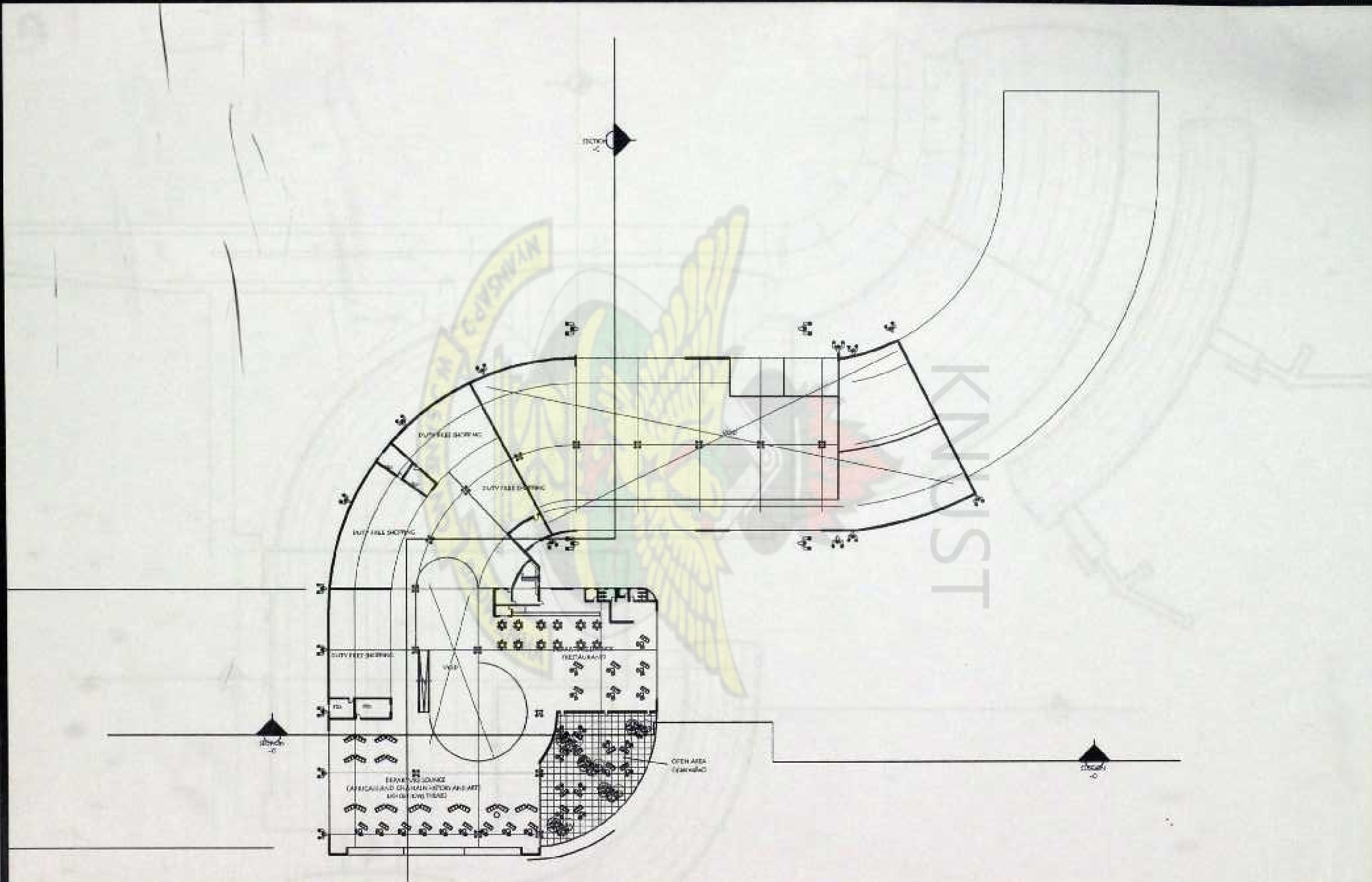
LEVEL 4 - DUTY FREE SHOPPING AND DEPARTURE LOUNGE



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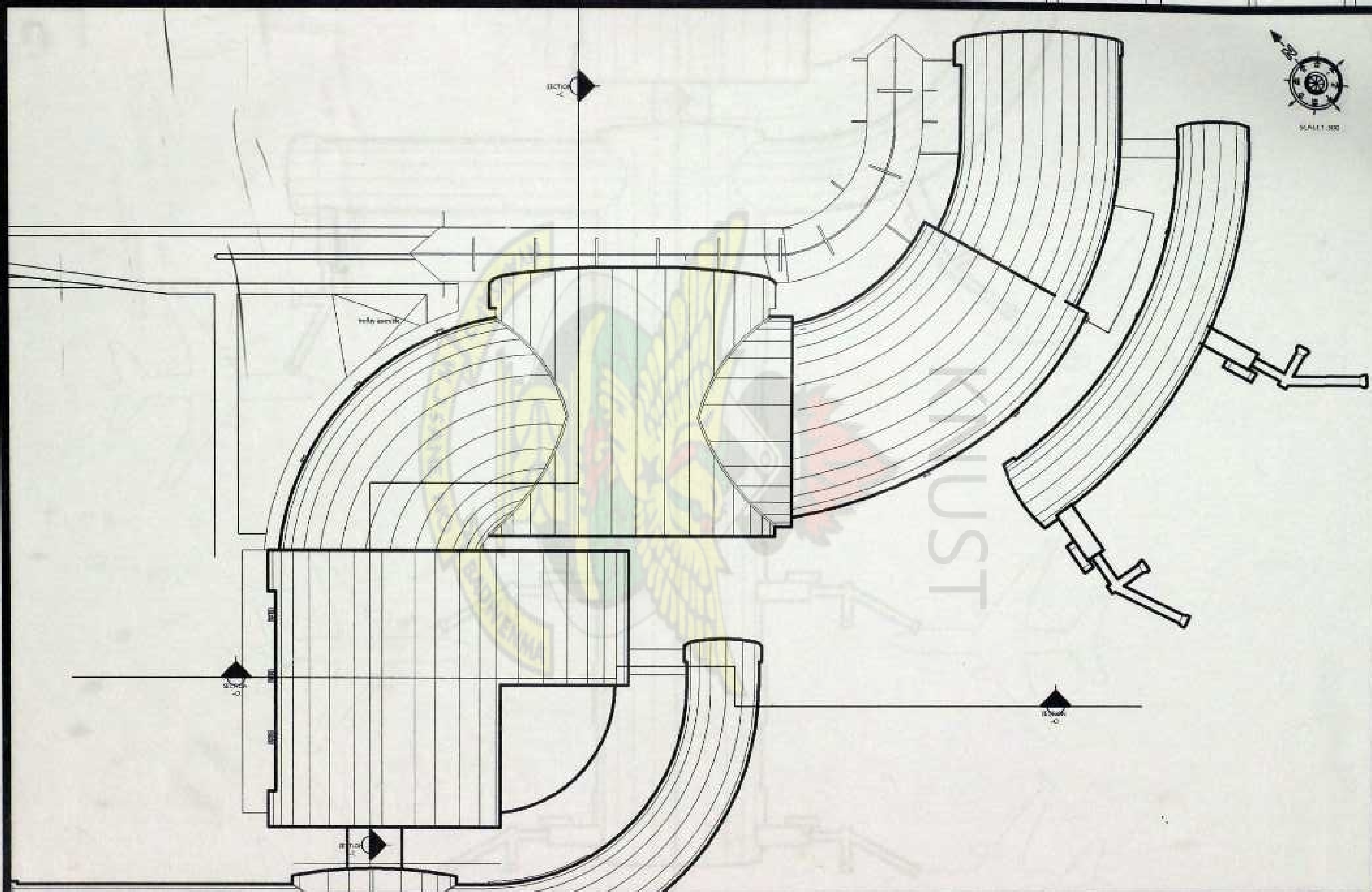
ROOF PLAN - MAIN TERMINAL BUILDING



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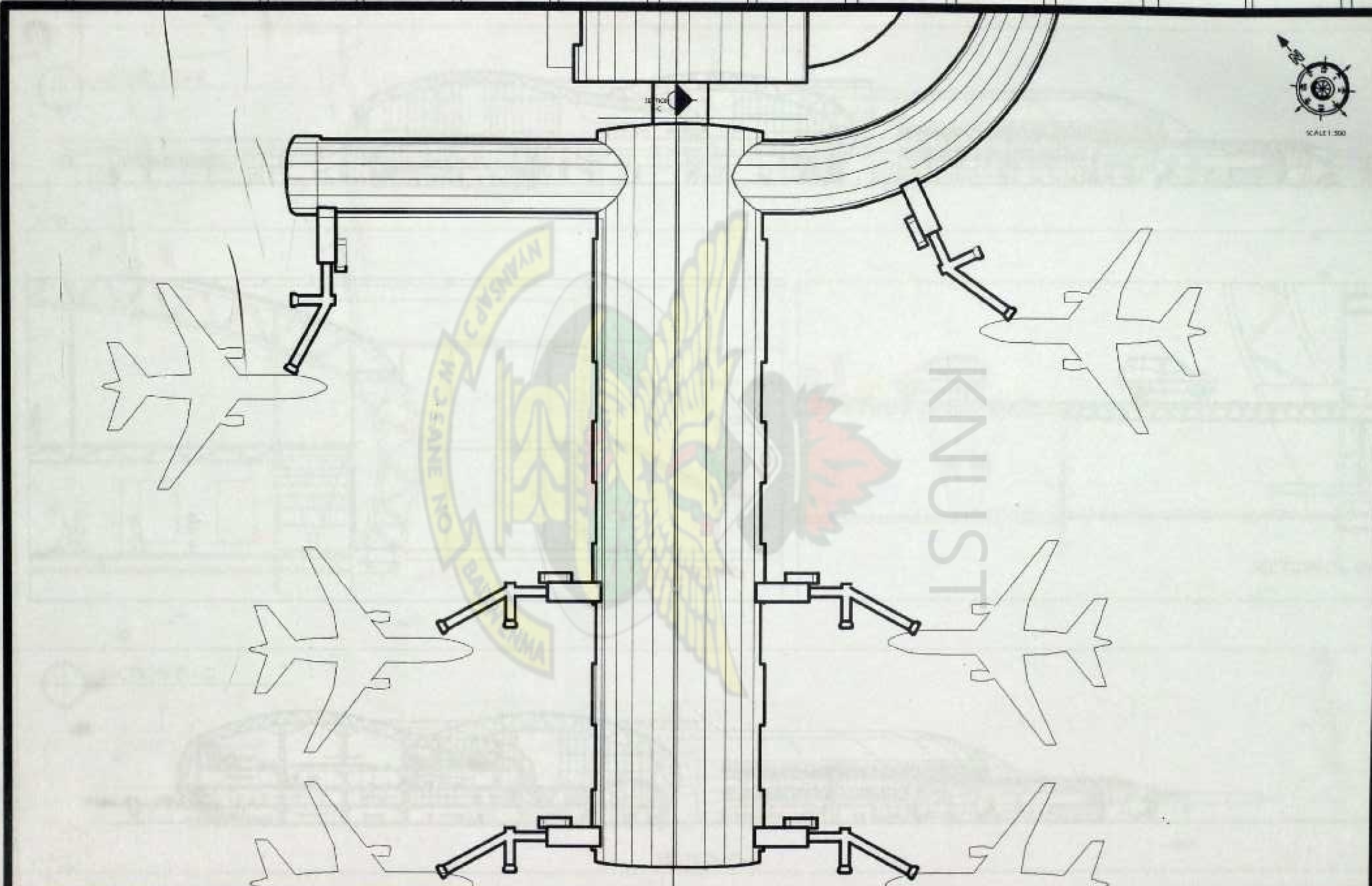
ROOF PLAN - HOLD ROOMS AND VIP LOUNGE AREA



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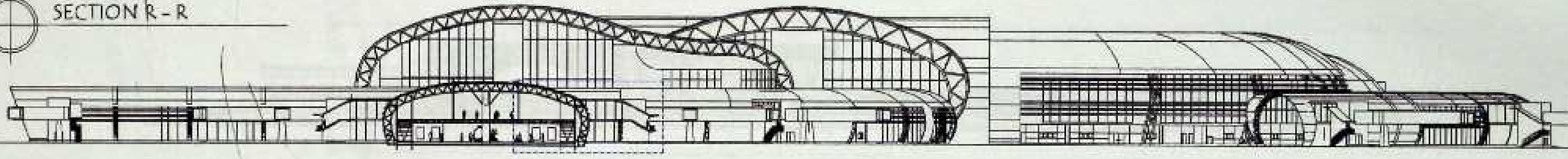
SECTIONS

SECTION R - R



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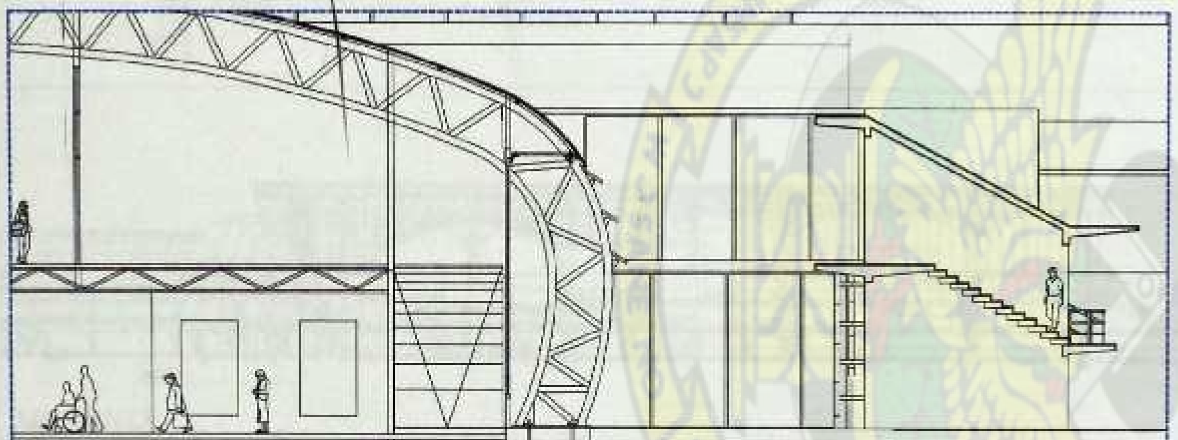
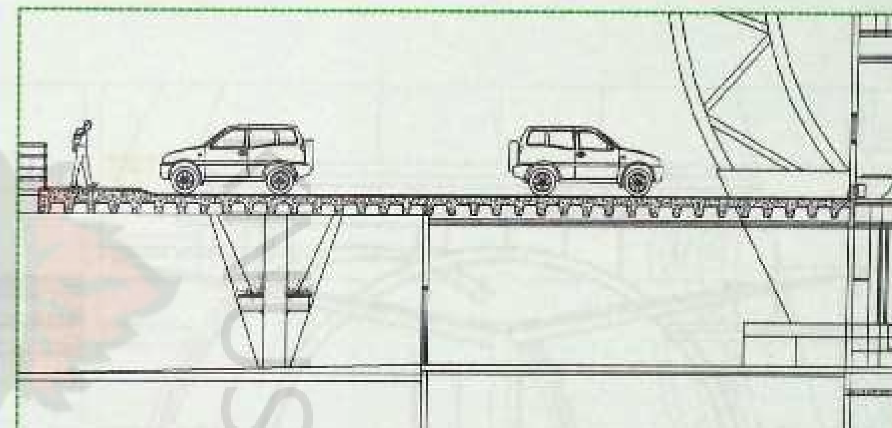


SECTION Ra

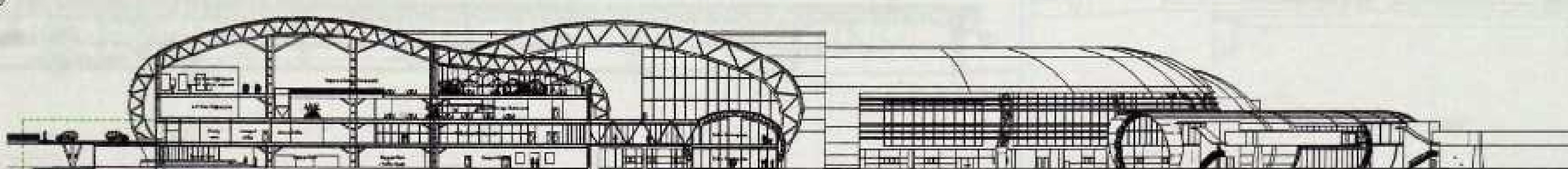
1 : 50



SECTION Oa-Oa

1 : 50

SECTION O - O



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SECTION O-O

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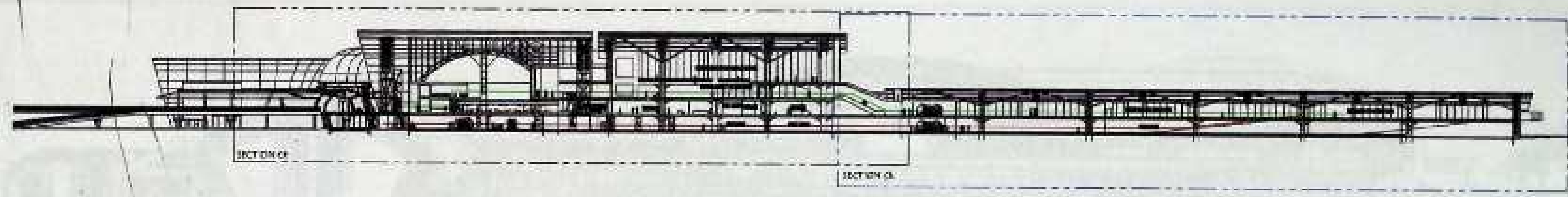
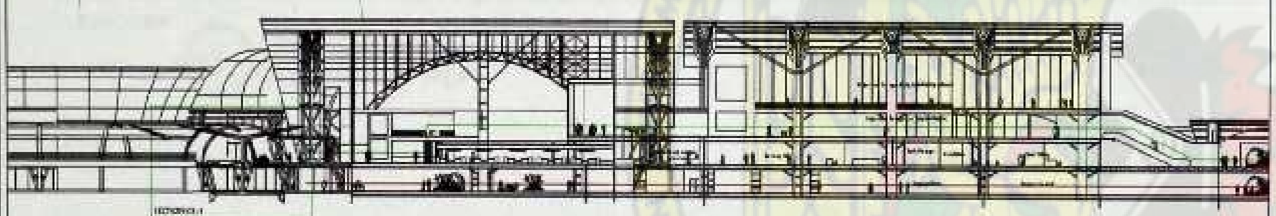
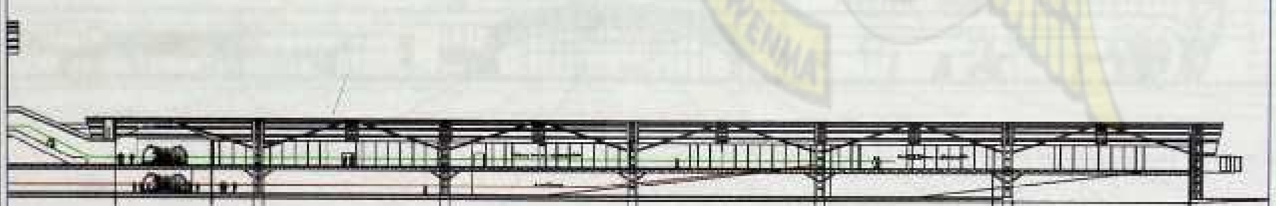


SCALE 1 : 500

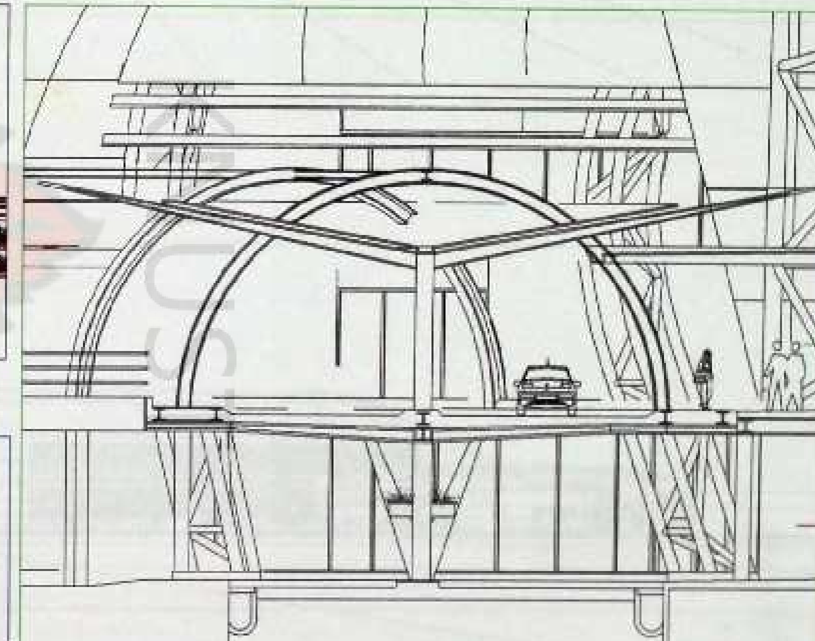
SECTION C - C
(FROM AIRSIDE - LANDSIDE VIEW AND VICE VERSA)



SECTION Ct
SCALE 1 : 300



SECTION Ck
SCALE 1 : 300



SECTION Ct - 1

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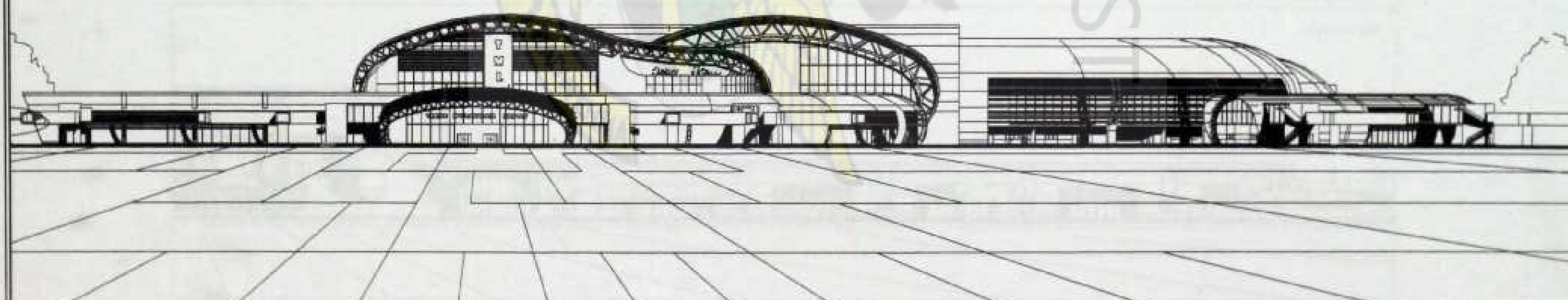
ELEVATIONS

SCALE 1:300

NORTH – EAST ELEVATION
(LANDSIDE VIEW)



SCALE 1:300

SOUTH – WEST ELEVATION
(AIRSIDE VIEW)

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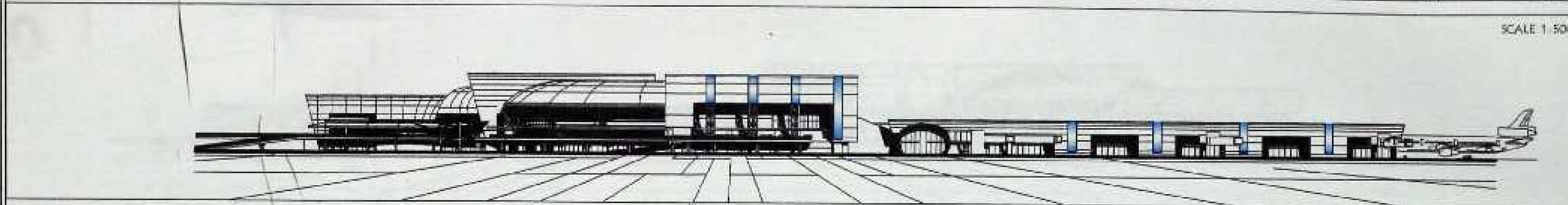
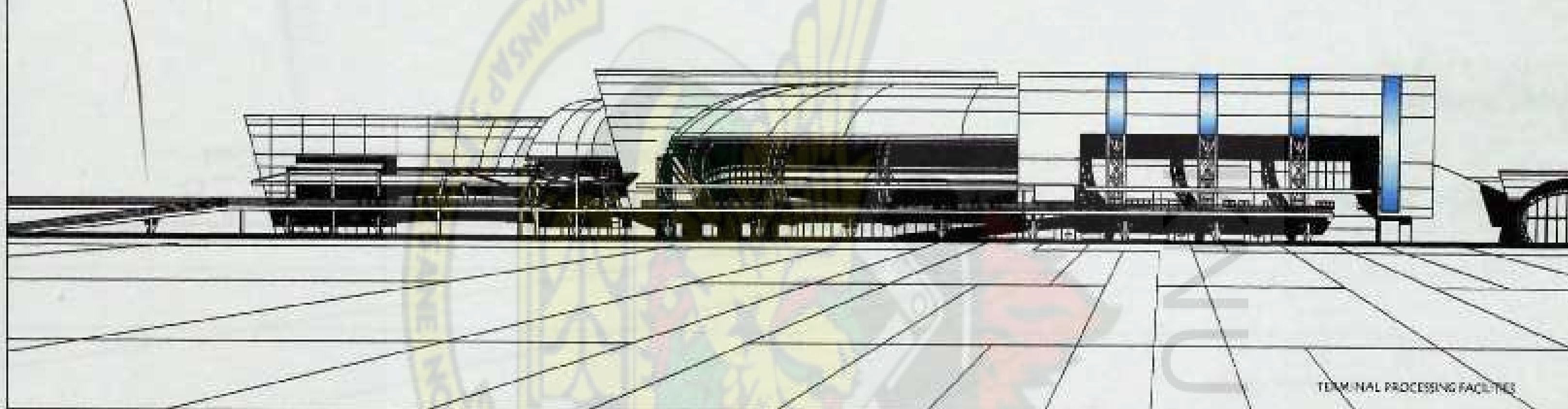
ELEVATIONS



NORTH - WEST ELEVATION
(LANDSIDE - AIRSIDE VIEW)



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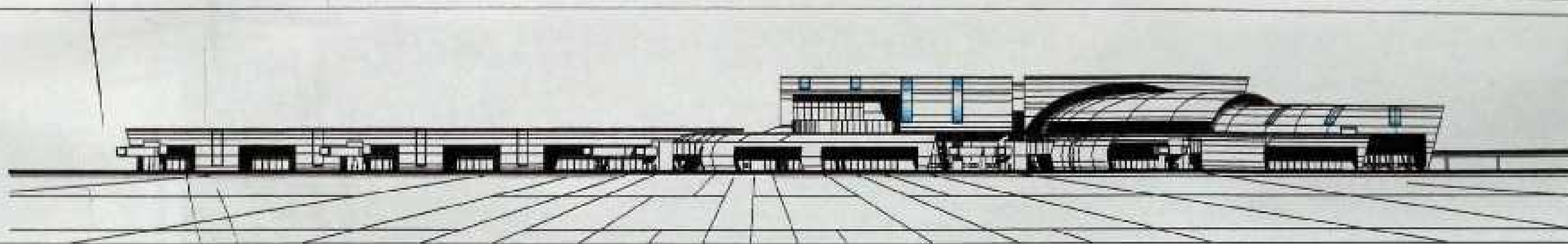
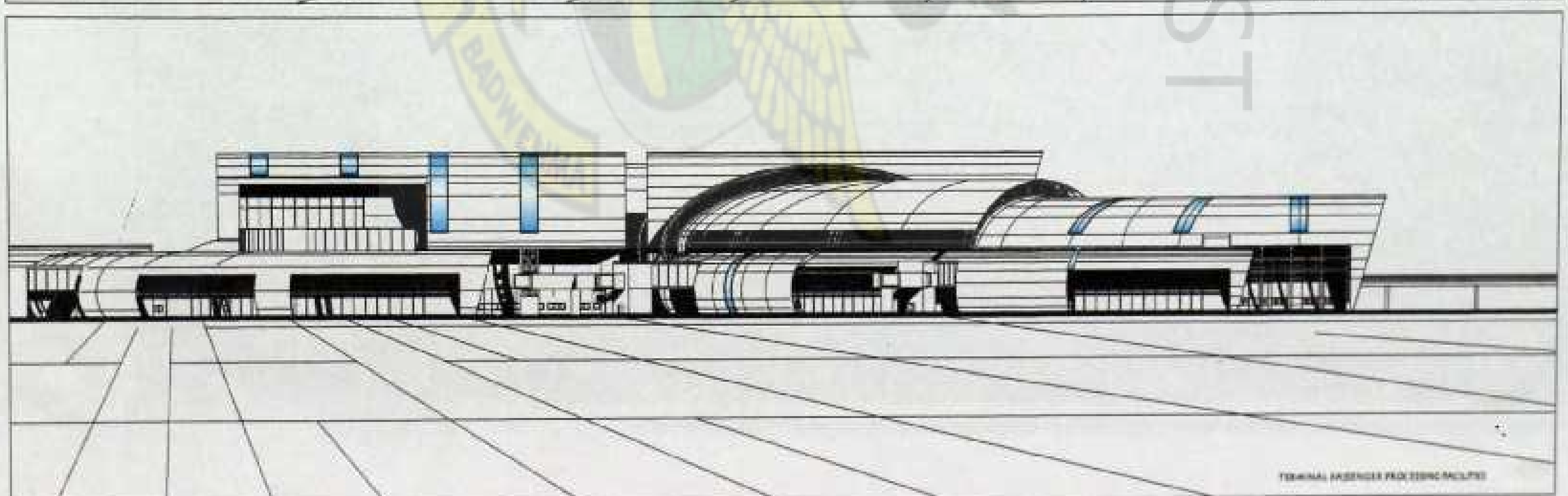
ELEVATIONS



SOUTH - EAST ELEVATION
(AIRSIDE - LANDSIDE VIEW)



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