Proposed Upgrade of Samuel Ládòkè Akíntọ́lá Airport, Alakia, Ibadan (Incorporating Safety Design Criteria in Airport Design)

Kelachukwu Johnson OKORIE
LCU/PG/002836

Being a MSc Thesis Submitted to the Department of Architecture, Faculty of Environmental Design and Management, Lead City University, Ibadan, Oyo State, Nigeria

In partial fulfilment of the Requirements of the Award of Master Degree (MSc) in Architecture

2023

Certification

This is to certify that, Kelachukwu Johnson OKORIE with matriculation number LCU/PG/002836 carried out this research work titled 'Incorporating Safety Design Criteria in Airport Terminal.' in the department of Architecture, Faculty of Environmental Design and Management, Lead City University, Ibadan, Oyo State, for the award of Master Degree (MSc.) in Architecture. The thesis is an outcome of an independent and original work. I have duly acknowledged all the sources from which the ideas and the extracts have been taken. The project is free from any plagiarism and has not been previously submitted.

…… ……

(Arc) Olaniyan Martins
(Supervisor)

Date

…… ……

Dr. (Arc) Adedire Funmilayo
(Head of Department)

Date

Dedication

I dedicate this research work to Almighty God and my loving family.

Acknowledgement

I express my sincere and heartfelt gratitude to the Almighty God for guiding me throughout this academic program and providing me with the knowledge, wisdom, and understanding for my research. Your name shall forever be glorified (amen).

I am deeply thankful to Lead City University for granting me the opportunity to participate in this MSc program. Their guidance, constructive criticism, and invaluable knowledge sharing throughout the program are immensely appreciated.

I would like to convey my profound appreciation to my Project supervisor, Arc. Laniyan Martins, for his scholarly guidance and invaluable advice during this thesis. I am also grateful to the head of the department, Dr. (Arc.) Funmilayo Adedire, for her leadership role in ensuring the timely completion of this program. My heartfelt thanks also go to all the lecturers of the department and my studio critics.

I am grateful to some highly placed and respected individuals who have contributed to the successful completion of this project, as well as those who spared their time to provide real-world application of classroom theoretical knowledge related to my project topic. Your assistance and suggestions are deeply appreciated.

Beyond the department, I extend my appreciation for the impactful knowledge granted to me by the Provost of the PG school, Prof. Afolakemi Oredein, and all the staff members of the PG school. To my ever-loving wife, Mrs. Chioma Okorie, who illuminates my path, and to my children, Osinachi and Kelachukwuemeka, I am truly grateful.

I sincerely thank my bosses, Arc. K.O. Lawal, Arc. Afolabi Adedeji (fnai¬), Arc. Oyenekan, and my colleagues Bayo Akinyemi, Dada Adeyinka, and Obisesan Oluwasegun for their inspiration and support. May God bless you all.

While acknowledging the assistance of the aforementioned institutions and individuals in this research work, I take full responsibility for any errors that may be found in the study.

Abstract

The rapid growth in air travel has necessitated more complex and larger airport terminals, intensifying safety and security concerns for aviation authorities and operators. This thesis explores the imperative of integrating safety design principles into all phases of airport terminal projects to enhance aviation facility safety and efficiency. It assesses evolving security threats, emphasizing proactive safety measures in terminal design and integrating safety considerations from project inception to ensure sustained safety measures. Detailed analysis of safety design criteria, such as emergency evacuation procedures, fire suppression systems, access control, and structural integrity, underscores their pivotal role in terminal safety. The paper also underscores the importance of aligning safety design with operational management, utilizing advanced technology and data-driven approaches to optimize safety protocols and emergency responses. The integration of safety measures with digital infrastructure enhances terminal resilience against unforeseen challenges. Drawing from international airports' case studies and best practices, it presents a comprehensive framework for safety design integration in airport terminal development, emphasizing collaborative efforts among architects, engineers, security experts, and airport authorities to achieve a balanced blend of safety, functionality, and aesthetics in terminal design. Ultimately, the paper advocates for a holistic approach where safety is a fundamental element integrated throughout development, enabling airports to create sustainable, secure, and passenger-friendly terminals, fulfilling their pivotal role in the global air transportation network.

Keywords: Airport Terminals, Airport, Aviation, Safety Design Criteria

Word Count: 220

Table of Contents

List of Figures

List of Plates

Chapter One

Introduction

1.1 Background to the Study

The design and management of an airport terminal has direct implications for the safety of the public, staff, and aircraft. Therefore, incorporating safety into its design is essential to ensuring a safe and secure environment. The incorporation of safety design criteria can be seen in numerous aspects of the terminal's structure, layout, and operational protocols.

Safety considerations play a significant role when designing or managing an airport terminal (*Smith et al., 2020*). This includes elements such as security checkpoints, surveillance systems, emergency exits, appropriate signage, as well as fire protection and evacuation plans. In addition, building materials used should be non-flammable and must meet local building codes (*Direnzo & Sumner, 2015*). Furthermore, the location of the terminals must consider potential hazards such as noise levels, air pollution, traffic congestion, and nearby hazardous sites (*Ghasemi et al., 2018*). As airports become increasingly busy with passengers and cargo, consideration must also be given to overcrowding and its effects on the overall safety of the terminal (Luo et al., 2019).

Various organizations have published guidelines which set forth specific requirements for airport terminal design and management. International standards are established by the International Civil Aviation Organization (ICAO) as part of Annex 14 – Aerodromes. These require that airport operators develop safety management systems (SMS) with regards to terminal operations (ICAO, 2016). The Federal Aviation Administration (FAA) also offers guidance documents that address various facets of airport terminal design and management (FAA, 2017). Additionally,

individual countries may have their own additional legislative requirements for airport safety based on their particular needs (*Kolářová & Šíma, 2013*).

In addition to regulatory requirements, recent advancements in technology offer new opportunities for enhancing airport safety. For example, intelligent video analytics allow for more effective monitoring of large-scale areas within the terminal (*Xu et al., 2019*). Automated access control systems can utilize biometric identification while minimizing human interaction (*Hussain et al., 2018)*. Intelligent lighting systems can adjust illumination according to environmental conditions, thus reducing operating costs and increasing visibility of travelers *(Zhang et al., 2014)*. All these technologies help contribute to safer and more efficient operations at the airport terminal.

In Nigeria, the aviation sector is one of the most important and rapidly growing industries. In recent years, there has been a significant increase in aircraft movements as well as passenger and cargo traffic at Nigerian airports due to increased international travel and trade. Despite this growth, however, there have been serious concerns regarding the safety of air operations in Nigeria, especially with respect to airport terminal design and management. The increasing number of passengers and aircraft necessitates improved safety measures at Nigerian airports in order to minimize the risks associated with air travel. This includes the incorporation of safety design criteria into the planning and operational processes for airport terminals. The primary purpose of these safety design criteria is to reduce risk, protect personnel, ensure the safe and efficient operation of the facility, and provide travelers with an enjoyable experience *(Oyeniyi et al., 2017)*.

Previous research works on the subject has largely focused on operational and procedural aspects, such as baggage screening and aircraft maintenance *(Nwasonuba & Okeudo, 2021)*. Little attention has been given to designing buildings that meet ICAO SARPs or evaluating their effectiveness in ensuring passenger safety. Furthermore, much of the literature available is limited to theoretical models rather than practical implementation strategies *(Ale et al., 2002)*. In view of these shortcomings, the current study would pay attention to examining whether existing safety design at Nigerian Airport terminals meet ICAO SARPs as well as evaluate its effectiveness in ensuring passenger safety.

1.2 Statement of the Research Problem

The Federal Airports Authority of Nigeria (FAAN) is responsible for ensuring the safety of all civil aviation activities in Nigeria. As part of their responsibilities, FAAN has established regulations for aircraft operations, air traffic control, and passenger safety. However, there is currently no consensus on applicable safety design criteria in Nigerian airports, resulting in inconsistent safety standards between different terminals. Moreover, many Nigerian airports lack the resources and infrastructure necessary to meet international standards, leaving them vulnerable to accidents or other incidents.

Despite the existence of these internationally accepted standards, the implementation of safety design criteria at Nigerian airport terminals is inadequate due to lack of proper enforcement mechanisms, limited resources and knowledge gaps amongst airport personnel *(Davies et al., 2020)*. In addition, majority of Nigerian airports are aging and have not been upgraded to meet the latest requirements set out by the ICAO and ACI *(Nwasonuba & Okeudo, 2021)*. For example, many of the smaller airports are still using outdated navigational equipment, which can

significantly increase the risk of accidents. Moreover, most Nigerian airports do not have adequate security systems and procedures in place, making them highly vulnerable to terrorist attacks *(Davies et al., 2020)*. Furthermore, emergency services at airports are often underfunded and lack the necessary training to handle emergencies *(Oyeniyi et al., 2017)*. These issues demonstrate how Nigerian Airports are failing to protect passengers, staff, and equipment from hazards associated with airport operations.

1.3 Justification of the Study

The aviation industry has been an important part of the Nigerian economy, providing jobs, economic investment, and tourism opportunities throughout the country. With increased air travel comes the responsibility to ensure that airports are designed and managed using the highest safety standards. This study seeks to understand how safety design criteria can be incorporated into airport terminal design and management in Nigeria.

For airline operators, ensuring the safety of their passengers is paramount. Incorporating safety design criteria into airport terminal designs will help them meet these needs, while also increasing customer satisfaction by creating a safe environment for travelers. Additionally, incorporating safety design criteria will reduce operational costs associated with delays due to incidents or accidents at the airport.

For the government, the study guarantees that the infrastructure investments made in the country's aviation sector are secure and safe for its citizens. It will also protect the reputation of the country as a tourist destination, since visitors may be less likely to visit if there are concerns about the safety of the airports.

Finally, for the people of Nigeria, the outcome of the study will create a safer environment for travelers and workers alike. A well-designed and managed airport creates an efficient and

pleasant experience for both passengers and those working in the facility, resulting in higher levels of job satisfaction and improved overall quality of life.

1.4 Aims and Objectives

The aim of this study is to evaluate the current safety design criteria in Nigerian airports, assess the level of compliance with global standards, and identify areas for improvement. Specifically, its objectives are to:

1. Examine existing safety design criteria used in Nigerian airports
2. Compare the safety design criteria used in Nigerian airports against international standards
3. Propose a safety design for managing Airport Terminals in Nigeria

1.5 Research Questions

The following research questions will be used to interrogate the objectives:

1. Which safety design criteria are used in Nigerian airports?
2. How does safety design criteria used in Nigerian airports differ from international standards?
3. What are the most effective strategies for improving safety and security in Airport Terminals in Nigeria?

1.5 Scope of the Study

The scope of this study is to examine the incorporation of safety design criteria into airport terminal designs and management practices in Nigeria. Specifically, this study will focus on

identifying existing safety design criteria currently employed in Nigerian airports and exploring the potential implications of incorporating additional safety design criteria into current airport terminal designs and management practices. In addition, this study will investigate how local airport policies and regulations can be used to ensure that new safety design criteria are consistently incorporated throughout all stages of airport terminal design and operations. Furthermore, this study will include a review of recent literature concerning best practices for incorporating safety design criteria into airport terminal designs and management processes in Nigeria. Finally, this study seeks to provide policymakers with recommendations for improving safety design criteria in Nigerian airports.

1.6 Definition of Terms

Safety Design Criteria: Safety design criteria are standards or requirements that must be met to ensure a safe airport terminal environment. These include measures such as fire protection, emergency evacuation plans, and security protocols. The importance of safety design criteria is to protect passengers, staff, assets, and provide an overall safe experience for all stakeholders.

Airport Terminal Design: Airport terminal design is the process of creating an efficient and secure physical layout for airports. This includes ensuring passenger flow is optimized, identifying areas where security can be improved, and making sure the space meets current safety standards. It's important for airports in Nigeria to incorporate safety design criteria into their terminals so they can meet the high expectations of travelers and ensure a smooth journey.

Management: Management involves overseeing the operations of an airport terminal, which entails monitoring activities and making decisions related to budgeting, staffing, customer service, and other aspects of running a successful airport. Incorporating safety design criteria into

management practices ensures that airport personnel are aware of and prepared to respond to any issue that could compromise the safety of passengers and staff.

Chapter Two

Literature Review

2.1 Overview of Airport Terminal Design and Management in Nigeria

Airport terminal design and management in Nigeria is an important topic of research. Airport terminals are a major part of the global aviation system, as they provide crucial infrastructure for air transport services that include passenger processing, baggage handling, security screening, retail outlets, concessions, customs and immigration services, ground transportation, and other amenities. In recent years, airport design has become increasingly complicated due to advances in technology, increased safety regulations, and greater customer demand (Chandra & Nascimento, 2018). As such, the effective design and management of airport terminals in Nigeria are essential for providing passengers with a safe, comfortable, and efficient travel experience.

Nigeria is a country of immense potential for the aviation industry. It has been estimated that the potential market size for the Nigerian aviation sector will be worth $3 billion by 2020, representing approximately 8% of the total GDP *(Folayan et al., 2019)*. However, despite this potential, there are numerous challenges facing the industry which need to be addressed if it is to reach its full potential. One of these challenges lies within the design and management of airport

terminals in Nigeria. This paper provides an overview of the current situation with regard to airport terminal design and management in Nigeria, including both existing infrastructure and future plans. It then goes on to discuss some of the key issues associated with airport terminal design and management, such as safety and security, operational efficiency, and customer experience, before concluding with a set of recommendations to improve the current state of affairs.

Currently, there are twenty two airports operating in Nigeria, of which seventeen are domestic and five are international. These airports are managed by the Federal Airports Authority of Nigeria (FAAN), who are responsible for the operation and maintenance of all facilities at the airports. The majority of the airports have undergone significant renovation over recent years, with the most notable being the renovation of the Murtala Muhammed International Airport (MMIA) in Lagos, which is the largest and busiest airport in the country. Despite this, many of the other airports remain outdated and inefficient, and in need of further investment and improvement.

In recent years, there has been increased attention given to airport design and management in Nigeria. Studies have highlighted the importance of designing and managing terminals in order to maximize operational efficiency and enhance passenger experience *(Gundu & Obinwa, 2016)*. Additionally, airport terminal design is seen as an important driver of economic growth and job creation in the country *(Kareem et al., 2017)*.

Several studies have discussed the need for modernizing and upgrading airports in Nigeria to meet growing demand *(Dawodu & Adedoyin, 2018; Agboola & Ogutuga, 2020)*. These studies suggest that modernization should focus primarily on improving infrastructure and facilities

within the terminals, such as check-in counters, waiting areas, and baggage handling systems. Additionally, there is a need for improved security measures, passenger information systems, and better access for disabled passengers.

Nigerian airports face significant challenges in terms of overcrowding, long queues, and flight delays *(Ogunka et al., 2015).* Research suggests that this can be addressed through improvements to airport processes and procedures, particularly related to staffing levels, resource allocation, and scheduling *(Adesina & Oduntan, 2018)*. Additionally, the use of technology can significantly improve customer service and reduce delays *(Ogunsola & Kolawole, 2019)*. For example, automated check-in systems and e-ticketing platforms can help to speed up the process of boarding and disembarkation.

Furthermore, air traffic control is another critical element of airport management in Nigeria. Several studies have examined the impact of air traffic control on safety and efficiency at Nigerian airports *(Adebayo et al., 2017; Otumala et al., 2017*). These studies suggest that the introduction of new technologies, such as advanced navigation aids, can contribute to more efficient air traffic management. However, they also highlight the need for proper training and updated regulations to ensure compliance with international standards.

Despite the potential benefits of modernizing airport terminals in Nigeria, several challenges remain. These include inadequate funding, lack of government support, and limited capacity in terms of human resources and technical expertise *(Dawodu & Adedoyin, 2018*). Furthermore, dated airport designs and outdated equipment further add to the challenges of providing efficient service (*Ajibola et al., 2019*). To overcome these issues, it will be necessary for the federal government to invest more resources into the development of airport terminals in the country.

However, despite the numerous challenges facing Nigerian airports, there are also opportunities for improvement. With the right investments and policies in place, Nigerian airports could become hubs of regional connectivity and economic growth (*Agboola & Ogutuga, 2020*). In particular, increasing investment in IT infrastructure could greatly improve customer experience and enable airports to adopt cost-effective solutions for managing large numbers of passengers (*Gundu & Obinwa, 2016*). Additionally, technological advancements, such as automation, blockchain, and artificial intelligence, could bring about greater efficiency and safety for both airlines and passengers (*Ogunsola & Kolawole, 2019*).

Overall, this section highlights the importance of airport design and management in Nigeria. It identifies the various challenges faced by the country's airports and outlines potential opportunities for improvement. It suggests that, with adequate investments and strategic planning, Nigerian airports could become hubs of regional connectivity and economic growth.

2.2 Identifying Potential Hazards and Risks in Nigerian Airports

Safety is one of the most important aspects of aviation. Airports are hubs for air travel and a central component of any country's transportation system, as well as an economic engine that supports many jobs and businesses. In Nigeria, airports play a critical role in transporting people and goods across the country and to other nations. As such, ensuring safety at these facilities is essential. This section aims to critically review the existing literature on potential hazards and risks in Nigerian airports. The research will focus on reviewing studies conducted in this area, including those which involve both qualitative and quantitative approaches.

Nigerian airports often face unique challenges due to their size and complexity. Risk identification is an important step in airport safety management, as it helps identify potential

hazardous events or conditions. Recognizing and understanding potential risks can help prevent incidents from occurring and reduce the severity of any accidents that may occur. A number of risk analysis tools have been developed to assist with this process (*Basu & Mookerjee, 2016).*

The hazard identification technique used most commonly in Nigeria is the Hazard Analysis and Critical Control Points (HACCP) system. HACCP was initially developed in order to ensure food safety but has since been adapted for use in other areas, including aviation safety. It involves seven steps, which include: conducting a hazard analysis; determining the critical control points; establishing critical limits; monitoring procedures; corrective actions; record-keeping; and verification (*Ibrahim et al., 2017)*.

In addition to HACCP, other risk identification techniques have been used in Nigerian airports. For example, *Ibrahim et al. (2017)* conducted a study on risk assessment and mitigation measures at Nigerian airports by employing an analytical hierarchy process (AHP). The results of the study showed that the major factors influencing risk at Nigerian airports included inadequate security, staff shortage, lack of maintenance culture, improper waste disposal practices, and poor lighting. Other studies have also used various risk identification methods at Nigerian airports. *Adebayo and Obong (2015)* employed a fault tree analysis approach to assess the risks associated with aircraft operations at Lagos International Airport. Meanwhile, *Ogunbanwo et al. (2016)* looked at the impact of human errors on flight safety at Kaduna International Airport using incident reports.

Various quantitative risk identification techniques have been used in Nigerian airports. *Basu and Mookerjee (2016)* examined how event tree analysis could be applied to identify potential hazards and risks at Abuja International Airport. The results indicated that the main sources of

risk were related to runway excursions, bird strikes, fuel tank overfills, incorrectly loaded cargo, and inaccurate weather forecasts. *Udegbe et al. (2018)* conducted a probabilistic risk assessment at Port Harcourt International Airport to determine the likelihood of each risk category. The most significant risks identified were related to fire, aircraft collisions, personnel injury, and environmental damage.

In addition to quantitative risk identification techniques, several qualitative approaches have been used to assess the safety of Nigerian airports. *Kehinde et al. (2019)* carried out a qualitative study on the perception of airport workers regarding the safety culture of Murtala Muhammad International Airport. They found that although employees felt that airport safety was important, they expressed concern about the lack of resources, training, and awareness of safety protocols. Furthermore, *Osinubi et al. (2018)* conducted interviews with stakeholders involved in airside operations at Kaduna International Airport to identify potential safety issues. The results revealed that the main safety concerns were related to ground handling activities, aircraft maintenance, operational procedures, and communication between personnel.

This review has provided an overview of the current state of research on identifying potential hazards and risks in Nigerian airports. Both qualitative and quantitative approaches have been utilized to assess the safety of these facilities. These studies have identified a range of potential risks, including runway excursions, bird strikes, fuel tank overfills, incorrectly loaded cargo, fire, aircraft collisions, personnel injuries, environmental damage, inadequate security, staff shortages, lack of maintenance culture, improper waste disposal practices, and poor lighting. Additionally, the perception of airport workers toward safety culture was found to be generally positive, yet there was concern about the absence of resources, training, and awareness of safety protocols.

2.3 Implementing Safety Regulations

Safety regulations are essential for the functioning of Nigerian airports. The implementation of such regulations has been a top priority for the Federal Airport Authority of Nigeria (FAAN) since its establishment in 1979. As one of the leading aviation authorities in Africa, FAAN has worked hard to create and maintain safety standards that meet international requirements. This review examines the current state of safety regulations at Nigerian airports, including the processes employed by FAAN to ensure their compliance. It also discusses the challenges associated with implementing such regulations in this context and provides recommendations for improvement.

Safety regulations have been an integral part of the aviation industry for many years. International organizations such as the International Civil Aviation Organization (ICAO) have developed standards and recommended practices that must be met by countries in order to operate aircraft safely. In Nigeria, the Federal Airports Authority of Nigeria (FAAN) is responsible for developing, maintaining and enforcing safety protocols at airports across the country *(Olaniyi et al., 2016)*.

The primary goal of FAAN's safety regulation program is to ensure that all Nigerian airports comply with ICAO standards. To do this, the organization employs a number of strategies and procedures. First, FAAN works closely with airlines and other stakeholders to develop safety plans tailored to each airport (*Ezeokoli et al., 2011*). These plans include detailed information on how to manage operations, respond to emergencies and handle hazardous materials. Additionally, FAAN conducts regular inspections of airports to check for compliance with safety protocols

(*Kayode & Adeyemo, 2017*). Furthermore, it requires airlines operating in Nigeria to submit reports each month detailing any potential incidents or accidents.

Despite these efforts, there are still significant challenges when it comes to ensuring the safe operation of Nigerian airports. According to *Ezeokoli et al. (2011)*, one major issue is the lack of resources available to FAAN. Despite being given the responsibility of regulating safety standards, the agency does not receive adequate funding from the government to carry out its duties effectively. This makes it difficult for them to hire qualified personnel and purchase necessary equipment. Additionally, the complexity of the Nigerian legal system poses another challenge, as it can be difficult to identify which laws are applicable in certain situations *(Ebong, 2007*).

Furthermore, the effectiveness of safety regulations at Nigerian airports may be compromised due to poor enforcement. *Kayode & Adeyemo (2017*) found that some operators are willing to ignore safety protocols in favor of cost-cutting measures. They noted that, in some cases, airlines may even bribe officials to overlook violations. Additionally, the authors argued that inadequate training can lead to human error, resulting in dangerous conditions.

This section highlighted the importance of safety regulations in Nigerian airports and discussed the various strategies employed by FAAN to ensure compliance. It has also identified some of the challenges associated with implementing such regulations in this context, such as limited resources and inadequate enforcement. Finally, it has provided suggestions for improvement, including increased government funding and improved training initiatives. As air travel continues to expand in Nigeria, it is essential that these issues are addressed to ensure the safety of passengers and crew members alike.

2.4 Enhancing Building Security with Physical Barriers

In recent years, airport security has become a major concern for both the public and the aviation industry. With increased global terrorism activities, airports have become more vulnerable to attack due to their large number of travelers, employees, and aircraft. This heightened vulnerability has led to the need for comprehensive security measures in order to protect the safety of passengers and staff. Physical barriers are one type of security measure that can be used to secure an airport against theft or terrorist activity. This section reviews the literature on the effectiveness of physical barriers in enhancing building security at Nigerian airports. It examines existing research studies on the impact of physical barriers on security levels and considers the implications of implementing such barriers in Nigeria's airports.

Nigeria's civil aviation system is currently undergoing significant changes aimed at improving its efficiency and reliability. The introduction of a new international terminal at Murtala Muhammed Airport (MMA) was designed to improve air transport services in and out of the country. However, with the current proliferation of threats posed by terrorists and criminals, there is an urgent need to strengthen building security at Nigerian airports. One way of achieving this is through the installation of physical barriers as part of an overall security plan.

Physical barriers are structures designed to either physically prevent access or deter potential perpetrators from accessing an area or building. Examples of physical barriers include fences, gates, walls, and bollards. These barriers act as a psychological deterrent and can also provide space between an intruder and other people in the vicinity, thus providing additional protection. Furthermore, they can limit access points into an area and can be equipped with alarms, sensors, and other forms of technology to detect unauthorized persons or objects.

A variety of theories and concepts have been applied to the study of physical barriers as a security measure. One theory is "target hardening" which suggests that increasing the difficulty and complexity of accessing a target will increase its resistance to attack (*Lambert et al., 2017*). By making it difficult for attackers to penetrate a given area, physical barriers can serve as a deterrence to would-be intruders. Another concept is "defensible space", which refers to the idea that design elements can be used to create areas where occupants feel safe and secure (*Newman, 1972*). By making an area more visible and open to surveillance, physical barriers can help to increase feelings of safety and reduce the likelihood of a crime being committed. Finally, social disorganization theory suggests that when communities lack adequate informal control mechanisms and resources, they tend to suffer from higher rates of criminal behavior (*Shaw & McKay, 1942*). By strengthening the physical boundaries of an area, physical barriers can help to reduce the opportunity for criminal activity.

Several studies have examined the use of physical barriers to enhance security at airports around the world. In 2015, Öztürk and colleagues conducted a study to assess the effects of physical barriers on security levels at Istanbul Atatürk Airport in Turkey. They found that the presence of physical barriers had a positive effect on perceived security among both staff and visitors. Additionally, the results indicated that physical barriers could be beneficial in reducing the risk of illegal entry, smuggling, and other types of criminal activity.

Similar findings were reported by *Sivasubramaniam and Chua (2015*), who studied the effectiveness of physical barriers at Changi Airport in Singapore. Their research showed that physical barriers had a positive impact on perceived security, particularly among female respondents. Moreover, the study revealed that physical barriers were effective in deterring attempted thefts and vandalism.

Sarabia et al. (2018) also investigated the efficacy of physical barriers at Madrid Barajas Airport in Spain. Their survey results indicated that physical barriers had a positive influence on perceived security, particularly among older participants. Furthermore, the study found that physical barriers reduced the rate of attempted thefts and decreased the amount of time required to pass through security checks.

Overall, the existing literature provides evidence to suggest that physical barriers can be effective in enhancing security at airports. However, there are some limitations that must be taken into account when considering the implementation of such barriers in Nigeria. Firstly, the cost of installing and maintaining physical barriers can be prohibitively expensive, especially when taking into account the likely costs associated with constructing these barriers in Nigeria (*Adegbite et al., 2018*). Secondly, it is important to note that physical barriers alone may not be sufficient to guarantee improved security; instead, they should be viewed as part of a larger security strategy that includes other measures such as staff training, technological improvements, and intelligence gathering (*Lambert et al., 2017*). Finally, while physical barriers may be able to reduce the rate of criminal activity, they do not necessarily address the underlying causes of insecurity within an airport environment (*Sarabia et al., 2018).* As such, any successful security strategy should incorporate a broader approach that takes into account contextual factors such as poverty, inequality, and political instability.

2.5 Employing Emergency Protocols and Procedures

Nigeria has one of the busiest airspaces in Africa, with over 60 international airports *(Nigerian Civil Aviation Authority, 2020*). Yet despite this heavy traffic, there are still significant concerns about the security and preparedness of its airports. Previous studies have highlighted the

inadequate implementation of safe operating procedures and a lack of adherence to international standards (*Adeyanju & Ademoye, 2019; Olukoya et al., 2018*). These issues are exacerbated by limited resources and funding for airport security as well as a lack of awareness among staff members (*Olukoya et al., 2018*). There is therefore an urgent need to improve the safety of Nigerian airports by implementing better emergency protocols and procedures.

Airport operators in Nigeria typically rely on manual processes when responding to emergencies, such as the use of fire extinguishers and evacuation slides (*Olukoya et al., 2018*). However, these methods may be ineffective in some situations due to inadequate training or a lack of preparation (*Adeyanju & Ademoye, 2019*). In addition, many airports struggle to coordinate and manage emergency responses, leading to delays and confusion (*Adeyanju & Ademoye, 2019*). For example, After a plane crash at Port Harcourt International Airport in 2010, it took nearly forty minutes for the National Emergency Management Agency to respond (*Ibrahim-Garba, 2012*). As a result, the Nigerian government has issued guidelines on speedier response times, but there is still room for improvement (FAA, 2017).

Furthermore, most Nigerian airports lack comprehensive plans for dealing with disasters, including natural hazards such as floods and storms (*Olukoya et al., 2018*). Without adequate planning, airports could be ill-equipped to handle unexpected emergencies, resulting in chaos and disruption (*Adeyanju & Ademoye, 2019*). Moreover, Nigerian airports often fail to comply with international regulations, such as those set out by the International Civil Aviation Organization (ICAO) and the Federal Aviation Administration (FAA) (FAA, 2017). These organizations provide guidance on how airports should prepare for and respond to crises, yet few Nigerian airports follow these rules.

The implementation of emergency protocols and procedures in Nigerian airports can be improved through increased investment in infrastructure and personnel. For instance, airports should invest in technology that can detect and respond to emergencies quickly and efficiently (*Adeyanju & Ademoye, 2019*). They should also invest in more sophisticated communication systems, which can help coordinate responses between different agencies (*Olukoya et al., 2018*). Additionally, airports should train their staff on emergency procedures and equip them with the necessary materials to deal with crises effectively (*Adeyanju & Ademoye, 2019*).

It is also important for Nigerian airports to develop comprehensive emergency plans that outline all possible scenarios and the steps required to respond to them (*Adeyanju & Ademoye, 2019*). This includes identifying risks, establishing lines of responsibility, and setting up robust communications networks (*Adekola, 2015*). Furthermore, it is essential for airports to regularly test these plans and update them as needed. Finally, Nigerian airports should strive to adhere to international guidelines, such as those provided by ICAO and FAA (FAA, 2017).

2.6 Training Staff on Safety Requirements in Airports

Safety is a top priority for any commercial airline. All airports are responsible for ensuring the safety of their passengers and staff, as well as providing them with a safe environment in which to operate. Nigeria has recently experienced numerous aviation incidents, including aircraft accidents, fires, and hijackings, that have highlighted the need to improve airport safety standards. As such, training staff on safety requirements at Nigerian airports is essential in order to ensure the safety of both passengers and personnel. This paper provides a critical literature review of existing research into how effective training staff on safety requirements could be implemented in Nigerian airports.

In recent years, there have been several studies conducted concerning the effectiveness of safety training for staff at Nigerian airports. Adedokun and Olayinka (2018) conducted a study to investigate the adequacy of current security measures employed by Nigerian airports. The authors found that most airports lack proper staffing and standard operating procedures (SOPs), meaning there is insufficient capacity to carry out security protocols or effectively train staff. Furthermore, inadequate funding was identified as a major impediment to successfully implementing safety training programs. These findings suggest that if Nigerian airports are to meet international safety standards, they will require increased resources and improved SOPs.

Adebisi et al. (2019) analyzed the impact of employee training on safety performance in Nigerian airports. Their research concluded that while employees had some knowledge of relevant safety regulations, they lacked an understanding of how to apply the regulations in practice. In addition, the majority of accidents investigated were due to human error, indicating that safety training should focus more on teaching employees how to use the knowledge they possess in order to prevent these types of errors from occurring. The authors conclude that a comprehensive and ongoing training program is necessary to help increase safety awareness among all staff members.

Amadi et al. (2020) evaluated the effectiveness of safety management systems (SMSs) in Nigerian airports. The study concluded that SMSs are not widely adopted and that there is no unified framework for implementation across all airports. Additionally, the authors noted that many airports lack sufficient resources to properly implement safety training programs. They recommend that future initiatives should seek to develop better strategies for integrating SMSs into airport operations, as well as provide additional support for those seeking to obtain safety certifications.

The body of literature reviewed suggests that adequate safety training for staff at Nigerian airports is lacking. A lack of financial resources and poor standard operating procedures prevents airports from properly implementing training programs. Moreover, the limited understanding of safety regulations among employees implies that even if training programs are introduced, they may not be effective unless they focus on developing practical skills. Finally, a unified approach to implementing safety management systems is needed in order to ensure consistency across all airports.

2.7 Utilizing Fire Protection Systems

Fire protection systems are designed to detect, suppress or extinguish fires before they cause significant damage to property and/or personal injury. These systems typically comprise smoke detectors, sprinklers, suppression systems, alarms, exit routes, and other components. The design and implementation of fire protection systems in Nigerian airports have been examined in several studies. *Olufemi et al. (2013*) conducted a survey of fire safety measures at four Nigerian airports, which included interviews with stakeholders and an examination of relevant documents. They found that there was a lack of standardization in terms of equipment and procedures used to manage fire risks at the different airports. Furthermore, the authors identified inadequate training and awareness among staff, as well as insufficient monitoring of firefighting activities, as areas for improvement. In addition, the study highlighted the need for adequate emergency response plans and evacuation procedures, as well as improved regulations relating to fire safety in Nigerian airports.

Other studies have also investigated the effectiveness of fire protection systems in Nigerian airports. Fapohunda and Shittu (2016) assessed the performance of fire extinguishers at six Nigerian airports. They concluded that the majority of fire extinguishers were either not working correctly or not located in designated locations. The authors recommended further testing and maintenance of fire extinguishers, as well as improved training of staff in their correct usage. Similarly, Odofin (2015) evaluated the availability of fire prevention and control measures at five Nigerian airports and found that access to water supplies and firefighting equipment was limited. He suggested that additional resources should be allocated to ensure that these facilities are sufficient to meet the demands of each airport.

In addition to examining the efficacy of fire protection systems in Nigerian airports, some studies have focused specifically on the assessment of passenger safety during emergencies. Adesina et al. (2018) studied the feasibility of a proposed emergency evacuation plan at two Nigerian airports. Their findings indicated that the existing infrastructure and procedures were inadequate for evacuating large numbers of people in a timely manner. Moreover, the authors noted that many passengers were unaware of the proper evacuation protocols and lacked confidence in the airport's ability to respond effectively in the event of an emergency.

Overall, the literature suggests that fire protection systems in Nigerian airports are currently inadequate. Most studies have identified deficiencies in the design and implementation of these systems, as well as in the knowledge and skills of personnel charged with managing fire risks. Although there have been some efforts to address these issues, more needs to be done to ensure that Nigerian airports are able to respond effectively in the event of a fire-related emergency.

It is also apparent that the current regulatory framework governing the use of fire protection systems in Nigerian airports is lacking. Currently, there is no legal requirement for airports to implement fire safety measures, and even where such measures exist, they tend to be poorly enforced. Furthermore, there is limited guidance available on how best to design, implement and maintain fire protection systems in Nigerian airports. It is therefore essential that the Nigerian government develops clear guidelines, suitable legislation, and enforcement mechanisms to ensure compliance with fire safety standards.

2.8 Designating Areas for Passenger Movement

There have been several studies over the years that have examined the issue of designating areas for passenger movements in Nigerian airports. Most of these studies have focused on the layout of existing airport terminals and infrastructure as well as their impacts on passenger movement efficiency and safety.

The earliest study was conducted by Ndubuisi (2006) who explored the impact of different layouts and configurations of terminal buildings and pathways on passengers' experience in Abuja International Airport. He used surveys to collect data from passengers and analyzed the results to determine where improvements could be made. His findings showed that there were numerous issues with the way the airport was laid out which led to inefficient passenger movements. For example, he identified overcrowding at certain points due to inadequate space, long queues, and confusion regarding which route to take. Furthermore, he noted that the lack of designated waiting areas was leading to an increase in aircraft delays due to passengers not being able to access their gates quickly enough. Consequently, he recommended various changes such as redesigning the layout of the terminal building and introducing more clearly defined routes and designated areas for different kinds of travelers.

In another study, *Oludare (2009)* investigated the effectiveness of signage systems in two major Nigerian airports: Murtala Muhammed International Airport (MMIA) and Port Harcourt International Airport (PHIA). Using both qualitative and quantitative methods, the researcher examined the role of signage systems in guiding passengers through the terminals efficiently and safely. His findings revealed that although signage systems were present in both MMIA and PHIA, they were lacking in terms of clarity and consistency, thus making it difficult for passengers to navigate the terminals effectively. In addition, he found that the signs were often outdated or incorrect, leading to further confusion. As a result, he suggested that clear, consistent, and regularly updated signage should be implemented in order to ensure smooth and efficient passenger movements in Nigerian airports.

A third study, conducted by *Ozonle (2014*), looked at the impact of airport infrastructure on passenger experiences in Lagos and Port Harcourt International Airports. Through survey questionnaires, the researcher gathered information about passengers' perceptions of the airports' infrastructure and services. In particular, he found that the airports lacked sufficient seating, lighting, and amenities, which resulted in passengers having to wait in long lines. Moreover, he uncovered that the availability of restrooms and restaurants was low, creating difficulties for passengers who needed to use the facilities or purchase food during layovers. Additionally, he discovered that the presence of adequate signage and directional cues was necessary in order for passengers to find their way around the terminals but that many of the locations were poorly marked or hard to understand. He concluded that these issues contributed to passenger dissatisfaction and need to be addressed in order to create an optimal travel experience.

Overall, the reviewed studies indicate that there are significant problems when it comes to designating areas for passenger movements in Nigerian airports. These include poor and unclear

signage, overcrowding, inadequate seating and lighting, and limited amenities. All of these factors contribute to inefficient and unsafe passenger movements and lead to negative passenger experiences.

The first two studies highlighted the importance of effective layout and signage in order to allow passengers to move around the terminals easily and safely. *Ndubuisi (2006)* proposed redesigning the layout of the terminal building and introducing more clearly defined routes and designated areas for different kinds of travelers. Similarly, *Oludare (2009*) argued for clearer, more consistent signage systems throughout the airports to guide passengers successfully. These studies demonstrate that proper planning and implementation of precise guidelines is essential for successful outcomes.

On the other hand, *Ozonle (2014*) pointed out the necessity of providing adequate seating, lighting, and amenities to ensure comfort and convenience for passengers. His findings also highlight the need for destinations to be clearly marked so that passengers can locate them without difficulty. Therefore, all three studies suggest that Nigerian airports require better design and management in order to promote efficient and safe passenger movements.

2.9 Managing Scheduling and Crowd Control Strategies

Scheduling and crowd control strategies used in airlines generally include flight schedules, gate assignments, boarding procedures, check-in processes, passenger flow management, and security protocols (*Mok & Leung, 2014*). In the context of Nigerian airports, these strategies can be divided into two main categories: pre-flight and post-flight scheduling and crowd control strategies. The pre-flight strategies involve tasks such as aircraft maintenance, ground handling, airline ticketing, baggage handling, and other activities that take place prior to passenger arrival.

Post-flight strategies focus on crowd control measures such as queue management, boarding process, and seating arrangements (*Ogunyemi, 2019*).

Various studies have been conducted to examine the effectiveness of different scheduling and crowd control strategies in Nigerian airports. A study by *Adeshina et al. (2017*) evaluated the impact of pre-flight processes on the efficiency of scheduling and crowd control strategies. Their results showed that improved coordination between ground handling staff and airlines led to better utilization of resources and faster turnaround times. Furthermore, they found that early communication with passengers helped reduce delays and improve overall satisfaction.

In another study, *Ogundele et al. (2019*) investigated the effectiveness of post-flight crowd control strategies in Nigerian airports. They concluded that effective crowd control strategies help reduce congestion during peak periods, facilitate smoother boarding processes, and minimize waiting times. Additionally, they argued that well-designed seating plans and queue management systems help improve passenger comfort levels.

Despite the positive findings from previous research, there is still room for improvement when it comes to managing scheduling and crowd control strategies at Nigerian airports. One area that has not been sufficiently addressed is the lack of technological advancements. Many Nigerian airports are still relying on outdated methods of scheduling and crowd control, which can lead to inefficient operations (*Ajayi et al., 2020*). Therefore, it is important for Nigerian airports to invest in modern technologies such as automated gates, self-service kiosks, and computerized booking systems to improve efficiency.

Additionally, the existing scheduling and crowd control strategies do not adequately address the needs of special groups, such as elderly people or disabled travelers. It is essential for airports to

develop appropriate strategies for accommodating these individuals so that they are provided with a comfortable and hassle-free travel experience. Finally, there is also a need for improved training programs for employees involved in scheduling and crowd control activities. This would enable them to acquire the necessary skills to effectively manage the various operational processes.

2.10 Ensuring Adequate Lighting and Visibility

Safety is paramount in any context, with airports being one of the most critical points where superior safety standards must be met. In such an environment, Ensuring Adequate Lighting and Visibility are two essential components to meeting these objectives and providing a safe atmosphere for travelers, staff, and other stakeholders (*Delmée & Cuéllar-González, 2018*). It has been established that adequate lighting in airline terminals not only helps promote positive passenger experiences but also provides an increased level of security (*Radwanova, 2014*). Illumination within airside areas, although often overlooked, must also meet minimum safety recommendations to enable visual recognition between aircraft and airport vehicles under different weather scenarios (*Hertel et al., 2017*). A study by *Nejat and Othman (2012*) revealed that lighting accounts for more than 70% of aircraft visual detection compared to contrast which stands at 27%. The study concluded that ensuring standard lighting levels can assist decision-makers when establishing aviation boundaries in densely populated regions can help promote safety standards.

Regarding lighting characteristics varying effects on people's behavior, according to *Bahadori (2017)*, appropriate lighting intensity has a direct relationship with the sense of security

experienced by users. Conversely, poor conditions, darkness, or monochromatic lighting can create unease amongst passengers, thus decreasing the overall experience and possibly compromising airport safety *(Aykurt & Uyulgan, 2019; Borresen, 2013).* Similarly, *Trimis et al. (2012)* have studied how intense glares produced from inadequate directed light may lead to tiredness and decreased performance for those working in selective airport sectors like air traffic control towers. Based on this evidence, it can be suggested that suitable light intensities should be meticulously selected depending on operational needs to reduce the likelihood of user distraction, confusion, or fatigue while still synthesizing a pleasing aesthetic look.

Ensuring proper airport visibility is another aspect critical for runway safety. According to *Rechowicz (2018)*, mist during early morning or foggy/rainy evenings diminishes the pilot's ability to recognize essential elements before landing due to the low amount of available natural lighting combined with the absence of proper infrastructure design (i.e., lights along taxiway channels). Thus, the assessment of clear visibility enhancement protocols, including limiting potential airspace obstacles, plus the dynamic implementation of ground lighting systems, become critical requirements for a successful landing. Recently developed tools combining physical model activities with computational models evaluate the impact of different meteorological variabilities (wind speed, turbulence, temperatures) on pilots' reaction times when faced with zero-visibility incidents. For instance, *Geiseler et al. (2019*) proposed a system based on Bayesian networks to identify optimum thresholds over visibility range variables considering specific use case applications such as specialized military operations.

Finally, Singh and Papagiannis (2010) reported the benefits associated with airport LED systems compared to traditional technologies. As energy usage rates constantly increase, initiatives toward higher "eco-sustainability" standards effectuated through green technology investment

are strongly recommended for economical and environmental reasons. Likewise, Selvam (2015) demonstrated that LEDs enable savings of up to 80% of conventional halogen lighting sources in terms of power frequency and lifetime usage. Concerning airport preferences, these outputs would benefit companies financially while fulfilling international regulations. Moreover, *Panchal et al. (2014)* claimed advantages related to reduced maintenance and improved static strength for dynamic intensity alteration during daytime cycles. All of the above indicate the significant positive implications behind adopting LED solutions within airport environments worldwide.

In summary, Ensuring Adequate Lighting and Visibility provides multiple benefits regarding airport safety and efficiency throughout all sectors ranging from navigability to enhanced user satisfaction. Good lighting and visibility settings decrease negative consumer perception and extend operating parameters due to progressive technological advancement involving high-resolution cameras and automated robotic inspections *(Reck and Clausetti, 2007*). Considering the acceleration of new digital products and services, there is utility in further studies focused on understanding human behavior under different artificial lighting conditions coupled with taking into account the latest advances in big data integrated sensor structures that accommodate precision monitoring along longitudinal runway stages. In line with this, more significant investments need to be devoted by decision-makers to developing intelligent automation techniques for risk analytics computation during airside operations. Only in this way could eventually be achieved the desired airport reliability and passenger safety capacities.

2.11 Establishing Standard Operating Procedures (SOPs)

Standard Operating Procedures (SOPs) are detailed, written instructions that outline the steps to be taken when completing a process and are used across the aviation industry to ensure safety. Specifically, SOPs have been used at airports to streamline operations, provide strategies for operational situations, facilitate continuity between personnel changes, create accountability for actions taken, and ultimately promote safety (*McClenahen., 2017*). As businesses optimize and automate their workflows through technological advancements, utilization of effective SOPs is becoming increasingly urgent to keep pace with this efficiency and maintain airport safety. Right now, there are differing standards in place which may lead to confusion regarding safety protocols among airport personnel and managers.

Studies suggest that implementing SOPs across various airlines can improve operational efficiencies and safety procedures across airports worldwide (*Lambert & Koppen, 2018*). In the U.S. alone, air carriers use 20 different maintenance control systems or methods to oversee inspections–which could arguably lead to increases in errors if there isn't one regulating method. Studies suggest that tangible profits may be made by using standard envelope processes across the board, such as using common maintenance control practices instead of multiple ones, resulting in an estimated $430 million economic benefit (*Cox et al., 2019*).

Following those results, cooperation among authorities needs to occur to ensure that all employees understand and abide by specific safety requirements (*Gorman & Shorrock,2017*). For example, clearly defining management and operations responsibilities within lines of authority over safety ensures consistency in action taken and promotes alignment among decisions made by members of the team operating within designated regions or corridors (*Rizvi*

& Kakar,..2015). A unified system leads to more efficient decision-making, free from contradictions. Implementing SOPs would prove helpful as long as these procedures mesh well with pre-existing structures—further demonstrating the importance of collaboration amongst regulatory agencies where non-overlapping tasks exist.

In terms of the effects SOPs yield, studies suggested exciting findings. When they were introduced, whether intentionally or unintentionally, researchers found that self-checking defined as "any behavior initiated by pilot crewmembers to detect shortcomings or weaknesses in flight operations" improved following the implementation of SOPs (*de Kort et al., 2014*). Perhaps pilots felt encouraged to either identify gaps in existing procedures or strengthen current practices after being exposed to them. Despite anecdotally feeling cautious previously about probing into colleagues' actions, the introduction of SOPs perhaps gives both pilots and other positions within the airport the push needed to make small changes continuously to ensure maximum safety.

Inextricably linked with efficient operation capabilities and improved safety efforts, another area worth exploring was cost–efficiency. *Hamilton et al. (2008*) note that when compared to conventional video surveillance, SOPs offer greater convenience, reduced costs due to limited human man hours being utilized, improved compliance with minimal enforcement continuing post-adoption, and higher accuracy ratios since all deviations from the outlined processes remain recorded via digital logs available for simplified analysis. With the current pandemic having put a severe financial strain on many businesses, profit margins often emerge as major deciding factors when it comes to adopting new technology; streamlined operations paired with lowered costs certainly create a case for airplane vendors and operators to look towards increased utilization of SOPs to stay profitable while still abiding by regulations.

Furthermore, it is essential to consider the broader implications of implementing SOPs specifically in automation risk and mitigating human error through instilling trust. Automation has continued to seep through every facet of the business, especially considering that much of the competition today centers around minimizing input times, optimizing shorter travel time durations, and other heightened service expectations *(McGurk & Twigger,2019).* It cannot be ignored that automation itself carries risks. Scientists believe that machines can sometimes contribute to ambiguous situations ultimately requiring humans to step in when something is amiss (*Ramesh et al.,2016).* Therefore, relying solely upon machines without proper oversight can pose an immense danger, and hence faith should be placed in the staff rather than mechanical responses. To cultivate a safe environment for passengers, workers must feel empowered to intervene if needed, as policies reiterate our need to maintain responsibility while increasing convenience while utilizing SOPs.

Establishing SOPs in airports makes sense to reduce confusion among personnel managing operational duties, mitigate human failings, and capitalize on the efficiency offered by technology advantages. Even though autonomy and precision offered throughout mechanized processes tend to create safer habits for personnel, further training each individual within the chain is necessary because human intervention remains the best way to approach everything especially when life is on the line. Considering all of the variables associated with airports in tandem with the outlined dilemmas accompanying SOPs, prioritizing cost-effectiveness and introducing/updating tightly regulated operations involving automated features, routine checking measures, and expanding employee involvement become essential to achieve effective and safe outcomes.

2.12 Maintaining Equipment and Vehicles

Maintaining airport vehicles and equipment is essential for ensuring safety and efficiency on the airfield. Reliable and fully functioning vehicles, ground equipment, aircraft ramps, taxiways, and runways are necessary to ensure safe flight operations (*Condon et al., 2018).* Thus, proper maintenance and inspection of all equipment and vehicles used by airports should be considered a top priority to ensure optimal performance and minimal downtime, which can lead to disruption, delays, cancellations, and even accidents *(Rivera 2014; Khan & Costanzo, 2017; Jasiak et al., 2019)*. This paper will review some of the literature related to maintaining equipment and vehicles used at airports, outlining the critical components of good practice, evaluating existing approaches to maintenance management systems, highlighting potential problems associated with improper maintenance, and discussing ways to achieve a high level of equipment/vehicle upkeep realistically.

To begin, it is beneficial to understand the broad scope of equipment and vehicles involved in aviation operations. According to Sammartino (2017), these include Ramp service equipment, such as deicing trucks, fuel delivery devices, electric carts with stairs and loader support modes; tow tractors for pushing planes; tugs and baggage conveyor belts; cargo handling machines; access stands; baggage trucks, and passenger buses, among many others. To properly maintain this assortment of equipment and vehicles, an effective system must be firmly established with regular checks and proper records showing when regular servicing has been performed. Such practices have not always been adequately followed, thus leading to dangerous situations due to non-functional or poorly maintained vehicles. For instance, *Kurata et al. (2016)* studied two fatal incidents caused by understaffed maintenance groups unable to keep up with vehicle repair requests. Similarly, *Rennie et al. (2013)* discovered that inadequate preventive maintenance

planning was linked to low utilization rates of transportation assets and inappropriately scheduled production times due to unserviceable equipment resulting in missed deadlines.

Since precise planning, constant surveillance, and professional knowledge are necessary to run a successful maintenance program, cost-saving principles are vital to monitor and optimize investments toward long-term improvement *(Hong & Kim 2018*). In particular, *Dickey and Youngblood (2017)* introduced a "Just-in-Time" philosophy combining quality control and inventory management strategy with labor efficiency tools like total productive maintenance (TPM) intended to reduce costs while stimulating greater job satisfaction through improved working conditions. Moreover, the authors introduce condition-based monitoring programs to track failure trends or recurring issues allowing engineers to diagnose malfunctions rapidly from centralized systems without having to inspect each piece of machinery individually.

In addition to TPM strategies, predictive analytics, as suggested by *Prakash et al. (2012),* provides an attractive alternative to traditional proactive maintenance methods. Predictive models allow operators to evaluate present risks and draw action plans based on past experiences making them more adept at preventing hidden faults or anticipating future errors. Coupled with advanced machine learning algorithms like those employed by *Harahap et al. (2015),* organizations could gain unprecedented insight into their routine maintenance outcomes, helping them accelerate repairs and promptly plan foreseeable requirements.

Lastly, a reliable Failure Mode Effect Analysis (FMEA) should also be implemented following the specifications outlined by *Kumar et al. (2016).* FMEA is a structured reactive method for determining potential or latent vulnerability within segmented processes and operating steps enabling resolution teams to determine corrective actions before unnecessary losses reach critical

stages *(Kumar et al., 2016)*. Also, *Chowdhury et al. (2018)* emphasized the importance of embracing such risk analysis techniques designed to mitigate component failure and transport disasters since they provide a comprehensive way to identify dependencies and assess general threats across entire asset life cycles.

Precautionary measures such as trending technologies and regular preventative inspections to minimize defects and reduce downtimes are indispensable components of any efficient security message applied to secure airport functions *(Tallonigro & Shibuya, 2013*). These solutions approach deficient areas such as dulling vehicle sensors, eroding brakes, worn exhaust parts, clogged air filter anomalies, engine oil deterioration, battery lifetime expectancy, etc. Cutting-edge management systems greatly benefit automotive operations, becoming cornerstone fundamentals of airport industry protocols ensuring reliability and client protection (*Dutta et al., 2014)*. When managed well, such technology allows complete transparency of all mechanistic activities opening a window of visibility over fleet performances, uncovering unforeseen motor compromises, consolidating multiple data sources, assimilating detailed insights, and helping raise overall standards exponentially *(Liu et al., 2012*).

In conclusion, adequate supervision, record keeping, adherence to SOPs, the inclusion of trend analysis programs, and coupling of risk assessment procedures represent precisely crafted ingredients of a sustainable maintenance strategy tailored to enhance beyond expectations, most, if not all, airport operational goals. Proactive maintenance search needs to extend its jurisdictional umbrella beyond decorative painting, seeking instead the root cause of every potential error embedded into mechanical elements bringing further aeronautical safety from early detection prevention processes.

2.13 Integrating Technology Solutions

Modern society is increasingly reliant on concept technologies to ensure the safety of passengers and personnel in airports. Technology solutions play a critical role in the breadth of operations, from security-related screenings via body scans, x-rays, metal detectors, and drug testing machines, to communication and navigation systems facilitating flight takeoffs and landings (*Eatough & Smart 2017*). This paper will review recent literature to discuss how integrating technology solutions in airport safety can improve services and increase efficiency.

The Aviation Transportation Safety Act 2002 requires all passengers traveling on international flights to be subject to additional security screening procedures (*Bryan, 2018*). Improved technological infrastructure has addressed this requirement more effectively, hastening passenger throughput while offering more accuracy through excellent accuracy detection capabilities (*Habibi et al., 2020*). The most well-known example of an advanced technical scanner is the 3D imaging scanner, which allows an image of concealed items or flaws to be generated without physical contact with passengers (*Gursahanyan & Gershman, 2019*). However, some countries face challenges due to financial limitations that prevent such systems' installation or integration within their airports (*Silva et al., 2016)*. To overcome these issues, less resource-demanding technologies, including intrusion detection systems and video surveillance technology, often present viable alternatives *(Bozzelli et al., 2019*).

Automation plays a crucial role in streamlining airport processes, reducing delays, higher service quality, and cost savings *(Kefela Malaka & Dosio 2021*). Software applications can now predict aircraft arrivals and departures by combining data from multiple sources such as air traffic control, radar signals, aircraft tracking systems, and weather databases *(Basirat, Mohtasebi &*

Bahnia, 2014). Automation has enabled airlines to shift towards self-service check-in counters and digital boarding passes and tickets, optimizing turnaround times significantly *(Tindle & Wheeler, 2015).* Furthermore, the utilization of autonomous robots has gained traction, accelerating gate changes, luggage handling, maintenance operations, and other ground services *(Mhedlid et al., 2018).* Although robot deployments require significant capital costs initially, making them difficult to justify solely for long-term savings *(Singhal, Sinha & Deshmukh, 2018),* they are often proven necessary due to processing issues, confinement of space, or hazardous operations not feasible otherwise.

Systemic deployment of devices influences a range of communications capabilities that span terminal relaying, voice connection, intercom usage, and ship broadcasts *(Lattanzi et al., 2019)*. Such a framework invites potentially costly interfaces but, at the same time, presents various operational advantages if integrated correctly *(Sanchez Blanco et al., 2018)*. Passengers benefit further owing to telecoms' ability to offer access to information regarding arrival/departure gates and restaurants *(Miller & Matzke, 2021).* Interconnected networks facilitated through wired or wireless broadcasting mediums facilitate the uninterrupted data flow between stations, providing flexibility in any disruption *(Ang & Soh, 2017).* Aside from improving delivery speed and reliability, deploying fiber optics increases customer satisfaction ratings remarkably due to faster loading response times *(Zhang & Huang, 2016).*

In summary, advancing integrative technology provides airports with immense opportunities to increase efficiency and convenience, whether ensuring secure passage via high-level scanning equipment, boosting operational effectiveness through automation, connecting networks, or transmitting essential information to passengers quickly. Airport teams should strive to develop multifaceted strategies when selecting and implementing technological solutions while

considering current needs and future trends. Innovative research and development initiatives related to robotics must continue so that positive results emerge. Clear roles and responsibilities should be defined between stakeholders to capitalize further on the gains offered by such implementations.

Chapter Three

Methodology (Case Studies)

Research methodologies are the tools employed in any research work to gather data, investigate and analyze them. The case study approach was employed for this research work. An action, event, or problem that involves a real or hypothetical circumstance and includes the intricacies you would meet in real life is called a case study. It can also be a record of building's problem and how they were solved. It entails a scrutiny of buildings, to note her type, background, facilities provided, functionality, materials used, management, services and maintenance etc *(Xie, 2017).* Case studies are a useful tool for illuminating the intricacies of real-world decision-making. While investigating a case study, you will analyze and apply knowledge, and reasoning to draw a conclusion" *(Xie, 2017).*

Here are some key architectural factors that are crucial in the design process which are used to exam the case studies.

I. **Passenger Flow and Circulation**: Efficient passenger flow and circulation are essential to avoid congestion and delays. Architects must plan for clear and logical pathways for arriving, departing, and transferring passengers. This includes designing spacious and easily navigable terminals, immigration and customs areas, baggage claim, security checkpoints, and boarding gates.

II. **Terminal Design:** The terminal is the heart of any airport, and its design should accommodate the expected passenger capacity while providing a pleasant and comfortable experience. Terminal layout, seating areas, retail spaces, lounges, and amenities should be strategically placed to enhance passenger convenience and satisfaction.

III. **Aircraft Apron and Taxiways**: Architects must plan the layout of the aircraft apron and taxiways to ensure smooth movement and parking of aircraft. Adequate space for airplane taxiing, parking bays, and maintenance facilities should be considered.

IV. **Runway Design:** The design and orientation of the runways are crucial for safe take-offs and landings. Factors like prevailing wind patterns, topography, and aircraft types expected to use the airport should be considered.

V. **Safety and Security:** Ensuring the safety and security of passengers and airport personnel is paramount. Architects need to incorporate security checkpoints, surveillance systems, emergency exits, fire suppression systems, and blast-resistant structures where necessary.

VI. **Accessibility:** The airport should be designed to be accessible to all passengers, including those with disabilities. This involves providing ramps, elevators, designated seating areas, and accessible restrooms throughout the terminal.

VII. **Sustainability and Energy Efficiency:** Modern airport designs prioritize sustainability and energy efficiency. Architects can incorporate green building materials, energy-efficient lighting, water conservation measures, and renewable energy sources.

VIII. **Baggage Handling System**: An efficient and reliable baggage handling system is crucial to prevent delays and lost luggage. Architects must allocate space for baggage processing, conveyor belts, and sorting areas.

IX. **Public Transport Integration:** International airports often serve as major transportation hubs. Integrating various public transport options like trains, buses, and taxis into the airport's design is important to facilitate seamless connectivity.

X. **Cultural Sensitivity:** International airports serve travellers from diverse backgrounds and cultures. Architects should be mindful of cultural sensitivities in their design choices, including architectural motifs, artwork, and prayer or meditation spaces.

XI. **Future Expansion:** Airport designs should be flexible enough to accommodate future growth and expansions. Master planning should consider long-term development to avoid the need for major disruptions later on.

XII. **Aesthetics and Identity**: The design of an international airport can also play a role in representing the identity and culture of the host country or city. Architectural elements and interior design can be used to create a sense of place and leave a lasting impression on passengers.

The case studies are however carried out are listed as follows;

1. TAG Farnborough Airport, Famborough, Orpington, Greater London, UK
2. Fort McMurray International Airport, Fort MacMurray, Alberta province, Canada.
3. Shenyang Taoxian International Airport, Shenyang, Liaoning province, China.
4. The Murtala Muhammed International Airport, Ikeja, Lagos, Nigeria.
5. Nnamdi Azikiwe International Airport, Abuja

Case Studies

3.1.1 Case Study One: The Murtala Muhammed International Airport, Lagos, Nigeria

The MMA2 experiment provides an insight into what it would look like when the private sector is involved in the provision of infrastructure, using the public-private-partnership model. This could help in solving the dire infrastructure deficit in the country. The MMA2, with its Multi-Storey Car Park (MSCP) and the facilities therein, is still a worthy example in the aviation landscape. Despite all the challenges, some of which may have been engineered by those against the MMA2 dream, its operators, Bi-Courtney Aviation Services Limited (BASL), have resolutely remained open for business. The endurance of the operators for the past one decade is what further makes the terminal tick. On the whole, the courage and the

resilience to make MMA2 work in the face of stiff opposition from vested interests is what counts for BASL and is a lesson for private investors.

DESCRIPTION

The Murtala Muhammed Airport Lagos, is a public airport and one of the main international airports in Nigeria, the New international airport terminal modeled after Amsterdam airport Schiphol was Opened for public use on !5th Day of March 1979.

The Airport was upgraded forty years after giving room for new facilities constructed by the Chinese Civil Engineering Construction Company (CCECC)

Table 1

Project Client	Federal Airports Authority of Nigeria. (FAAN)
Capacity	14,000,000 passengers per annum
Land Area	56,000 square metres
Other facilities	

Merits: The airport is equipped with Category One navigational equipment, safety facilities, and infrastructure.

Plate 3. 1:MMA International terminal

Source: Researcher's Archives

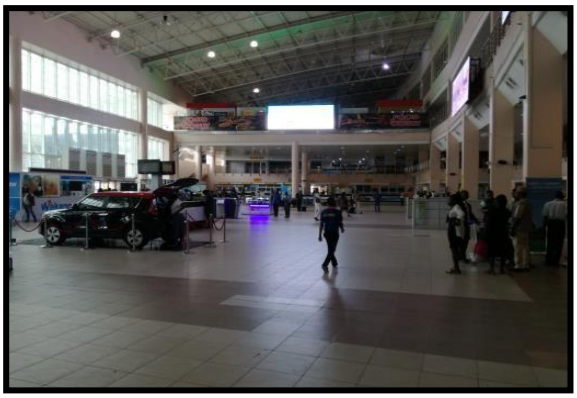


Plate 3. 2:MMA terminal departure concourse
Source: Researcher's Archives

Plate 3. 3:MMA Exterior view
Source: Researcher's Archives

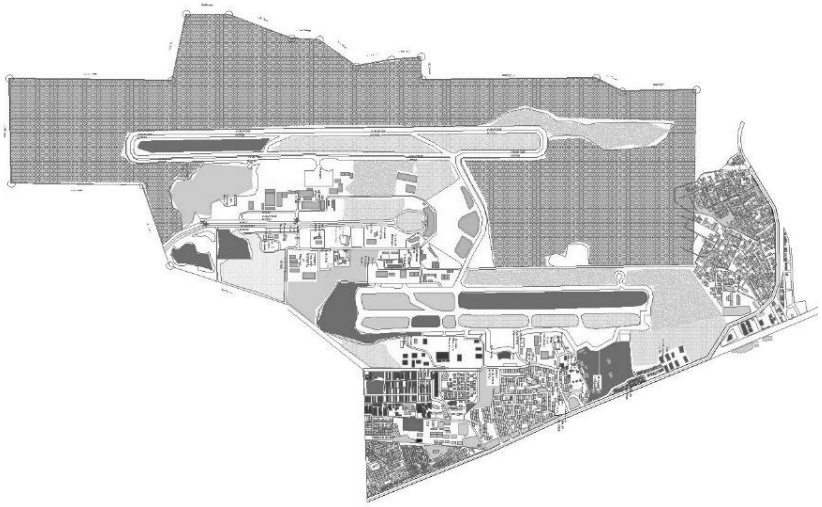


Figure 3. 1: Murtala Muhammed International Airport General Site Layout
Source: Google imagery

Table 2

S/N	**FACTOR**	**GOOD**	**FAIR**	**BAD**

I.	**Passenger Flow**	✓		
II.	**Circulation**	✓		
III.	**Terminal Design**	✓		
IV.	**Aircraft Apron and Taxiways**:	✓		
V.	**Runway Design:**	✓		
VI.	**Safety and Security**	✓		
VII.	**Accessibility**	✓		
VIII.	**Public Transport Integration:**	✓		
IX.	**Sustainability and Energy Efficiency**			✓
X.	**Baggage Handling System**		✓	
XI.	**Cultural Sensitivity**	✓		
XII.	**Future Expansion**		✓	
XIII.	**Aesthetics and Identity**	✓		

3.1.2: Case Study Two: TAG Farnborough Airport

3DReid's aim was to create a building, which picks up on and reflects the technology and beauty of the aircraft. The project has been given a RIBA Award. 3DReidArchitects, located at Farnborough, Orpington, Greater London, BR6, UK. The Landscape Architect – Lovejoy,

Structural steelwork, Rowecord Engineering, Contractor – TAG Construction Management and constructed in the year 2010. As the home of British aviation, Farnborough Airport offers expert full-service facilities for based and transient aircraft, alongside over 240,000 sq ft of temperature-controlled hangarage.

Farnborough Airport also offers exceptional aircraft assistance, renovation and maintenance services through its on-site partners Gulfstream Aerospace Corporation and Dassault Aviation Business Services (DABS).

Plate 3. 4: TAG Farnborough Airport Terminal Building Exterior
Source: Google Imagery

Plate 3. 5: TAG Farnborough Airport Apron
Source: Google Imagery

Figure 3. 2: TAG Farnborough Airport Terminal Site Layout
Source: Google Imagery

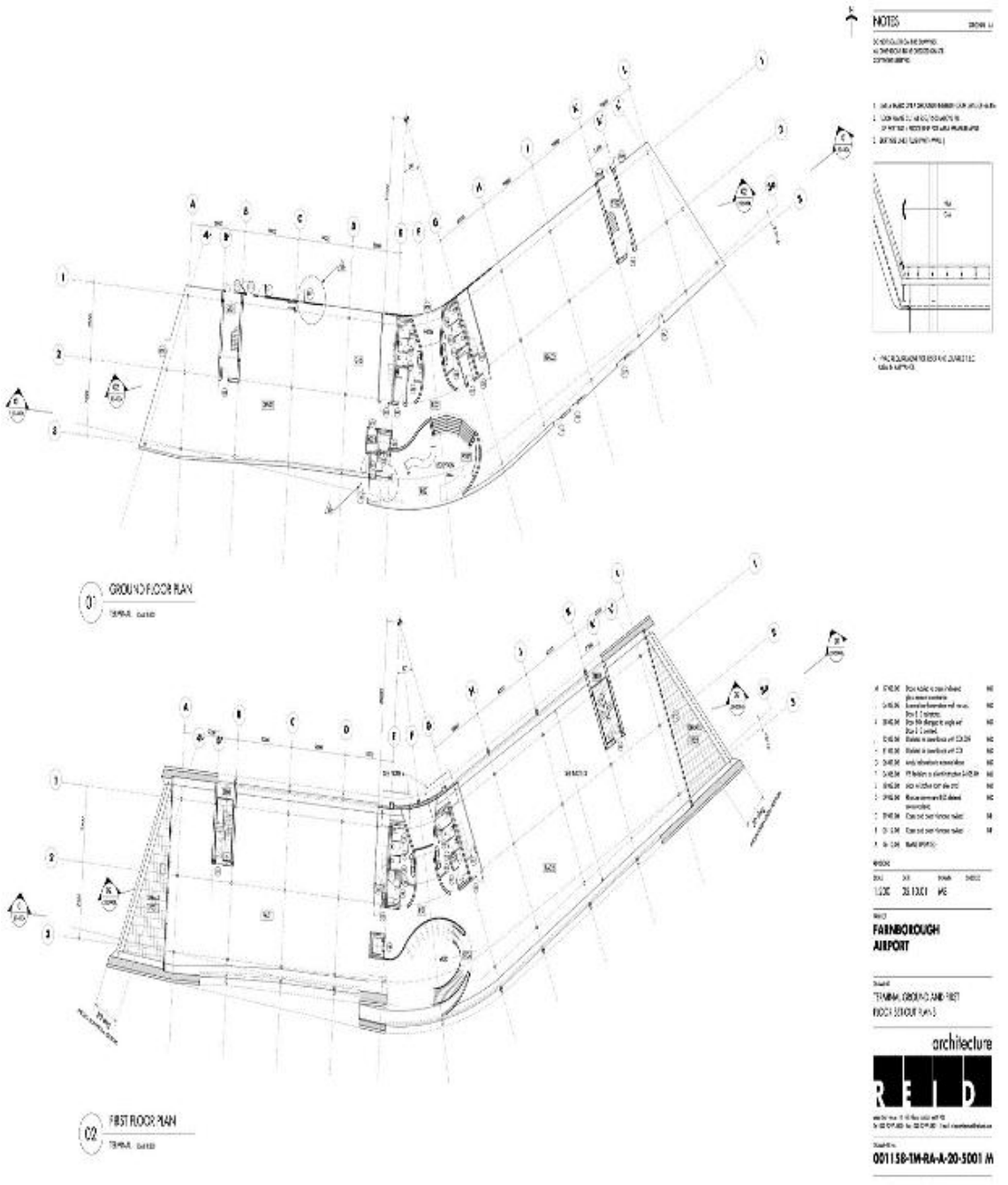


Figure 3. 3: TAG Farnborough Airport Terminal Building Floor plans
Source: Google Imagery

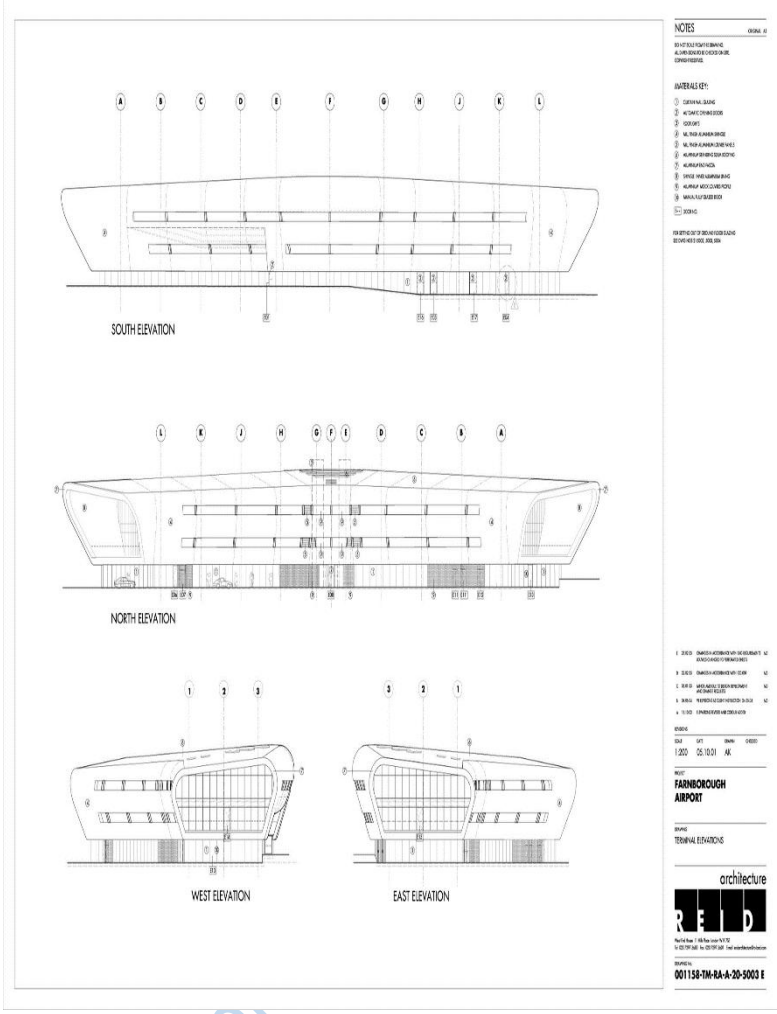


Figure 3. 4: TAG Farnborough Airport Terminal Building Elevations
Source: Google Imagery

Table 3

Project Client	Macquarie Infrastructure and Real Assets (Europe) Limited.
Capacity	33,120 aircraft per annum
Land Area	310 hectares
Other facilities	

Merits

i. Farnborough Airport's iconic wave-shaped hangarage currently offers over 240,000 square feet of temperature-controlled space for based and transient aircraft. It is suitable for accommodating BBJ and Airbus aircraft, along with their accompanying storage facilities. Additionally, the airport boasts 35 acres of outside ramp space for secure parking.

II. Farnborough Airport is known for its 24 hours terminal security and secure hangar access.

Table 4

S/N	FACTOR	GOOD	FAIR	BAD
XIV.	**Passenger Flow**	✓		
XV.	**Circulation**	✓		
XVI.	**Terminal Design**	✓		
XVII.	**Aircraft Apron and Taxiways**:	✓		
XVIII.	**Runway Design:**	✓		
XIX.	**Safety and Security**	✓		
XX.	**Accessibility**	✓		
XXI.	**Public Transport Integration:**	✓		

XXII.	**Sustainability and Energy Efficiency**	✓		
XXIII.	**Baggage Handling System**	✓		
XXIV.	**Cultural Sensitivity**	✓		
XXV.	**Future Expansion**	✓		
XXVI.	**Aesthetics and Identity**	✓		

3.1.3 Case Study Three: Fort McMurray International Airport

The Architects were office of McFarlane Biggar architects in Fort McMurray, AB, Canada. Architect in charge was Steve McFarlan and the Project Architect was Rob Grantarea. The building covers 86500m^2 of land and was constructed in the year, 2014.

Plate 3. 6: Fort McMurray International Airport Terminal Building
Source: Google Imagery

Socially, the area's rich history and thriving industry have fostered tremendous diversity within the resident community. They have also created the impetus for a large transient population—temporary residents drawn to resource- based jobs who fly back to their home communities frequently between work cycles.

Plate 3. 7: Fort McMurray International Airport Apron
Source: Google Imagery

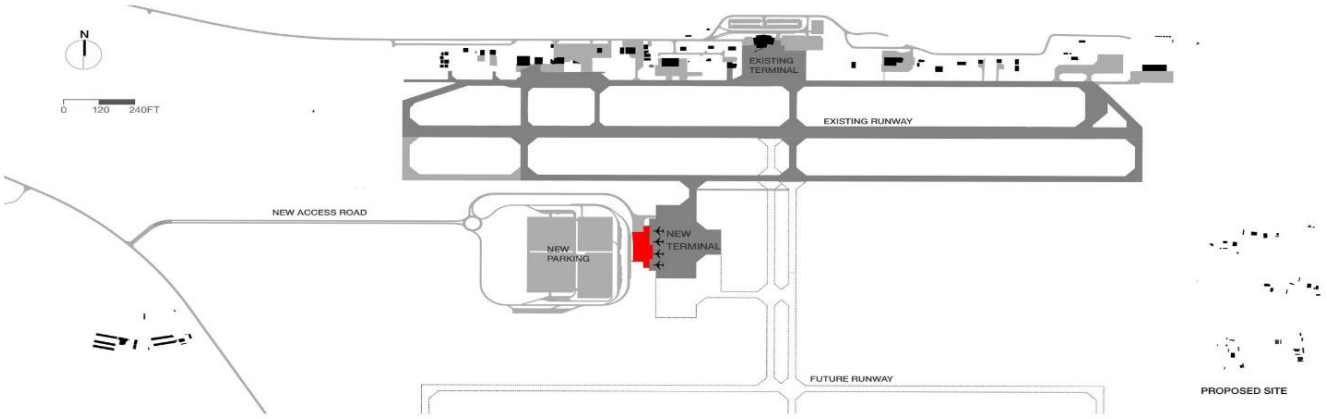


Figure 3. 5: Fort McMurray International Airport General Site Layout

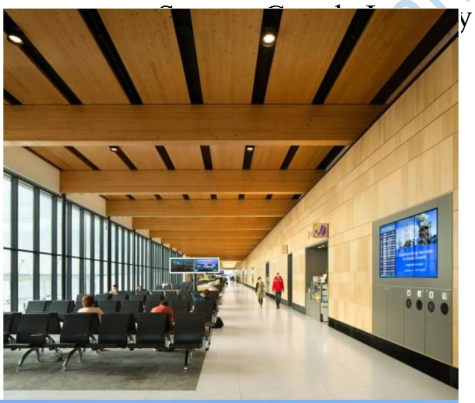


Plate 3. 8:Fort McMurray Airport terminal interior
Source: Google Imagery

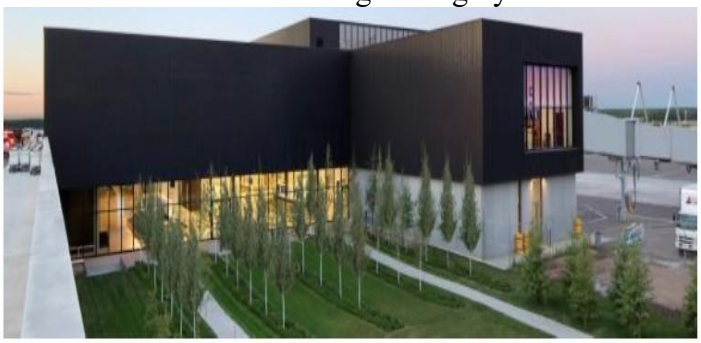


Plate 3. 9:Fort McMurray Airport terminal Exterior

Table 5

Project Client	Fort McMurray Airport Authority (FMAA),
Capacity	1,500,000 passengers per annum
Land Area	5.12 sq. kilometres
Other facilities	

Merits

Fort McMurray International Airport roof design displays one of the largest applications of **Cross-laminated timber (CLT)** in North America.

Table 6

S/N	FACTOR	GOOD	FAIR	BAD
I.	**Passenger Flow**	✓		
II.	**Circulation**	✓		
III.	**Terminal Design**	✓		
IV.	**Aircraft Apron and Taxiways**:	✓		
V.	**Runway Design:**	✓		
VI.	**Safety and Security**	✓		
VII.	**Accessibility**	✓		
VIII.	**Public Transport Integration:**	✓		

IX.	**Sustainability and Energy Efficiency**	✓		
X.	**Baggage Handling System**	✓		
XI.	**Cultural Sensitivity**		✓	
XII.	**Future Expansion**			✓
XIII.	**Aesthetics and Identity**		✓	

3.2 Factors Of Consideration

3.2.1 Analysis of Findings from Case Studies

Below are common features deduced from all the case studies which shall be c onsider in the proposed project design;

- **Escalator, Stairs and Lift positioning**

The proposed airport terminal escalator, stairs and lift will provide convenience to the passengers. By strategically placing escalator, stairs and lifts throughout the terminal, it ensures easy and quick access to different levels of the airport, making it more efficient for travelers to navigate the terminal. This can greatly benefit individuals with mobility challenges or those carrying heavy luggage, as they can easily access different levels without having to rely solely on escalators or elevators. Furthermore, well-positioned Escalator, stairs and lifts also help to reduce overcrowding by providing alternative routes for passengers to move between levels, thus enhancing the overall flow and organization of the airport terminal.

Plate 3. 10: Escalator, Stairs and Lift positioning
Source: Google Imagery

- **Physically challenged parking**

Physically challenged parking spaces in airport terminals are designated parking spaces specifically designed for individuals with disabilities. These spaces are located close to the terminal entrance, making it easier for individuals with physical limitations to access the airport. These parking spaces are design wider than standard parking spaces, allowing wheelchair users to comfortably maneuver in and out of their vehicles, without any obstruction. They are situated near accessible ramps and walkways, making it safer for individuals with mobility aids to enter and exit the terminal.

In addition, physically challenged parking spaces are marked with the international symbol of accessibility, which consists of a blue wheelchair icon on a white background. This clear and recognizable symbol helps to distinguish these spaces from other regular parking spaces, ensuring that they are used only by those who genuinely require them.

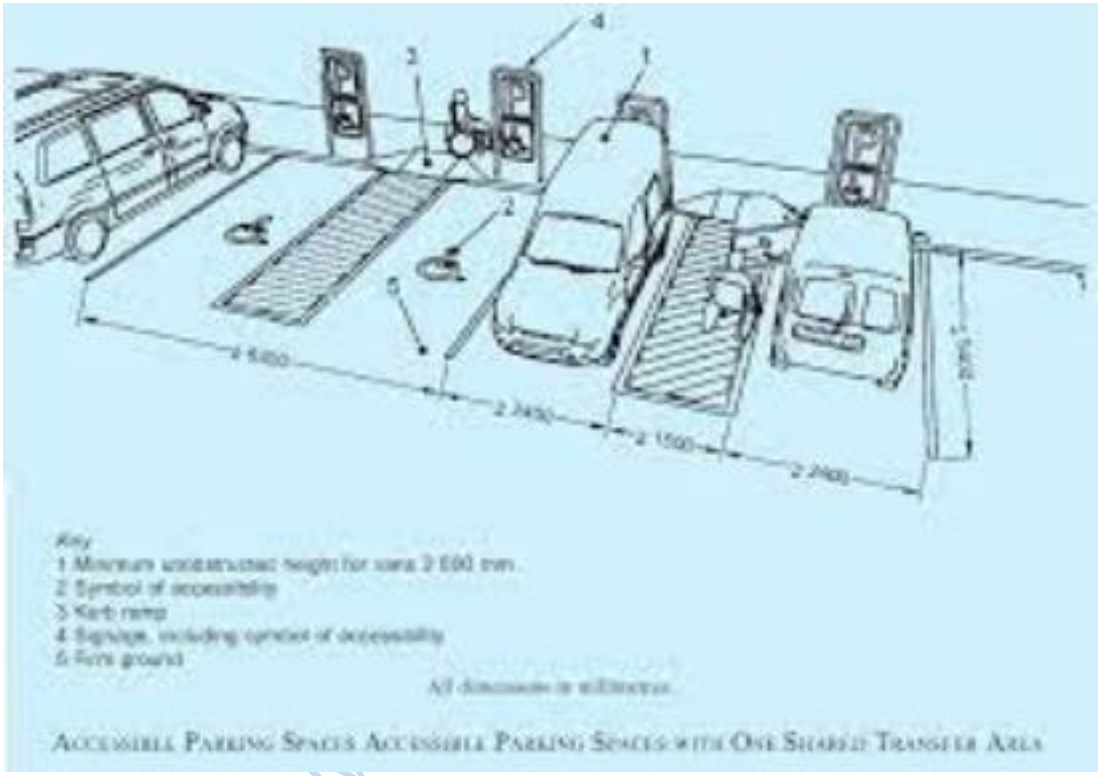


Figure 3. 6: Physically challenged parking details
Source: archi-monarch.com

- **Use of signage, directions and marking**

From the case studies, Signage plays a crucial role in an airport terminal, parking areas, and runways for ensuring efficient navigation, safety, and communication. In an airport terminal, signage is used to guide passengers throughout the facility, providing directions to various facilities and amenities such as check-in counters, security checkpoints, gates, restrooms, shops,

and restaurants. It helps passengers easily find their way and reduces confusion and delays.

Plate 3. 11: Airport terminal signage, directions, and marking
Source: www.designworkplan.com

Figure 3. 7: Airport terminal signage, directions, and marking
Source: shutterstock

In parking areas, signage is essential to direct drivers to available parking spaces, designate different types of parking (such as short-term, long-term, or handicap parking), indicate entrances and exits, and provide information on payment methods and regulations. Clear and well-placed signage ensures smooth traffic flow and the proper utilization of the parking space.

Plate 3. 12:Airport road signage, directions, and marking
Source: Alamy Stock Photo

On runways, signage plays a critical role in ensuring the safe movement of aircraft and vehicles. Runway signage includes markings and lights that provide pilots with vital instructions and information, such as the runway threshold, centerline, holding positions, taxiway entrances, and exits. These signs help pilots navigate the complex airport environment and prevent accidents,

especially during low visibility conditions.

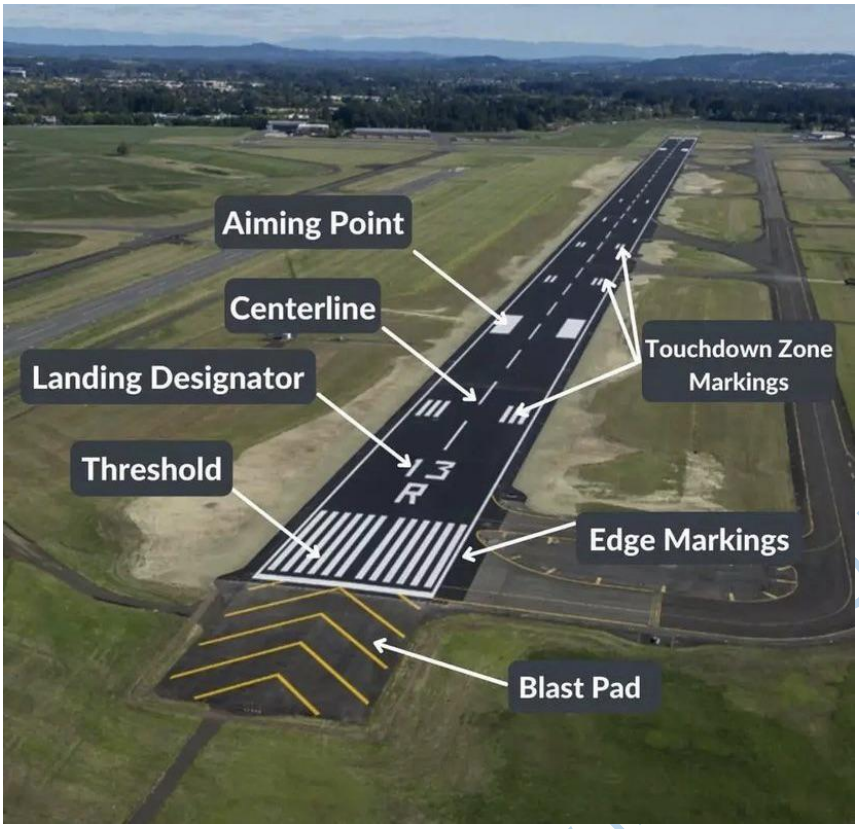


Plate 3. 13: Airport runway signage, and marking
Source: www.reddit.com

Overall, signage is a vital component of airport infrastructure, aiding passengers, drivers, and pilots in efficient navigation, safety, and the smooth operation of airport services.

- **Fire safety and fighting equipment**

From the case studies it was deduced that Fire safety is of utmost importance in any aviation setting, including airport runways, parking spaces, hangarage and terminal buildings. This is due to the presence of flammable substances such as jet fuel, as well as a large number of people who need to be kept safe in case of a fire emergency.

In an airport runway and parking space, fire safety measures primarily focus on preventing fires and having effective means of extinguishing them. This includes regular inspections of fuel pipelines, proper storage and handling of fuel, and sufficient fire hydrants or extinguishers strategically placed throughout the area. In addition, runways and parking spaces are often equipped with foam and powder-based fire suppression systems, which can quickly and effectively smother and extinguish a fire, minimizing damage and reducing risks to personnel.

In hangars, where aircraft are stored and maintained, fire safety measures are also in place. Apart from fire extinguishers and fire detection systems, hangars are equipped with fire sprinkler systems that provide a continuous supply of water to suppress or extinguish fires. These sprinklers are strategically placed to ensure maximum coverage and protect the valuable assets inside the hangar

Within airport terminals, fire safety is a more complex matter due to the presence of passengers, staff, and a variety of facilities. Airport terminal buildings have a combination of active and passive fire safety measures. Active safety measures include fire detection systems such as smoke detectors and sprinkler systems, as well as a well-structured fire alarm system to evacuate the people within the building as quickly as possible. Passive safety measures involve fire-resistant materials used in construction, fire-rated doors, fireproof compartments, and evacuation routes that are clearly marked and easily accessible.

Moreover, airport terminals are equipped with firefighting equipment, including portable fire extinguishers, fire hose reels, and standpipe systems that enable firefighters to access water sources to extinguish fires. Additionally, airports have dedicated firefighting vehicles known as ARFF (Aircraft Rescue and Firefighting) vehicles, which are specifically designed to handle

aircraft-related fire emergencies. These vehicles are equipped with various firefighting agents, such as foam, water cannons, and dry powder extinguishers, which can be used to control fires and carry out rescue operations swiftly.

In summary, fire safety measures and firefighting equipment in an airport runway, parking space, hangarage and terminal are comprehensive and multi-faceted. They aim to prevent fires, promptly detect any fire incidents, and provide swift and effective means of extinguishing fires while ensuring the safety and evacuation of passengers and personnel.

- **Use of effective ramp systems**

An effective ramp system is essential for the smooth functioning of an airport terminal, parking space, and runways.

In an airport terminal, the ramp system is used to connect aircraft to the terminal building, allowing passengers and crew to safely and efficiently move between the aircraft and the terminal. This system includes boarding bridges or jetways that provide a covered pathway for passengers to board and disembark from the aircraft without being exposed to the elements. Additionally, baggage handling equipment is used on the ramp to transport luggage to and from the terminal, ensuring efficient and timely delivery.

In the parking space, an effective ramp system allows vehicles to access different levels or sections of the parking structure. This system typically includes ramps or inclined pathways that are specifically designed to accommodate the flow of vehicles, ensuring smooth traffic movement and easy entry and exit. Proper signage, lighting, and markings also contribute to the efficiency and safety of the ramp system, making it convenient for drivers to navigate and find parking spaces.

On runways, the ramp system plays a crucial role in ensuring safe and efficient aircraft movement. This system includes taxiways, which are the pathways that connect the runway to the terminal or other airport facilities. Taxiways allow aircraft to move between the runway and other parts of the airport, such as hangars or maintenance areas. Proper design and maintenance of taxiways are essential to prevent congestion, minimize taxi times, and enable smooth and timely aircraft operations.

Overall, the effective use of ramp systems in airport terminals, parking spaces, and runways is vital for streamlined operations, passenger convenience, and aircraft safety. Proper planning, design, and maintenance of these ramp systems as seen in the case studies contribute to the optimal functioning of airports, improving overall efficiency and passenger experience.

- **Lighting and Ventilation**

The lighting and ventilation systems play crucial roles in ensuring the efficiency and safety of airport facilities such as the terminal, hangar, runway, and parking spaces.

In an airport terminal, proper lighting is essential for ensuring clear visibility for passengers and staff. Adequate lighting illuminates key areas such as check-in counters,

Plate 3. 14: Airport terminal lighting arrangement
Source: www.reddit.com

security checkpoints, boarding gates, and baggage claim areas, helping to enhance security and ease of navigation. Furthermore, it contributes to creating a welcoming and comfortable atmosphere for travelers. Alongside lighting, ventilation systems ensure a pleasant indoor environment by regulating temperature, humidity, and air quality. They help maintain a fresh and comfortable atmosphere, reducing the risk of pollution or unpleasant odors, and overall improving the passenger experience.

Plate 3. 15: Airport terminal lighting arrangement
Source: www.reddit.com

In a hangar, lighting plays a critical role in creating a safe and well-illuminated work environment. Hangar lighting is typically designed to provide ample brightness and even distribution of light to enhance visibility during maintenance or aircraft servicing. Proper lighting is especially crucial for mechanics to inspect and work on various aspects of the aircraft. Additionally, hangar ventilation systems help to control temperature, humidity, and air quality, ensuring a conducive working environment while also preventing the accumulation of potentially harmful substances, such as fumes or gases. For runways, lighting systems are essential for safe aircraft navigation, especially during takeoff, landing, and taxiing. The runway lighting consists of various lights, including approach lights, runway edge lights, centerline lights, and taxiway

lights, each serving a specific purpose to guide pilots and keep them aware of the runway's location and boundaries.

Plate 3. 16: Hangarage lighting arrangement
Source: www.reddit.com

These lighting systems are designed in a way that provides enough brightness and visibility in all weather conditions, enabling pilots to execute their maneuvers accurately.

For runways, lighting systems are essential for safe aircraft navigation, especially during takeoff, landing, and taxiing. The runway lighting consists of various lights, including approach lights, runway edge lights, centerline lights, and taxiway lights, each serving a specific purpose to guide pilots and keep them aware of the runway's location and boundaries. These lighting systems are designed in a way that provides enough brightness and visibility in all weather conditions,

enabling pilots to execute their maneuvers accurately.

Plate 3. 17: Airport runway signage, and marking
Source: google imagery

In airport parking spaces, lighting is crucial for ensuring the safety and security of vehicles and pedestrians. Adequate lighting allows drivers to navigate through the parking area easily, reducing the risk of accidents or damage. Well-lit parking spaces also discourage theft and vandalism. Ventilation systems are not typically installed in open parking spaces, but proper airflow and circulation are important for covered parking areas to prevent the buildup of pollutants or odors.

In summary, the lighting and ventilation systems in airport facilities such as terminals, hangars, runways, and parking spaces are critical for ensuring safety, enhancing visibility, maintaining a comfortable environment, and optimizing operational efficiency. These systems are designed to meet specific requirements, ensuring the smooth functioning of airport operations.

- **Aesthetics**

For every case study, carried out aesthetics of the terminal and the airport as a whole was seriously put into consideration so as to create a natural environment by using element peculiar to their local environment.

The aesthetic of an airport refers to the overall visual appeal and design elements that create a certain atmosphere and experience for passengers. It encompasses various aspects, such as architectural style, interior design, artwork, signage, and overall ambience.

The aesthetic of an airport plays a crucial role in shaping a passenger's perception of the facility. It is aim to create a welcoming, comfortable, and functional environment, while also reflecting the culture and identity of the location.

Architecturally, airports often strive for a balance between functionality and aesthetics. Airports feature sleek and contemporary designs with open spaces, natural light, and efficient layouts that ensure smooth passenger flow. Some airports also incorporate elements of local or regional architecture to give travelers a sense of place.

Interior design plays a significant role in enhancing the overall aesthetic. color schemes are utilized, materials, and furniture that create a pleasant and harmonious atmosphere. Comfortable seating, pleasing lighting, and well-maintained amenities contribute to the overall impression of the airport.

Artwork and installations are increasingly being incorporated into the airport designs, aiming to offer a cultural experience and engage passengers. These range from large-scale sculptures and murals to interactive displays that provide entertainment and information.

Signage and wayfinding systems are also crucial for the aesthetic of an airport. Clear and visually appealing signage helps passengers navigate the airport easily and enhances their overall experience as stated earlier.

Ultimately, a well-designed airport aesthetic contributes to a positive passenger experience, making travel more enjoyable and memorable.

Chapter Four

Site Analysis and Design Synthesis

4.1 Study Area/Site Selection

The proposed site is located at Alakia in the city of Ibadan, Oyo state, Nigeria. The city of Ibadan is the administrative headquarter of the old western region of Nigeria and now Oyo state's capital. It (Figure 4.1) is the third largest metropolitan area, by population, in Nigeria.

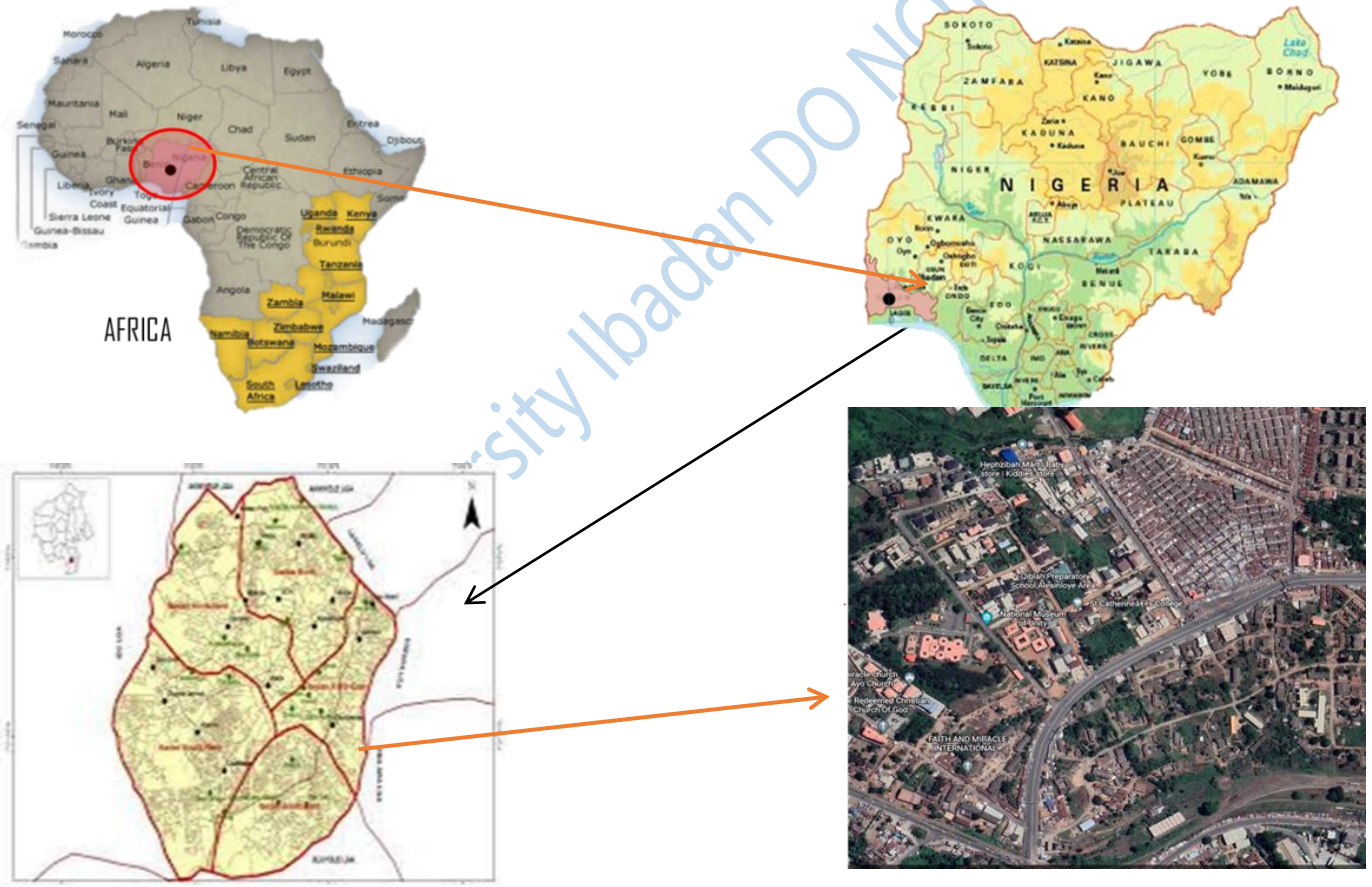


Figure 4. 1: Location Map
Source: Google Imagery

Ibadan is home to a population of over 3.8 million people (World Population Review, 2023). Its climate according to the Atkinson system of classification is that of the warm

humid zone. Ibadan is divided into five (5) local government areas namely, Ibadan North, Ibadan North-East, Ibadan North West, Ibadan South East, Ibadan South West.

4.2 Site Selection Criteria

Ibadan, the capital of Nigeria's Oyo State, is served by Samuel Ladoke Akintola Airport. In June 1982, Joseph Wayas, a former Nigerian Senate president, ordered it. Alakia, in Oyo State's Egbeda Local Government Area, is where the airport is situated. The Samuel Ladoke Akintola Airport Upgrade is long overdue due to the daily rise in customers, as the current airport facilities are unable to meet the demand, forcing users to travel 133 kilometers to the nearest airport.

Figure 4. 2: Proposed site
Source: Google Earth Imagery

4.3 Project Analysis and Synthesis

4.3.1 Site Analysis/Inventory 1

The chosen location for the "Samuel Ladoke Akintola Airport Upgrade" is a critical aspect of the design proposal as it marks the point where the tangible progress of the development begins to

take effect. The site selection holds great significance as it profoundly influences the final composition of the solution in all aspects. Various experts, including geographers, geologists, and geometrics, evaluate the site's contextual suitability and appropriateness. The site's unique features, such as its microclimate, result from a complex interplay of factors like orientation, size, topography, temperature patterns, humidity, precipitation, vegetation, water presence, sunlight availability (especially in urban areas), and the influence of neighboring structures.

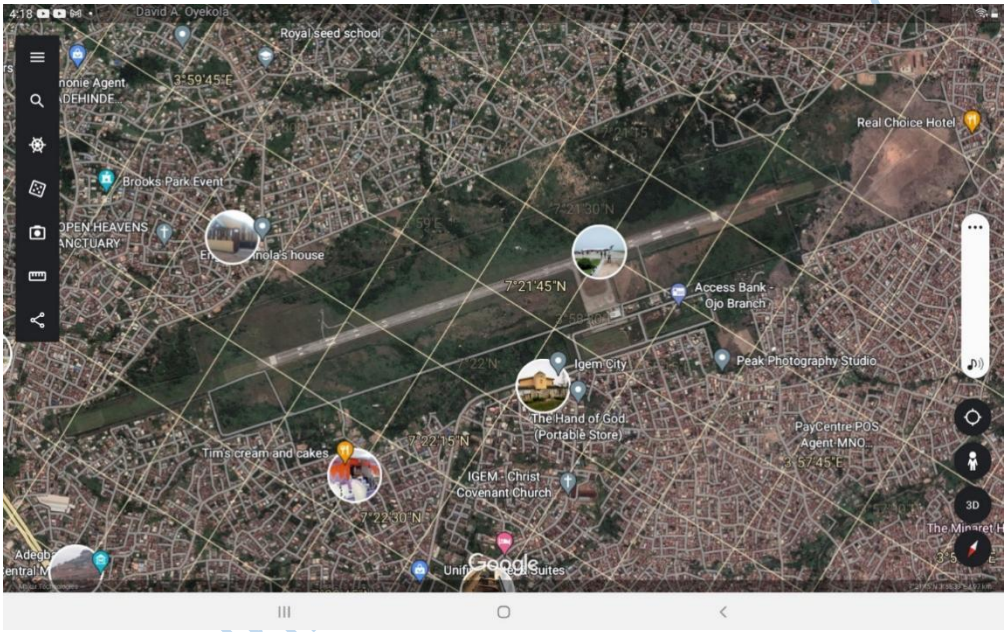


Figure 4. 3: Site Analysis
Source: Google earth Imagery

Consequently, thorough research and analysis of the project site are vital to comprehend its suitability for the intended purpose. The geographical and physical characteristics, including water bodies, access, vegetation, local climate, and utility lines, significantly impact the layout of the building. Moreover, the surrounding structures play a crucial role in shaping the character, aesthetics, and design efficiency of the airport upgrade. To ensure a successful design, a

comprehensive understanding of the site and its interactions with its environment is of utmost importance.

It is best to know your site to better understand how well-suited it is for the intended use. Fulfilling the design's purpose is the motivation. The relationship between the site and the building can be functionally developed with the use of site analysis. Every design choice needs to aim to serve the location while also being a clear reflection of and adaptation to the surroundings.

Figure 4. 4: Site Analysis
Source: Researcher's field survey, 2023

4.4 Site Climate and Vegetation

Rainfall and Wind

Ibadan falls within the zone in Nigeria that has an average of 250mm of rainfall per day in the wet season. Average rainfall for a year in Ibadan is 100cm-200cm. The town has over 9 months of rainfall every year. The town is also affected by the tropical continental and tropical maritime air masses and the equatorial easterlies.

There is the presence of series of electric thunderstorms during the beginning and end of the rainy season. The prevailing wind direction is south-west, which is rain bearing since it takes its origin from the sea. The direction of the wind is form the south to the North in the wet season and from the North to the south in the dry season.

Temperature

January temperature conditions in Ibadan ranges between 20°-26°C while July temperature condition is below 26°C. This is brought about by the warm guinea currents that wash the western coastline of Nigeria. Monthly daily temperature ranges from 80°F to 94°F while the minimum daily temperature is between 69°F to 73°F. The difference between the two is not so large and annual temperature is almost even all the year round.

Humidity

Humidity is between 9% in the *harmattan* season and 1% in the wet season. Evaporation rate is higher during the *harmattan* and very low in the humid periods.

Vegetation

Ibadan falls within the tropical zones with temperature throughout the year ranging from 21°C to 29°C and therefore, has temperatures high enough for rapid plant growth. Annual rainfall also varies between 100cum and 200cum. Under the prevailing climatic conditions, Ibadan falls within the vegetation zone of the high tropical rainforest. The site itself is secondary forest since

it has been cleared and cultivated at one time or the other. There are still some large tress and dense bushes on the site. Agricultural activity and laterite excavation is carried out on the site.

4.5 Design Recommendations for Oyo State

Based on the known climatic data of Oyo State, it is relatively easy to arrive at a general specification for building design in terms of climate control. The design recommendation for Oyo State is being arrived at after diagnosis of its climate data through the uses of Mahoney tables. The followings are the recommendations:

i. Use East-West Orientation for the long axis of buildings

ii. Open spacing for breeze penetration

iii. Single banking, permanent ventilation

iv. Use large openings, 40% - 80% of wall area.

v. Openings in north and south walls at body height

vi. Protect openings from rain and sun.

vii. Protection from heavy rain needed

4.6 Brief Analysis

To address the growing number of airport users and cater to their needs effectively, the proposed airport upgrade will be a cutting-edge facility designed to alleviate traveler stress. The upgrade plan encompasses a comprehensive range of fully functional facilities, aiming to provide a world-class airport experience for passengers and aviation stakeholders alike. The upgraded airport will feature state-of-the-art elements, including:

Airport Terminal: The new terminal will be designed to accommodate the increasing passenger traffic efficiently, offering a seamless and comfortable journey for travelers.

Hangarage: Modern hangar facilities will be incorporated to cater to the needs of aircraft storage and maintenance, ensuring the smooth operation of aviation services.

Apron and Runway: The apron and runway areas will be expanded and enhanced to accommodate more aircraft movements and ensure safe and efficient operations.

Banking and Entrance: The airport upgrade will feature convenient and accessible banking services and a welcoming entrance area for arriving passengers.

Driveway and Driving Aisle: A well-designed driveway and driving aisle will facilitate smooth traffic flow, making drop-off and pick-up processes hassle-free.

Parking Lots: Spacious and well-organized parking lots will be provided to cater to the growing number of vehicles used by travelers and visitors.

Pedestrian Walkway: The airport upgrade will feature well-marked and user-friendly pedestrian walkways, ensuring easy navigation for passengers within the terminal premises.

Offices: Modern office spaces will be included to accommodate airport staff and stakeholders, facilitating efficient administrative operations.

Recreation Zones: Lounge areas, bars, and restaurants will be strategically placed to offer passengers comfortable relaxation and dining options.

Service Spaces: The upgrade will incorporate functional service areas, including ramps, stairs, conveniences, and storages, to support smooth airport operations.

The overall design will prioritize passenger convenience, safety, and comfort, transforming the airport into a world-class facility that sets new standards in air travel. The upgraded airport will be a testament to modern architecture and a significant step forward in enhancing the travel experience for all its users.

4.7 Design Criteria/ Consideration

The upgrading of Samuel Ladoke Akintola Airport in Ibadan aims to address the challenges in the commercial zone by providing an international airport that facilitates seamless movement for air travelers and goods. This upgrade will eliminate the need for a 133km journey before boarding flights to various destinations, reducing stress and improving convenience. The following design considerations play a crucial role in shaping the overall building:

Proximity: Customer surveys have highlighted that proximity to the destination is the primary concern for parking decisions. Therefore, the upgraded airport should prioritize convenient parking facilities while ensuring that design excellence is not compromised.

Accessibility: The airport's car park should be easily identifiable within the street network, with entrances strategically located along main roads for ease of use.

Pedestrian Circulation: To accommodate the high number of pedestrian movements relative to parked cars, the design should include easily navigable pedestrian routes, walkways, stairways, lobbies, and lifts.

Lighting: The impact of design on pedestrians' wellbeing and security is a significant concern. The airport should strike a balance between daylighting, interior lighting, and exterior lighting

control, especially concerning the facade design. Lighting fixtures should be vandal-resistant and easy to maintain, and fluorescent lamps can be used as directional aids.

Direction and Way-finding: To facilitate easy navigation for all motorists, clear internal signage and floor markings directing cars to parking spaces should be incorporated, addressing a commonly overlooked aspect of new car parks.

Fire Protection: The construction materials should prioritize non-combustible elements, meeting the required structural fire regulations. Under specific restricted circumstances, waivers for structural fire requirements may apply for buildings less than 15.2m high, such as cast-in-place concrete, pre-cast concrete, and structural steel.

Safety and Security: Ensuring transparency and visibility, doorways, lift lobbies, and lift doors are recommended to be made of clear glass. Public stairways should be wide and well-lit, and all pedestrian routes should be clearly signposted in both directions. Eliminating potential hiding places, such as under open stairs, enhances security. Utilizing security devices for video, audio, and emergency buttons to call police or fire services enhances safety.

Aesthetics: Aesthetics are of paramount importance as the airport upgrade will contribute to the beauty and urban image of the region. The architectural design should be mindful of creating an appealing and visually pleasing structure.

By giving due consideration to these design factors, the upgraded Samuel Ladoke Akintola Airport will not only address the challenges in the commercial zone but also provide an efficient and welcoming gateway for air travelers, elevating the cityscape and overall urban image.

4.8 Brief Development

The Airport Upgrade will primarily focus on space planning and management to enhance the design of the airport facilities. This design will present a comprehensive planning proposal for construction, led by the Oyo State Government, as a significant element of the ongoing Mega City project aimed at upgrading Oyo State. The airport upgrade will adhere strictly to established standards, ensuring that the following essential spaces are thoughtfully provided:

Terminal Building

Runways and Taxiways

Apron Area

Parking Facilities

Passenger Amenities

Security Measures.

Wayfinding and Signage

Baggage Handling and Check-in Facilities

Retail and Commercial Spaces

Green Spaces and Landscaping

By carefully considering and providing these essential spaces, the Airport Upgrade will transform the airport into a modern, efficient, and passenger-friendly facility, complementing the ongoing efforts to upgrade Oyo State as part of the Mega City project.

4.9 Spatial Requirement and Analysis

4.9.1 Space Allocation/ Schedule of Accommodation

Table 7

S/N	**SPACE**	**AREA(m^2)**
1	Meeters And Greeters Hall	500
2	Baggage Claim	1299
3	Security Post	32
4	Toilets	50
5	Arrival Hall	1000
6	Emergency Clinic	50
7	Banks And Retail Stores	300
8	Departure Hall	2245
9	Restaurant	616
10	Check-In Counter	50
11	Offices	180

12	Ticketing Counter	500
13	Banks And Retail Store	100
14	ICT Department	100
15	Finance Department	100
16	Human Resources	100
17	Human Relations	100
18	Corporate Affairs Office	100
19	Quality Control	50
20	Security Checking Departure	63
21	Baggage Control Office	60
22	Airline Offices (Logistics)	50
23	Departure Lounge	781
24	Marketing Office	100
25	Security Department	65
26	Pilot Briefing Room	150
27	Terminal Control Room	30

28	Boarding Tower/ Bridge	30
29	Hangarage Warehouse	401
30	Hangarage Workshop	616
31	Hangarage Lecture Room	112
32	Hangarage Library	64
33	Hangarage Main Control	112
34	Hangarage Dining	253

4.10 Conceptual Development

Winters (2007) says that terminals resembled train stations and hangars resembled train sheds. Airplanes interiors also resemble Pullman rail cars. All of this was an effort to assure passengers that there was really nothing strange and new about air traveling.

An airport upgrade goes beyond being a mere practical area; it should be envisioned as a destination that enriches the neighborhood and enhances the city living experience. The focus is on transforming the airport into more than just a place to catch a flight. The upgrade plan includes a range of facilities catering to the needs and comfort of passengers and visitors.

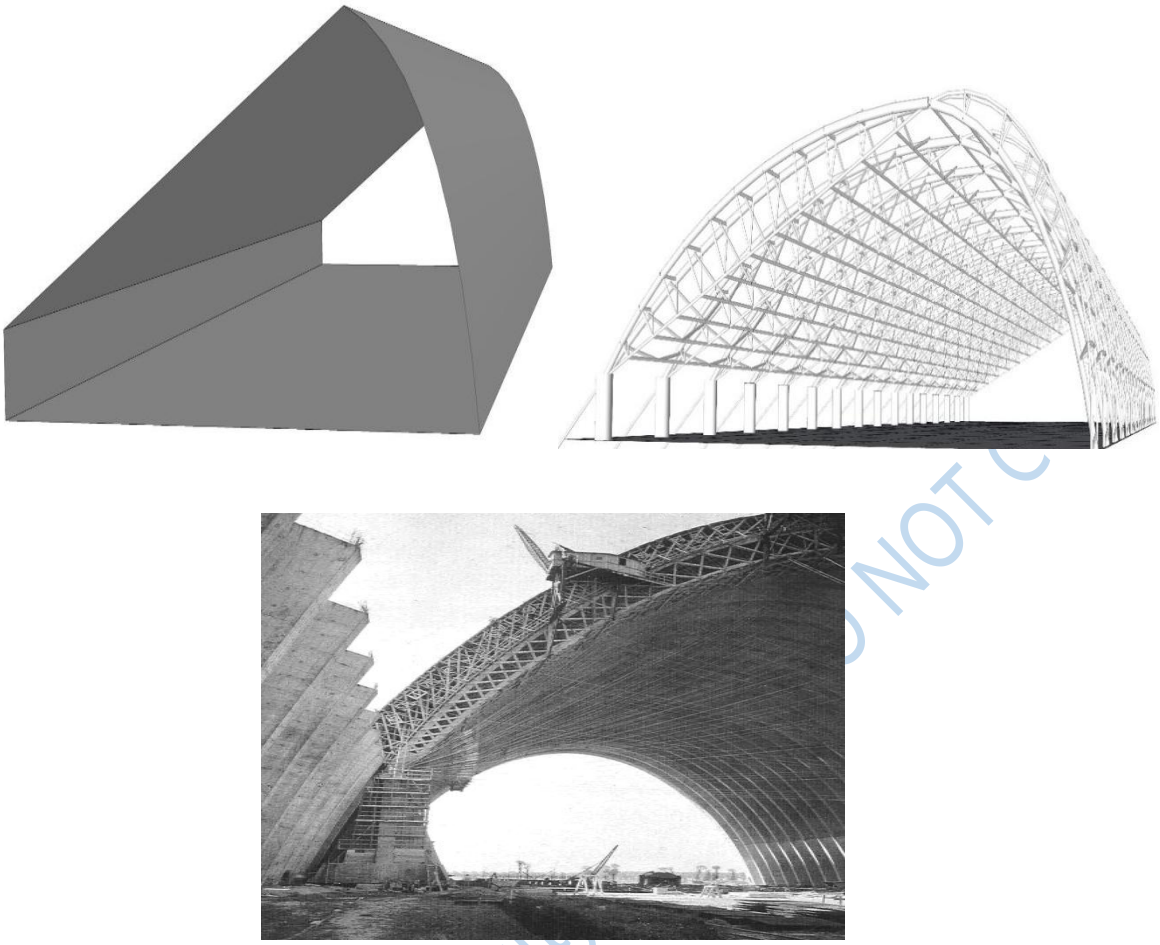


Figure 4.5: Conceptual Development

The design aims to incorporate various amenities and features, such as well-maintained restrooms, inviting lounging areas, and green spaces, to create a pleasant and welcoming environment. Additionally, the upgraded airport will house diverse facilities like shops, co-working spaces, and electric vehicle charging stations to cater to modern travelers' needs and encourage sustainable practices.

Embracing the function-to-aesthetics principle of architectural design, the conceptual formwork is carefully curated. This means that functionality and practicality are balanced with aesthetics, resulting in an airport that is not only efficient but also visually appealing. The design strives to

create a captivating and artistic space, transforming the airport into a form of public art architecture.

By approaching the airport upgrade with a holistic perspective, integrating both functional and aesthetic aspects, it will become a thriving destination within the city. Passengers and visitors will not only appreciate the convenience of travel but will also enjoy a fulfilling and enriching experience during their time at the airport. This upgrade will undoubtedly contribute to the overall enhancement of the neighborhood and the city's urban fabric.

Chapter Five

Appraisal, Recommendation and Conclusion

5.1 Project Appraisal

5.1.1 Construction Method and Material

a) Pre-Construction Operations

To ensure a successful pre-construction phase for the airport upgrade, it is vital to undertake the following essential steps:

Conduct a Feasibility Study: Thoroughly analyze the viability and potential benefits of the airport upgrade. This involves assessing market demand, price projections, environmental impact, and legal requirements.

Define Project Objectives: Clearly state the goals of the project. Establish precise and measurable objectives to be achieved during the construction phase, considering the intended purposes of the airport upgrade, such as improving infrastructure, enhancing services, or increasing capacity.

Select an Appropriate Location and Consider Zoning: Choose a suitable area that meets the requirements of the airport upgrade. Ensure that the chosen location complies with zoning regulations and provides ample space for both current and future needs of the airport.

Assess and Mitigate Risks: Identify potential risks and challenges during the construction phase and develop effective mitigation plans. Being prepared for unforeseen circumstances will help minimize delays and cost overruns.

Implement Sustainable Practices: Integrate sustainable building practices into the design and construction process to reduce the airport's environmental impact and improve energy efficiency.

Engage with the Community: Involve the local community from the outset of the project. Address any concerns they may have and communicate the benefits that the airport upgrade will bring to the neighborhood, such as improved transportation options, economic growth, and enhanced travel experiences.

By adhering to these crucial measures, the pre-construction phase for the airport upgrade will be well-organized and well-executed, paving the way for a successful and transformative airport enhancement.

b) Substructure

The substructure of the building comprises of mainly foundation. The soil within the site is sandy it is a reclaim land from the sea Normal pile foundation would be employed in this case because of the characteristics of the soil. The quality of the foundation materials will offer resistance to chemical and pose adequate compressive strength; this will aid in conveying the weight of the building without any form of differential settlement. The operations that are mainly involved in substructure stage are:

i. **Site clearing:** all obstruction on the space to be occupied by the buildings is to be removed to allow for other operations to follow. Any plants that exist on the building site must be removed.

ii. **Site hoarding:** it is the erection of barrier around the perimeter of the site to improve security and protection of equipment and materials. The material to be used for the hoarding is corrugated galvanized zinc sheets nailed on timber frames

iii. **Topsoil:** the topsoil over the space on the land covered by the buildings is dredge from the sea. The top soil to be used for landscape planting will be imported to the area of need.

iv. **Setting out**: the transfer of dimensions on the building drawings to the site is called setting out. The buildings are to be set out in relation to the existing road that is the reference point for the buildings. The setting out is to be done with the use of theodolite to achieved higher degree of accuracy compared to other methods.

v. **Foundation:** after the setting out has been completed and certified by the consultants. The pilling is to be done by pilling equipment to the specified depth by the structural engineer considering the soil bearing capacity test.

vi. **Hard-core filling**: the hard-core should be 300mm thick weathered rock. It should be well compacted and levelled.

vii. **Damp proofing**: the damp proofing material should be in 3 plies of bituminous felt laid over the area of the foundation. It is to disallow capillarity of water to the floor slab.

viii. **Casting of in-situ ground floor slab:** the ground floor slab is to be constructed to a thickness specified by the structural engineer. The floor slab should be reinforced. It must be checked and signed off by the structural engineer before progress of work. The piling from the required depth to the surface, upon the preparation of the head, will receive overlaid concrete judging the approach elevation level to determine the difference to the natural ground level.

c) Superstructure

The building will be concrete framed structure. Reinforcement concrete will be used for columns, beams, and slabs. Sand Crete and non-flammable light partition for walls. The ceiling and doors will be fire rated and the floors will be finished generally in non-slippery vitrified floor tiles of different materials and textured in different places. Fire resistant finishes will be used. Mechanized anti-fire equipment will however complement the anti-fire efforts. The superstructure comprises of five basic components namely; floors, walls, doors & windows, ceiling and roof.

Floors: In the buildings, in-situ mass concrete floor slab as well as reinforced concrete floor slab is used. While in-situ mass concrete floor slab is used for ground floor in ground floor of the building, reinforced spaced rafter concrete floor slab is used for the suspended floors.

Foundation System: The foundation method will be specified by the engineer in order to withstand the total loads of the structure.

Expansion Joint: Owing to the natural law of expansion and contraction which also occurs in buildings, two leaves of sandcrete hollow blocks with cavity of 50mm will be used at distance interval of twenty-five meter as expansion joints.

Walls: Reinforced concrete columns and beans and sandcrete hollow blocks will be used.

Windows: Tinted glass in deep bronze aluminum portables shall be employed in the project.

d) Finishes

External wall: High-quality water-resistant paint of approved colors and quality and aluminum claddings.

Internal walls: High quality approved bright color paints.

Ceilings: High quality approved water resistant and bright color paints on soffits of slabs.

Floors: Use of epoxy coating on the reinforced concrete floor to provide durability and resistance to chemicals and oil. Also, easy to maintain and clean.

e) Building Services

Water Supply

Water supply to the site would also be forming the forming the existing water supply mains along the major road for distribution of water to the site/borehole supported with a reservoir is also required.

Sewage Disposal

Private sewage treatment installations will be built at various locations on site. They will consist of soil pipes, inspector chambers, septic tanks and soak-away pits.

Drainage

Both underground and surface drainage pattern will be used since the proposed site plan is of different level. The drainage method used will be channeled to the public drainage.

Electricity

The supply of electricity power shall be solely from solar energy. And each building will generate its own electric power. This is going to be achieved by using Active solar technology.

f) External works

The designs include lawns, trees, shrubs, ground cover and seasonal planting. Planting shall be maximized as an aid environmental quality and to serve in the effort to contain and eradicate damaging pest and pathogen.

1. Side Walk and Road–ways

Project shall generally provide for new street sidewalks curbs and road-way pavements, consultation with physical design department of Eko Atlantic's project will be done in this regard.

2. Parking

All parking lots should be paved unless otherwise required in the specific requirement or task order. Porous pavements are desirable when budget and site condition allows.

3. Street Tree

The site shall provide for new street trees. Appropriate tree pits and grates are required.

4. Drainage

All surface storm water shall be collected on site, in an underground drainage system. Area grading shall provide for drainage away from building. Reduce run off minimizing paved and other impervious surface.

5.2 Conclusion and Recommendation

Airport terminal design should prioritize safety to safeguard passengers, staff, and infrastructure. By taking human factors into account, implementing emergency preparedness measures, ensuring structural integrity, prioritizing fire safety, and incorporating advanced technologies,

airport authorities and designers can create secure and efficient terminals. Regular evaluation and enhancement of safety design criteria are essential to address evolving risks and challenges in the aviation sector. By placing a strong emphasis on safety, airport terminals can retain their status as convenient transportation hubs while also serving as reliable symbols of security and hospitality.

References

Adebayo, B. E., Akintomide, H. I., & Okunnu, K. G. (2017). Investigating the Impact of Air Traffic Control Services on Operations Safety at Nigerian Airports. *International Journal of Science and Technology*, 6(8), 867-875.

Adebayo, J.T., & Obong, T.K. (2015). Aircraft operation risk assessment using Fault Tree Analysis Approach: A case study of LAGOS international airport. *Journal of Civil Engineering and Construction Technology*, 6(10), 123–137.

Adegbite, A.E., Oyedele, L.O., Aliyu, A.A., Lawal, H.B., Ibrahim, A.I., Buhari, E.D., & Adejumo, O.A. (2018). Security challenges facing aviation sector in Nigeria: An empirical investigation. *International Journal of Asian Social Science*, 8(10), 738–754.

Adekola, A.A. (2015). Emergency Response System: Implications for Disaster Mitigation in Nigeria. *Journal of Sustainable Development,* 8(5), 18–30.

Adeshina, S. O., Olayiwola, J. K., Akinyemi, E. S., & Okonkwo, C. P. (2017). Evaluation of Pre-Flight Processes in Nigerian Airports: Impact on Scheduling and Crowd Control Strategies. *European Journal of Scientific Research*, 146(1), 1–11.

Adesina, S. O., & Oduntan, F. R. (2018). Analysis of Service Quality Delivery at Nigerian Domestic Airports. *International Journal of Business Administration*, 9(4), 64-77.

Adesina, T., Ogunsanmi, K., & Yahaya, A. (2018). Review of Emergency Evacuation Plans in Selected Airports in Nigeria. *Journal of Transport and Logistics Engineering,* 1(2), 11-17.

Adeyanju, O., & Ademoye, E. (2019). *Airports Risk Assessment Framework for Emergency Preparedness in Nigeria. Sustainability,* 11(9), 2524.

Agboola, O. A., & Ogutuga, J. T. (2020). Airport Infrastructure Development: Challenges and Prospects. *Journal of Aviation Technology and Engineering, 9*(1), 11-19.

Ajayi, T. S., Daramola, I. B., & Asuzu, M. U. (2020). Challenges of Crowd Management in Nigeria Civil Aviation Authority Airports: Implications for Quality Service Delivery. *International Business Management, 14*(8), 468–478.

Ajibola, D., Atere, M., Shuaibu, Y., & Umar, A. (2019). Strategies for Improving Airport Terminal Efficiency in Developing Countries. *Global Journal of Emerging Market Economies,* 11(3), 291-307.

Ale, B., E Smith and R. Pitblado (2002) Safety Around Airports- Development in the 1990s And Future Direction. A Conference paper in www.howstuffworkom Automation. A Report For National Aeronautic and Space

Ang, K., & Soh, B. P. (2017). Integration of LTE network into railway communication system infrastructure—A survey. *IET Communications,* 11(4), 436–446.

Aykurt, M. Y., & Uyulgan, S. (2019). Comprehension principles of airport space design: Physical and psychological effects of spatial layouts in airports. *Structural Design of Tall and Special Buildings*.

Bahadori, K. (2017). Effects of illumination efficiency, colour temperature, rendering index and light pollution caused by indoor lighting. *Journal Of Advanced Research In Fluid Mechanics And Thermal Sciences*, 48(1), 8–15.

Basirat, M. H., Mohtasebi, S. S., & Bahnia, R. (2014). Airport arrivals prediction using artificial neural networks: A comparative study for two major Iranian airports. *Information Systems Frontiers,* 16(2), 295–311. https://link.springer.com/article/10.1007/s10796-012-9399-0

Basu, P.K., & Mookerjee, S. (2016). Event tree analysis for runway excursion risk assessment: A case study of Abuja international airport. *International Journal of Environmental Science and Development*, 7(6), 576–582.

Borresen, J. C. (2013). *Light and Space in Architecture*. John Wiley & Sons.

Bozzelli, T. F., Cappelletti, A., De Lillo, V., Montemaggiore, G., Ouerghi, L., & Baldini, G. (2019). Evaluating automated approaches to assist screening checkpoints of crowded airports. *IEEE Access*, 7, 41971–41986. https://www.researchsquare.com/article/rs-43754/v1

Bryan, N. J. (2018). Implementing Unexpected Change: Analyzing TSA's Efforts to Effectively Respond to 9/11. Global Politician, 13. Retrieved from http://www.globalpolitician.com/24856-implementing-unexpected-change

Chowdhury, A., Banwet, D. K., Beladi, H., & Bhattacharya, G. (2018). Assessment of underlying contributing factors influencing reliability model uncertainty: An application in industrial noisy sensor networks. *IEEE Transactions on Systems, Man, and Cybernetics: Systems,* 48(7), 1027-1040.

Condón, M. Y., Craik, L. E., Peartree, N., & Areeshi, M. (2019). Total Quality Management implementation in China's airport construction projects: Factors influencing customer satisfaction. *Sustainable Development,* 27(1), 194-215.

Cox, J. M., Baca, H. E., Grace, L. A., Lambert, G. C., Overy, P., Tipton, R. H.,& Yang, Y. (2019). Aviation Maintenance Cost Benefits of Adopting Global Airline Standards: An Economic Model Analysis (NTSB/SS-19/01). Available from: https://www.ntsb.gov/_layouts/ntsb.aviation/brief2.aspx?ev_id=20180210X10133&key=1

Davies, M., Isah, A., Olufemi, R., & Yehezkel, G. (2020). Assessing the adequacy of safety control measures in the operation of aviation in Nigeria. *Journal of Air Transport Management,* 83, 101686.

Dawodu, S., & Adedoyin, A. (2018). An Overview of Airport Modernization in Nigeria. *International Journal of Scientific Research in Multidisciplinary Studies,* 4(2), 33-37.

DeKort, D. W., Carbonell, N. A., Roth, E.M., Regan, A. B., Clark, E., Fenstermacher, K., & … Wiener,E.(2014). Enhancing cockpit safety culture: Developing aircraft prototypes to study effects of innovative technologies. *Autonomous Robots*, 37(3),247–266.

Delmeė, M., & Cuéllar-González, E. (Eds.). (2018). *Handbook of Airport Operation and Management.* Routledge.

Dickey, B., & Youngblood, W. (2017). Just-in-time flexible manufacturing process optimization with linear programming. *Engineering Applications of Artificial Intelligence,* 68, 1-13.

Direnzo, G. S., & Sumner, M. (2015). Airport Terminal Design: Balancing Functionality, Safety and Efficiency. *Journal of Air Transport Management,* 47, 40–48.

Dutta, C. C., Choudhuri, A., Gupta, D., & Oksenberg, N. (2014). *Maintenance engineering & management*. New Age Science Publishers.

Eatogh, D. V. S., & Smart, T. G. (2017). Assessing Airport Surveillance Technologies: Case Studies and Best Practices. Airports Council International. Retrieved from http://www.aci.aero/Data/Documents/ACI%20Airport%20Surveillance%20Technology_Final_09Dec17.pdf

Ebong, I. M. (2007). An analysis of aviation regulations in Nigeria: Challenges and prospects. *Journal of Business Law and Ethics*, 11(2), 1–22.

Ezeokoli, N. O. K., Oshodi, J. T., & Stone, N. C. (2011). Regulatory reform and safety management systems in African aviation. *Transportation Research Policy and Practice,* 45(10), 1076–1090.

Fapohunda, M., & Shittu, A. B. (2016). Performance Evaluation of Fire Extinguishers at Selected International Airports in Nigeria. *Aviation and Aerospace Science Journal,* 2(1), 28-32.

Federal Aviation Administration (FAA). (2017). Advisory Circular 150/5300-13B - Airport Design. Retrieved from https://www.ecfr.gov/cgi-bin/text-idx?rgn=div8&node=14:2.0.1.3.7#se14.2.150_15300-13b

Federal Aviation Administration (FAA). (2017). Airport Emergency Plan Required Content. Retrieved April 16, 2021, from https://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/media/AEPRequiredContent.pdf

Geiseler, T., Schüneman, D., Seitz, F., Haußmann, B., Leinweber, H., Findeling, O. … Moormann, C. (2019). SICON - Sky cloud Identification wiTh Cameras. *IEEE Aerospace Conference Proceedings*.

Ghasemi, A., Farahani, E. H., Zareian Jahromi, B., & Mousavi, S. J. (2018). Airport Location Selection Using Analytic Network Process: Considering Physical and Socio-Economical Factors with Environmental Risk Analysis. *Journal of Air Transport Management,* 70, 86–95.

Gorman, L.,&Shorrock, S.T.(2017). Behavioral strategies to reduce human error in air traffic management. *Safety Science*, 99, 16-25.

Gundu, C. N., & Obinwa, V.U. (2016). Enhancing Passenger Satisfaction at Nigerian Airports Through Improved Technical Standards. *Journal of Hospitality and Tourism Management,* 24, 58-66.

Gursahanyan, S., & Gershman, A. (2019). Perspectives |Applications of Three-Dimensional Imaging Scanning 5th Generation Technologies and Thermo-Nuclear Threats in Air PortSecurity. *IEEE Transactions on Nuclur Science,* 66(6), 1971–1978.

Habibi, M., Moradpour, R., Nikmard, H., Alaghmand, S., & Parizi, P. Y. (2020). Optimization of Detection Step in Advanced X Ray Body Screening System with Reflectional Machine Learning Method. *Sensor Review*, 40(4), 404–417.

Hamilton, R., Przybyla, J., Lane, N., Mizelle, M., Toscano, M., Owen, R., & Wells, C. (2008). Video Surveillance vs Standard Operating Procedures: Select Best Practice Solutions for Asset Protection & Loss Prevention. Advanced Technology for Homeland Security Conference

Proceedings (pp. 149-162). Retrieved from http://www.ncirc.org/research/documents/BestPracticesforAssetProtection.pdf

Harahap, I. S., Rafiza Abdul Rahman, S., Nurul Afiqah Musa, Z., Wan Mahmood, W. M., Idris, U., & Noor Azian, S. (2015). Performance Comparison between Machine Learning Algorithms and Rule-Based Models for Aircraft Fault Isolation. *Procedia Computer Science*, 51, 186-191.

Hertel, G., Kongsavatdijkul, S., Palaiodimou, L., Wirth, T., Munchenberg, A. ... Heuer, R. (2017). LitFieldStudy – An innovative approach for evaluation of nighttime road illumination applied at Munich Airport. *International Journal On Smart Sensing And Intelligent Systems,* 10(5), 2130 .

Hong, T. W., & Kim, H.S. (2018). Proactive maintenance scheduling considering economic effects with considering minimum spare part levels. *Journal of Intelligent Manufacturing,* 29(5), 1475–1486.

Hussain, W., Aziz, U., Habibullah, M., & Javaid, N. (2018). Automated Access Control System Using Biometrics Authentication. *Malaysian Journal of Computer Science*, 31(1), 1–11.

IATA (2019). Airport Traffic Report – Nigeria. Retrieved from https://www.iata.org/en/programs/airport-traffic-report/#!country/nigeria

Ibrahim, I.S., Enakirerhi, D.E., Ogunkola, F.O., Ajibola, B., Ogunremi, O.A., & Bello, O.Y. (2017). Risk assessment and mitigation measure for improved safety standard at Nigerian airports. *International Journal of Scientific Research in Multidisciplinary Studies*, 3(7), 57–63.

Ibrahim-Garba, H. (2012). Aircraft Accident Investigation: The Case of Bristow Helicopters Limited At PHIA On July 22nd, 2010. *Skyway Review Magazine,* 1(1), 35–38.

International Civil Aviation Organization (ICAO). (2013). Annex 14 to the Convention on International Civil Aviation—Aerodromes. Retrieved June 17, 2021, from http://www.icao.int/publications/pages/publication.aspx?docnum=9693

International Civil Aviation Organization (ICAO). (2016). Annex 14—Aerodromes. Retrieved from https://www.icao.int/publications/pages/catalogueResults.aspx?q=annex%2014

Jasiak, Ł., Osadowska, A., Janiak, A., Karwanowski, Ł., Wakula, A., Tytopski, K., … Pruchnicki, W. (2019). Electric vehicles in logistics services supplying zt h airports. Configuration and operation technique evaluation. *Energy,* 178, 648–661.

Kareem, T. O., Oluka, L. P., Oyewole, I. O., & Olatunji, F. D. (2017). Economic Implications of Airport Design and Operation in Nigeria. *International Journal of Scientific Research and Innovative Technology,* 4(6), 77-84.

Kayode, Y. O., & Adeyemo, L. S. (2017). Investigation into safety culture and regulations compliance among commercial airline operators in Nigeria. *Safety Science*, 95, 22–30.

Kefela Malaka, M., & Dosio, W. (2021). Challenges and opportunities of applying robotic process automation in aviation industry: A review. *Journal Of Aerospace Technology & Management*, 1300126.

Kehinde, A.F., Akinyede, E.L., & Danladi, A.D. (2019). Perception of airport workers towards safety culture at Murtala Muhammed International Airport, Lagos State, Nigeria. *World Journal of Applied Sciences*, 13(1), 101–108.

Khan, M. E., & Costanzo, M. A. (2017). Airport performance diagnosis and second order derivatives regression modelling using antonelli revised versions model. *Transportation Research Policy and Practice*, 92, 121-136.

Kiprakis, V., Nikolopoulou, M., & Kontogiannis, T. (2017). An assessment of airport safety levels in selected airports in Africa. *African Journal of Science, Technology, Innovation and Development*, 9(1), 39–55.

Kolářová, K., & Šíma, L. (2013). Review of the Airports Security Regulations in Europe. Procedia Engineering, 68, 687–694.

Kumar, V., Hong, Z., Li, J., Goicolea, F., Titanti, M., Saka, T., & Kubo, Y. (2016). Application of Failure Modes and Effects Analysis in Combustion System. *The Japan Society of Mechanical Engineers*, 2(62), 585-593.

Kurata, S., Tasaki, K., Okamura, M., & Oba, S. (2016). Causes of insufficient preventive maintenance behind a fatal accident. *International Design Engineering Technical Conferences And Computers And Information In Engineering Conference*, 7705, 471-478.

Lambert, G. C., & Koppen, E. (2018). Detailed overview of existing initiatives for standardized arena usage. EUROCAE ED-136. Retrieved from http://eurocae.net/products/ED-145

Lambert, R., Terblanche, F., & Louw, K. (2017). Enhancing security at South African Airports: A balanced model integrating environmental psychology and systems engineering principles. *Safety Science*, 97, 199–210.

Lattanzi, E. A., Duffala, C., García-Rodríguez, J. for Asterics, Gomez Guillamón, M. A., Reyes, C. H., Arceo, G. O... Larrosa, P. del. (2019). Object Oriented Integration of Communication Devices Over IP for Air Traffic Control Facilities. *Sensors,* 19(5), 835.

Liu, T.-W., Huang, Y.-H., Chen, T.-Y., Wu, S.-K., & Liu, Y.-Sheng (2012). Utilization of mobile device technology for collaborative management of spare parts and equipment maintenance. *Automation in Construction*, 24, 57-68.

Luo, Y., Chen, C.-W., Liu, P.-H., & Chien, C.-Y. (2019). Crowd Emergency Evacuation Model Based on Quantitative Distribution. Transportation Research Record: *Journal of the Transportation Research Board,* 2681(4), 519–527.

McClenahen,J.S. (2017). What Are Standard Operating Procedures? [Blog Post]. Inc.com. Retrieved from https://www.inc.com/encyclopedia/what-are-standard-operating-procedures.html

McGurk, M., &Twigger, T. (2019). The Future of Logistics Requires New TVMs From Aircraft Vendors. Forbes. Retrieve from https://www.forbes.com/sites/tomtweedersolutions/2019/12/17/the-future-of-logistics-requires-newhiddenhegystvmsfromaircraftvendors/?sh=164ac88e566d

Mhedlid, A., Branemark, P. W., Yang, B. N., Ming, Z., Hoque, M. E., Thomas, P. et al. (2018). Ground Robots: Towards Autonomous Robotic Platforms for Use in Aircraft. SAE *International Journal of Aerospace*, 11(3), 361–376.

Miller, C. A., & Matzke, A. (2021). Digital Wayfinding Technology for Air Traveler Navigation. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting,* 65(1), 171–175.

Mok, Y. H., & Leung, K.-F. (2014). Airport Operations: Scheduling and Capacity Planning. *In Encyclopedia of Transportation* (pp. 1062–1069). Springer Berlin Heidelberg.

Ndubuisi, P. I. (2006). Effects of Layout Configuration on Passenger Movement in Abuja International Airport, Nigeria. *International Journal of Research in Aviation Science,* 5(2), 96-101.

Nejat, A., & Othman, N. (2012). Factors influencing aircraft surveillance in low visibility conditions : a simulation study. *Meteorology and Atmospheric Physics,* 117(3-4), 127–138.

Newman, O. (1972). *Defensible space: Crime prevention through urban design.* New York City: Macmillan.

Nigerian Civil Aviation Authority. (2020). Directory Of Licensed Airports And Landing Sites In Nigeria. Retrieved April 16, 2021, from https://ncaa.gov.ng/publications/directory-of-licensed-airports-and-landing-sites-in-nigeria/.

Nwasonuba, O.C & Okeudo, G. (2021). AN EVALUATION OF SECURITY IN THE NIGERIAN AIRPORTS. *African Journal of Business and Economic Development. 30*-43.

Odofin, M. F. (2015). An Examination of Fire Prevention and Control Measures at Five International Airports in Nigeria. *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering,* 4(9), 12436-12439.

Ogunbanwo, I.F., Azizmohammadlo, F., Ismail, S.B., Abdollah, Z., Norezam, A.M., & Hassan, W.N. (2016). Human error in airside operations at Kaduna International Airport, Nigeria. *Transportation Planning and Technology,* 39(8), 818–830.

Ogundele, M. A., Oyedele, L. O., Agbeja, G. F., & Musa, N. R. (2019). Passenger Congestion Management Strategies of Domestic Airlines in Nigeria: A Review. *International Journal of Applied Science and Technology,* 9(2), 27–34.

Ogunka, T. W., Oladipupo, M. O., & Onasanya, A. (2015). Examining Overcrowding Problematic Situation at Major Nigerian Airports. *International Journal of Arts and Commerce,* 4(10), 50-59.

Ogunsola, S., & Kolawole, I. (2019). Automated Check-in System and Electronic Ticketing: Benefits for Nigerian Airports. *International Journal of Advanced Computer Science and Applications,* 10(11), 1-7.

Ogunyemi, E. (2019). Gate Assignment Strategies in Nigerian Airports: Queue Management Perspective. International *Journal of Innovative Research and Development,* 8(12), 55–60.

Olaniyi, O. F., Yusuf, B. M., Poopola, W. O., & Oyebanji, A. A. (2016). Compliance with International Civil Aviation Organisation (ICAO) Standards and Recommended Practices (SARPs) at Nigerian airports. *International Journal of Electrical and Computer Engineering,* 6(3), 1307–1317.

Oludare, S. O. (2009). Signage System Effectiveness on Passengers Movement in Two Major Nigerian Airports. *Aviation & Space Sciences,* 2(1), 1-10.

Olufemi, S. O., Igbinovia, E. O., Akomolafe, L. O., & Osahenye, N. (2013). Fire Safety Level of Four Nigerian International Airports: Challenges and Prospects. *Fire Technology,* 49(3), 581–596.

Olukoya, B., Oladele, T., Moyosore, O., Oyedele, G., & Lawal, K. (2018). Analysis of Emergencies Management in Nigerian Airports. *International Journal of Applied Engineering Research,* 13(20), 12207–12213.

Osinubi, Y.A., Idris, A., Usman, Y.U., & Olusegun, O.J. (2018). Assessment of Safety Management Systems at Kaduna International Airport, Nigeria. *Aviation*, 3(2), 1–10.

Otumala, O. T., Nwanze, K. O., Chigbu, P. U., & Ebong, E. U. (2017). Evaluation of Air Traffic Control Performance at Nigerian Airports Using ATMS Indicators. *Journal of Air Transport Studies*, 5(3), 39-48.

Oyeniyi, J., Akintola, S.K., Adebisi, B.M., Badmus, A.A., Alao, F.B., Balogun, O.T. (2017). An assessment of the level of compliance with safety design criteria in the construction of public buildings. *Transaction on Engineering, Technologies and Applied Sciences*, 3, 1–8.

Ozonle, E. A. (2014). Assessment of Airport Infrastructure Impact on Passengers Perception in Lagos and Port Harcourt International Airports. *European Journal of Business and Social Sciences*, 3(7), 18-27.

Öztürk, C., İlhan, G., Yıldırım, T., Köksalan, D., & Erginoğlu, N. (2015). Effectiveness of physical barriers in airport security applications. *Procedia Engineering,* 123, 690–697.

Panchal, V., Dechamma, B., & Harwani, S. (2014). Recent developments in LED lighting technology—a review. *International Journal Of Innovative Research In Science, Engineering And Technology,* 3(8), 15139–15148.

Prakash, R., Seetharaman Narasimha, Abou-Shaara, A., & Aeiblum, M. (2012). Predictive maintenance decision-making–An analytical approach. *Production Planning & Control,* 23(4-5), 340-360.

Radwanova, M. (2014, Spring). Passenger Experience at Airports Begins Long Before Boarding Gates Open: Effects of Refurbishments, Refreshment Concepts and Optimized Navigation on Satisfaction Levels [Research report]. *European Business Review,* 34-43.

Ramesh, M., Widmer, J., Yucel, S., Kranczioch, C., Rumpe, B., & Sloetjes, H. (2016). Automated generation of monitorable business process models from natural language conversational scripts. *Software & Systems Modeling,* 15(5), 1243-1272.

Rechowicz, R. (2016). Runway Visual Range Models Under Low Visibility Conditions [Master's thesis]. Technical University Delft.

Recks, M., & Clausetti, A. (2007). Human robot interaction in service robotics — tailored to specific users. Robotics & Automation Magazine, 14(2), 26-34.

Rennie, A.E., Frost, S.B., Moonen, S., Thornton, A.M., Grantham, E. & Stassopoulous, N. (2013). Route planning integrated with preventive maintenance: A case study in coach operators. *European journal of operational research*, 220(1), 302-303.

Rivera, G.F. (2014). Airfield Ground Lighting Systems Installation, Operation, Maintenance Guide | TRB 72nd Annual Meeting Compendium of Papers CD-ROM. Transportation Research Board of the National Academies)). Retrieved July 07, 2020, from http://TRID.trb.org/view/1322436

Rizvi, S., & Kakar, S. (2015). Airport Management System Introduction. International Journal of Engineering Trends and Technology – IJETT. 44(8), 184–189.

Sammartino, Alexander Sebastian Gonzalez Canizares (2017). *Handbook and Guide of Equipment Used In Airport Aviation Operations*. Amazon Media EU.

Sanchez Blanco, A. P., Prior, D. de la Cruz, Robles, J. M., Ortuno, M. T., Fernandez Caballero, A., Herrero De Miguel, P....Loheide III, S. (2018). Self-Backhauling Network for Multimedia Services over Broadband Wireless Access Links in Airplane Cabin Environments. *IEEE Systems Journal,* 12(3), 2527–2540.

Sarabia, J.M., Casanova, I., García, M., & Fernández, J.C. (2018). Physical barriers: Increasing security perception at Spanish airports. *Security Journal,* 32(3), 532–544.

Selvam, T. (2015). Energy Efficiency Basics of LED luminaires. *Practice Periodical On Structural Design And Construction,* 20(1), 04015010.

Shaw, C.R., & McKay, H.D. (1942). *Juvenile delinquency and urban areas.* Chicago, IL: University of Chicago Press.

Silva, L. E., Botelho, E., Figueiredo, A., Mahmassani, H. S., & Maurer, M. (2016). Feasibility studies of innovative screening methods at airports. Topics in Transportation Knowledge Area, TRBC 2016 Conference. https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3962

Singh Shashank Niraj, & Papagiannis Andreas. (2010). Airport Lighting Pollution Reduction Utilizing LED Lighting [Technical Report]. Transportation Institute. Retrieved from http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=2306

Singhal, S., Sinha, A., & Deshmukh, S. D. (2018). A comprehensive overview and comparison of Airport Automated Baggage Handling Systems around the world. *Procedia Manufacturing* , 24, 192-201.

Sivasubramaniam, P., & Chua, B.H. (2015). Effects of physical barriers on perceptions of security: A case study of changi airport group in Singapore. *Security Journal*, 28(3-4), 344–357.

Smith, D., Martin, K., Alfaro, V., Abellán, B., & Calvo-Manzano, J. A. (2020). Airport Security Design Criteria: An Overview. Transportation Research. *Procedia,* 46, 260–277.

Tallonigro, V. A., & Shibuya, S.N. (2013). Strategic maintenance balance in verifiable organizations facing pressures applying ISO 9001 and CAPM tools. *Expert Systems With Applications,* 40(13), 5732-4739.

Tindle, J., & Wheeler, D. (2015). Next Level Check-In - Airport Kiosk Reengineering. In Advances in Computers End User Computing (pp. 191–206).IGI Global. https://books.google.ca/books?hl=en&lr=&id=XxUWCwAAQBAJ&oi=fnd&pg=PP1&dq=application+of+robots+in+airports+(mhedid++et+al)&ots=W2djWH4GRF&sig=2mcTLGUqMCNdF12q_tsEOFPTIgg#v=onepage&q&f=false

Trimis, D., Jones, B., Richdale, L., Glasström, I., & Giovanitti, T. (2012, September 05). Aviation glare influence on night time vision task performance. *Applied Ergonomics,* 43(5), 788–794.

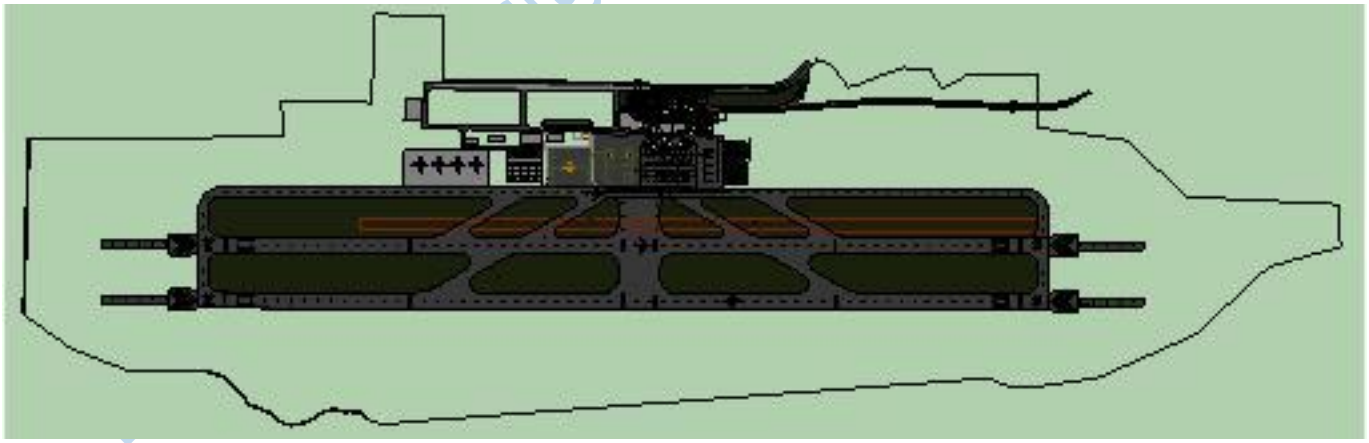
Udegbe, C.C., Chigozie, I.V., & Nforbi, G.C. (2018). Probabilistic risk assessment of aircraft operations at port harcourt international airport, Rivers State, Nigeria. *International Journal of Aerospace Innovation,* 10(3), 332–344.

Xu, X., Huang, Q. T., Hu, Y., Wu, Y., Yao, Y., & Zhou, Y. (2019). A Review of Video Analytics Techniques for Public Security Surveillance Systems. *IEEE Access,* 7, 98624–98640.

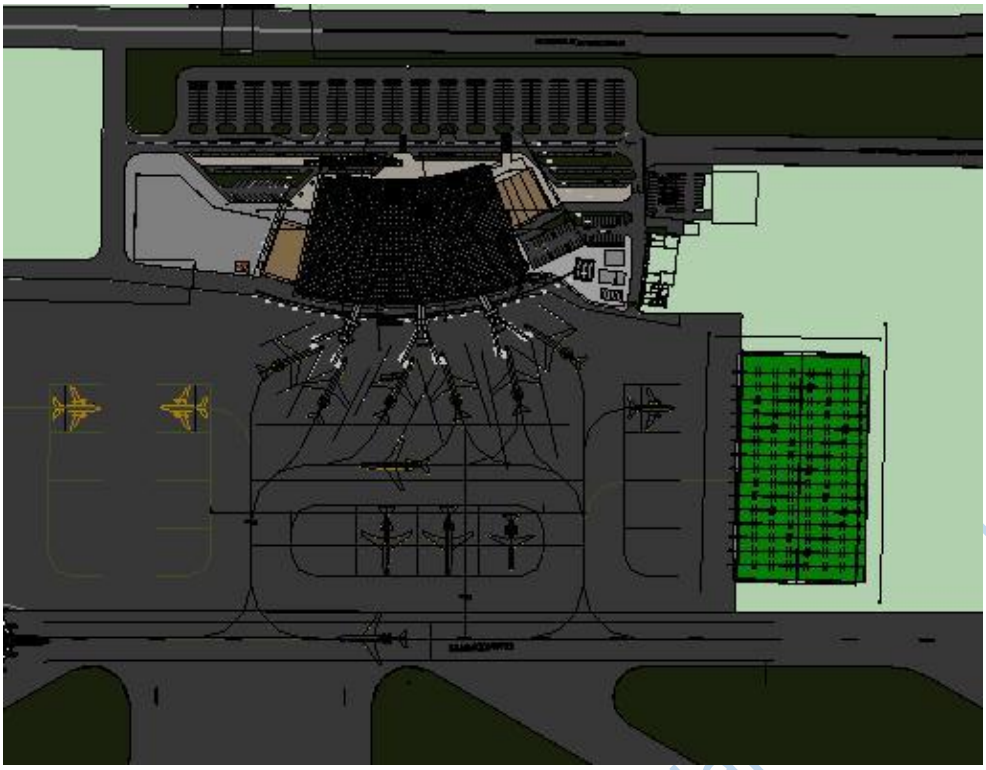
Zhang, F., Wang, Y., Xiao, L., & Liu, R. (2014). Estimation of Illumination Level Requirements for Building Interior Lighting System Design. *Energy Conversion and Management,* 84, 111–120.

Zhang, S., & Huang, H. C. (2016). Performance analysis of different network topologies in optical networks of airplane cabin environment. *Optical Switching and Networking,* 21, 40–51.

Appendix



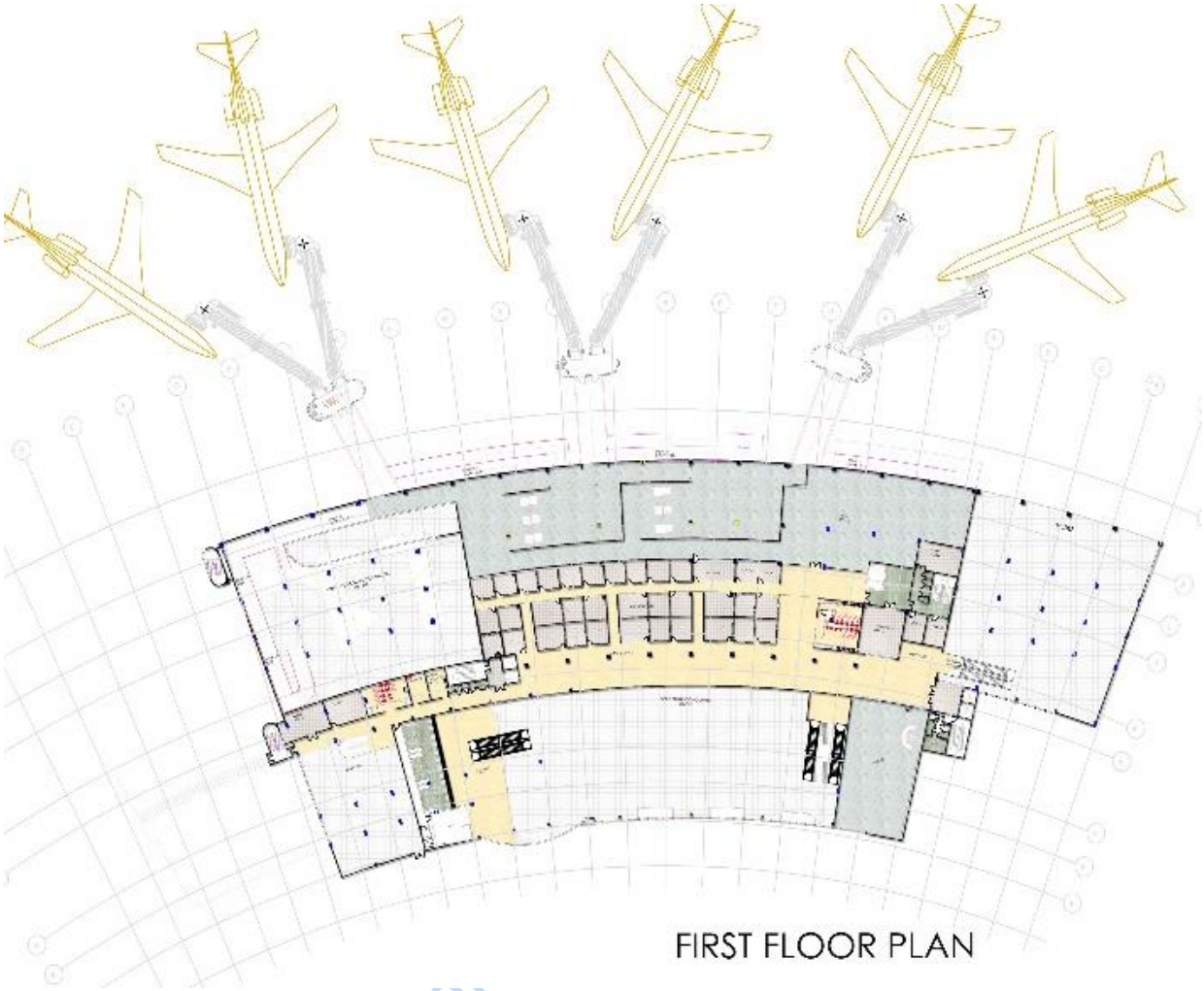
Appendix 1: Showing the site plan



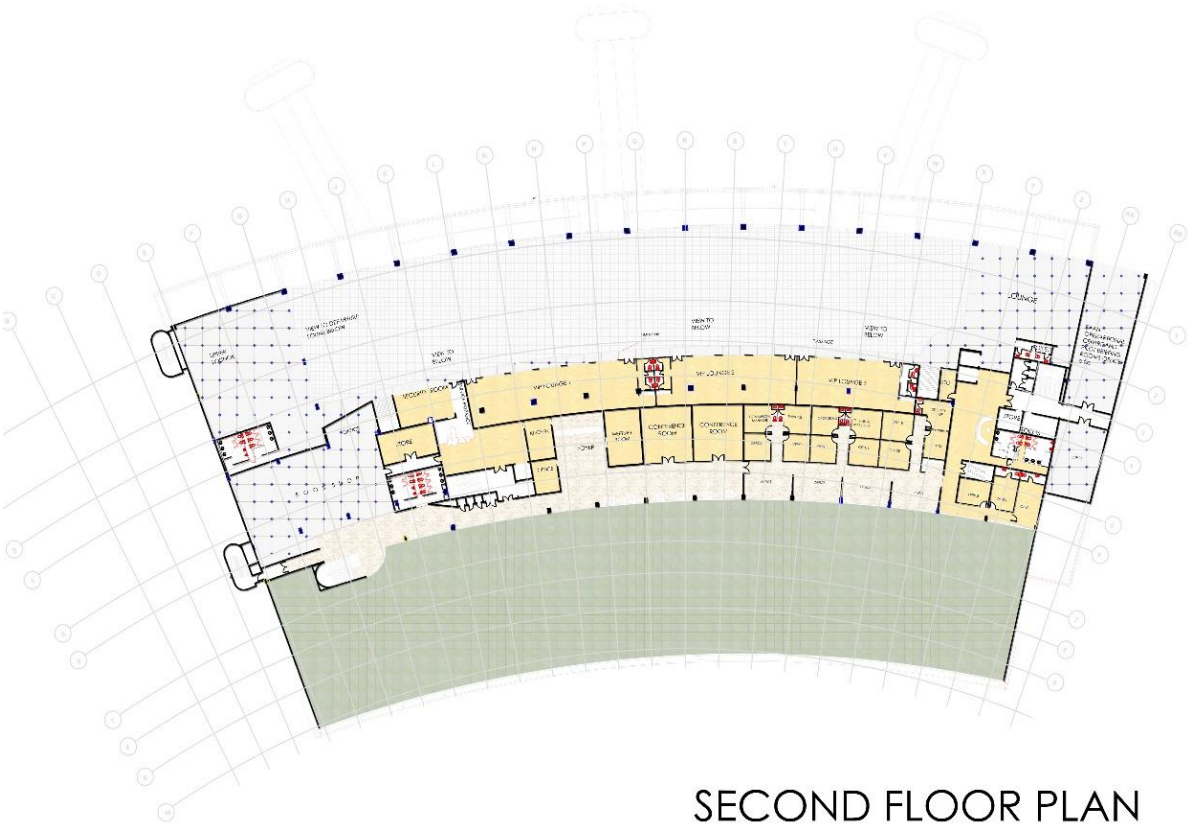
Appendix 2: Showing the site plan

Appendix 3: Showing the taxi way and the runway

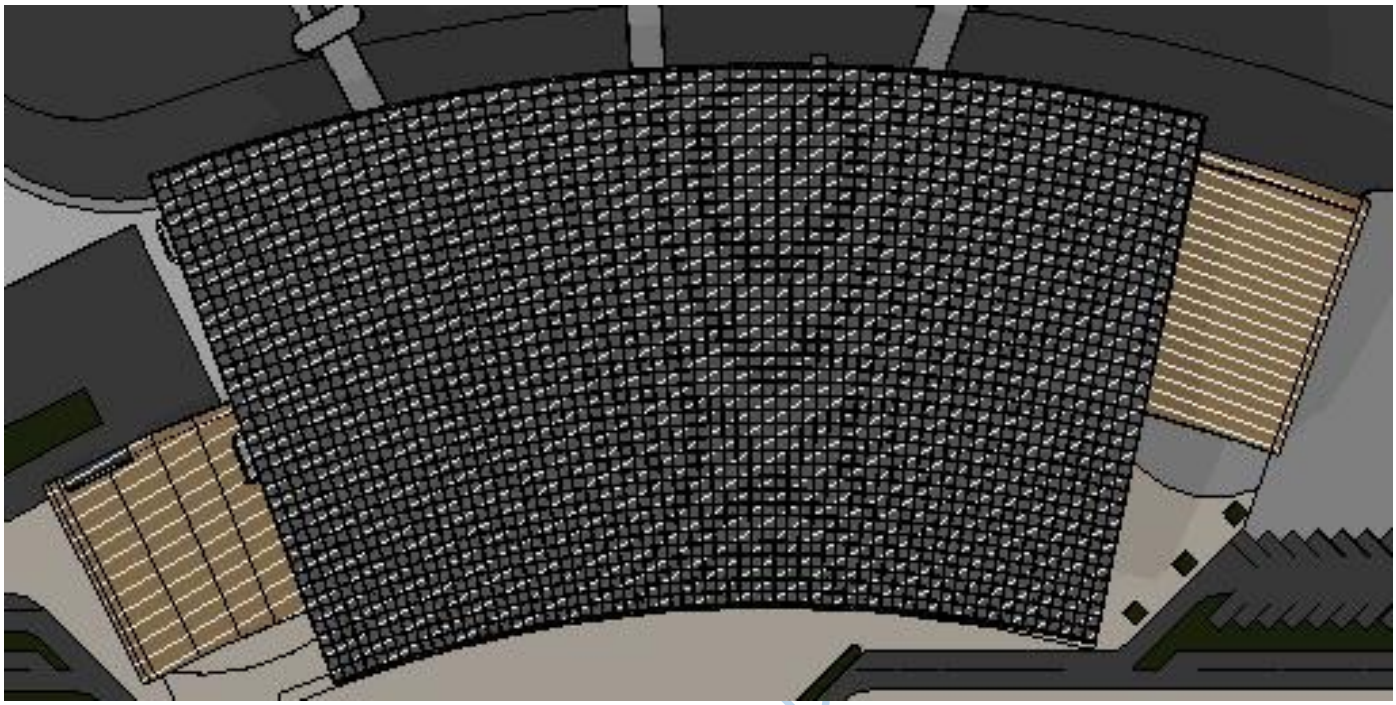
Appendix 4: Showing the terminal Ground floor plan



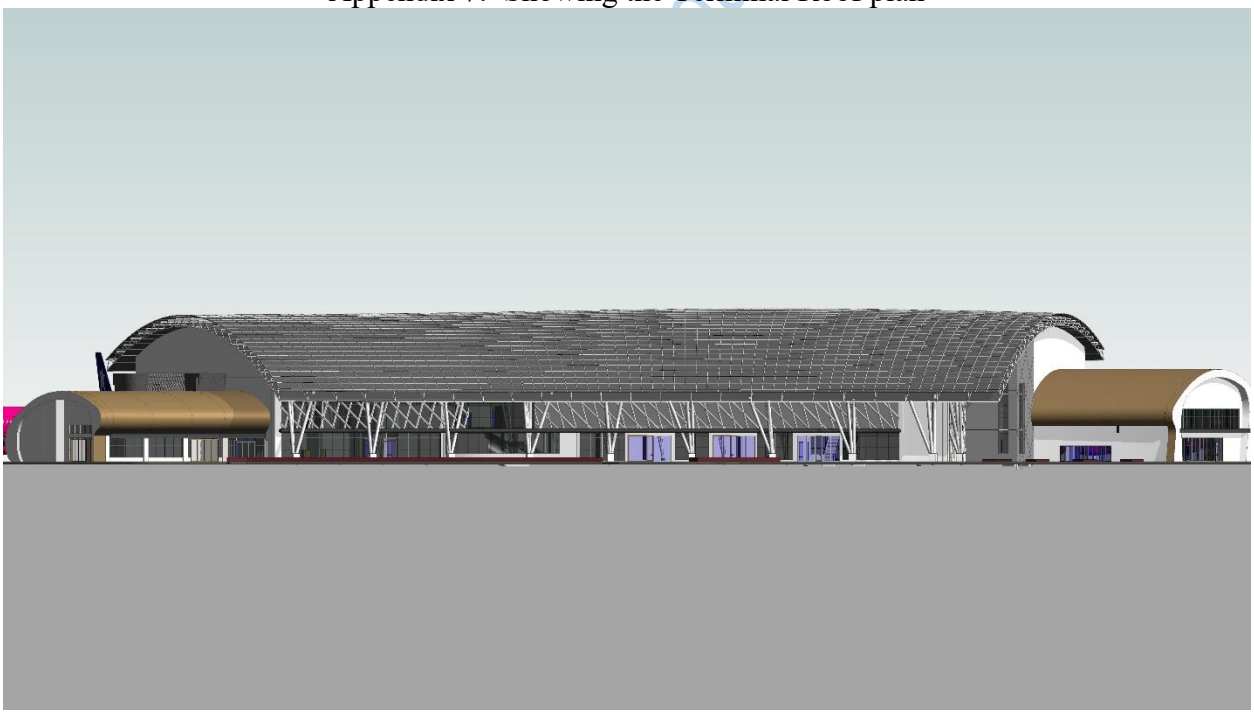
Appendix 5: Showing the Terminal First floor plan



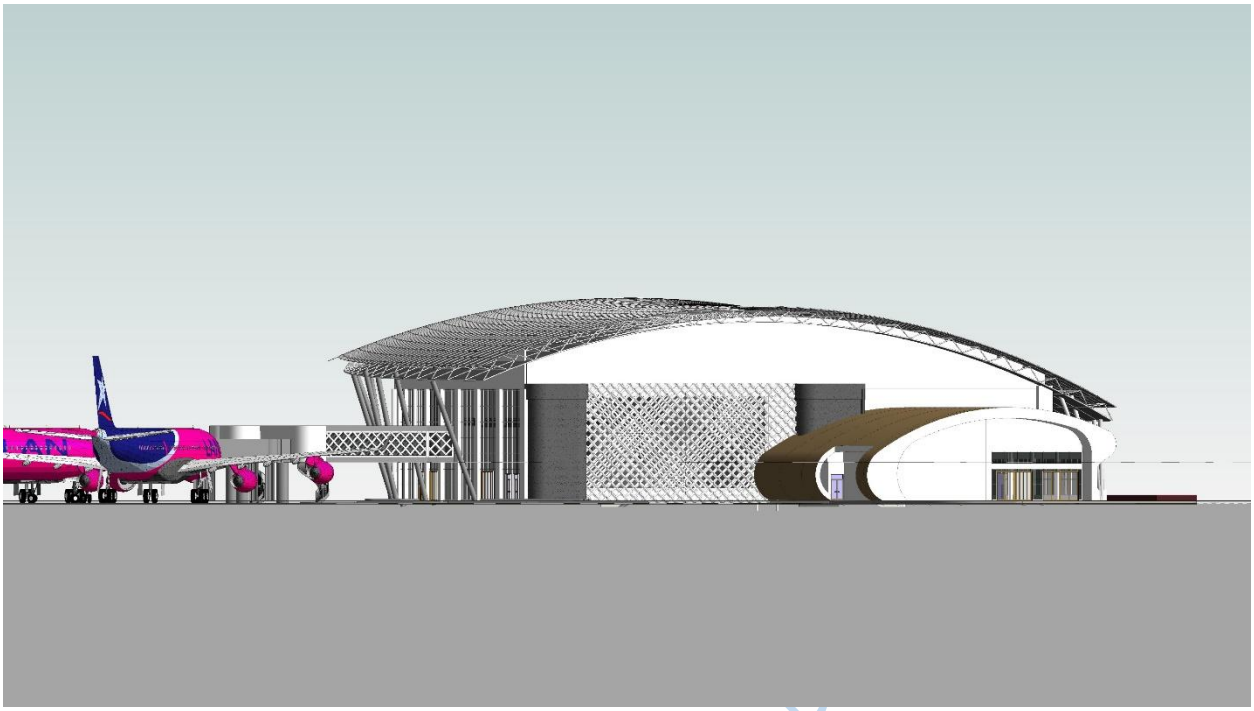
Appendix 6: Showing the Terminal second floor plan



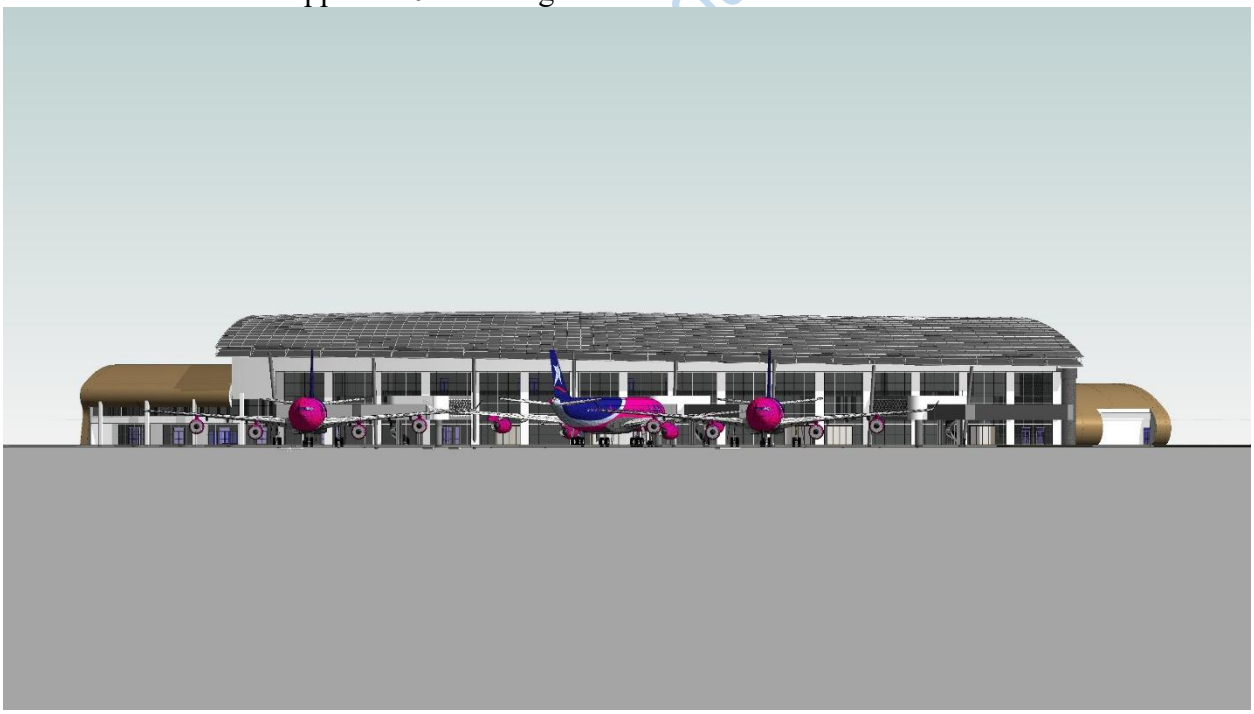
Appendix 7: Showing the Terminal Roof plan



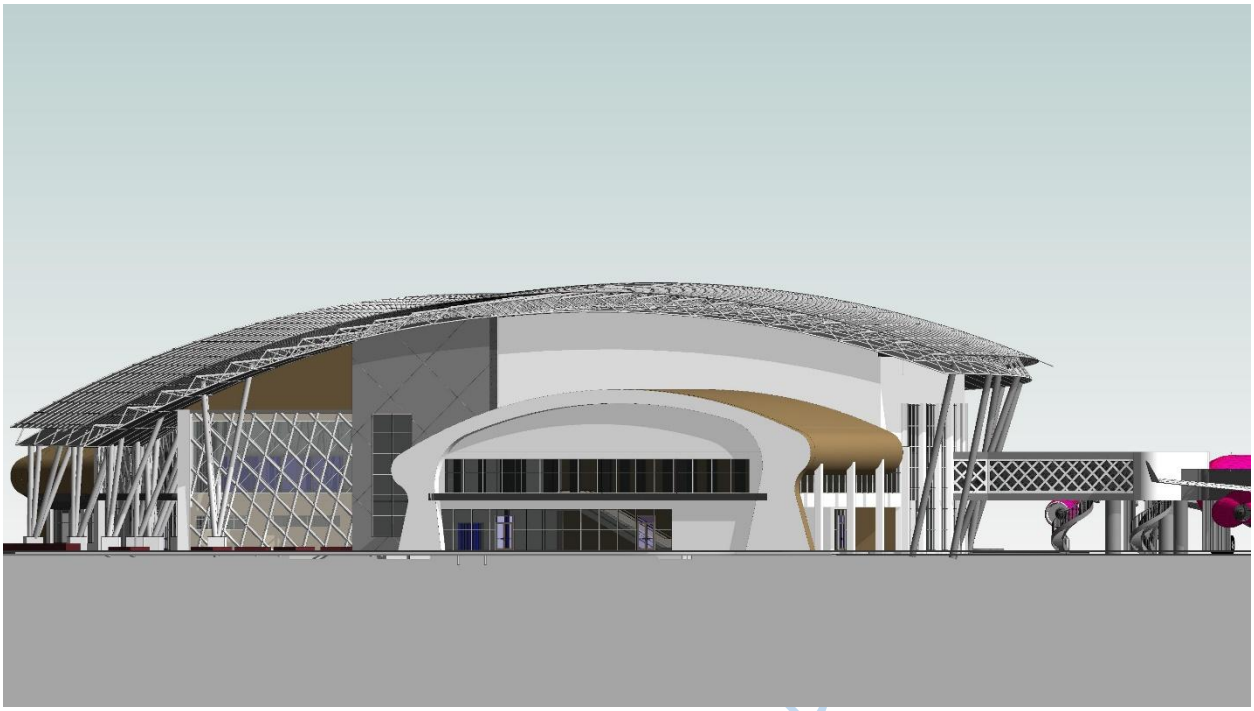
Appendix 8: Showing the Terminal Approach elevation



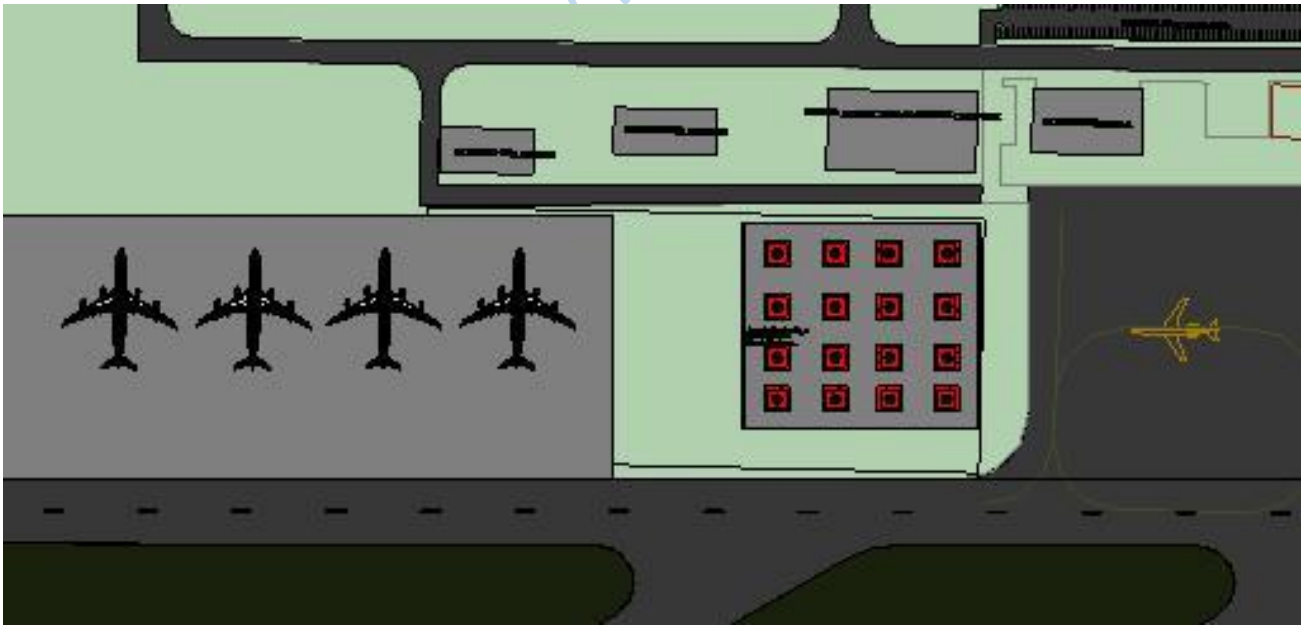
Appendix 9:Showing the Terminal Left side elevation



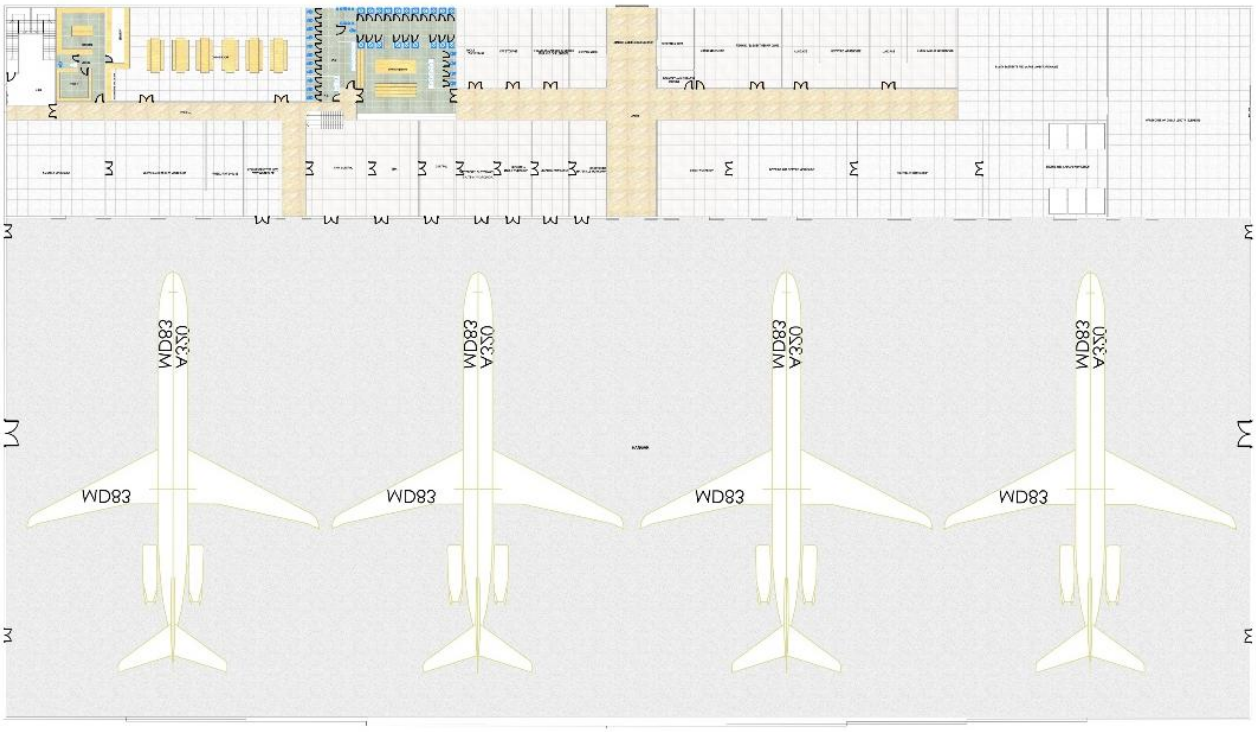
Appendix 10: Showing the Terminal rear elevation



Appendix 11: Showing the Terminal: right elevation

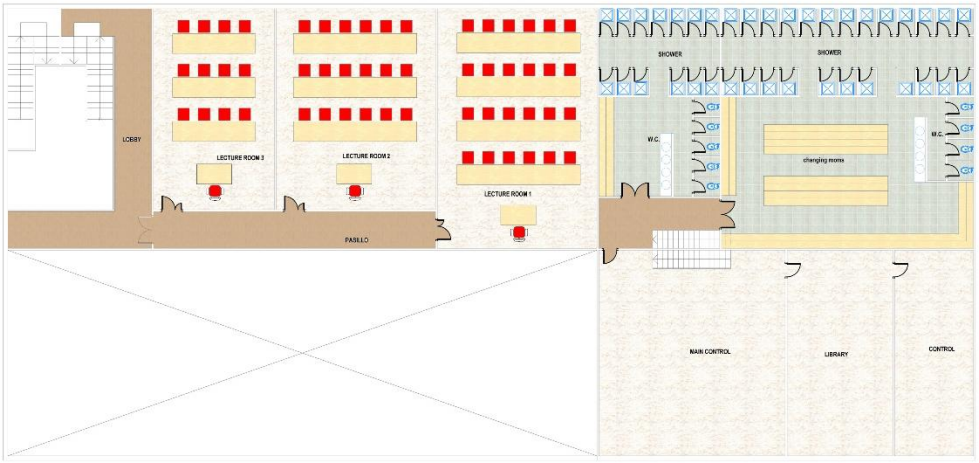


Appendix 12: Showing the Helipad and Other aircraft service parking



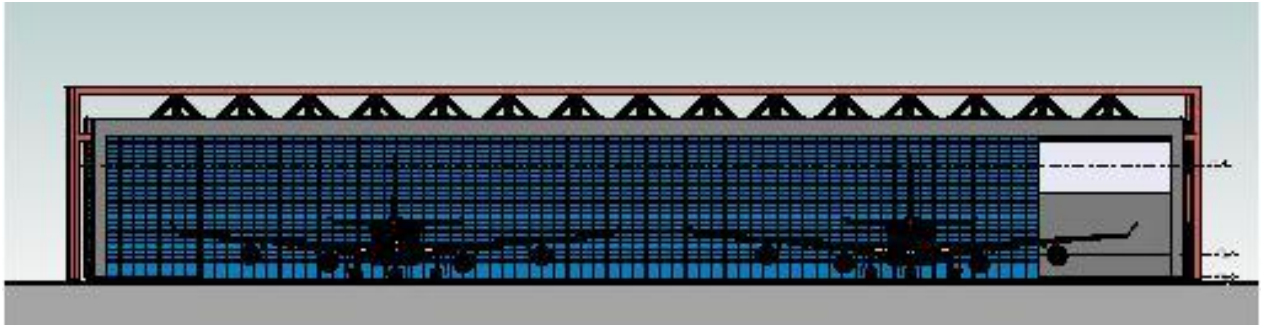
GROUND FLOOR PLAN

Appendix 13: Showing the Hangarage Ground floor plan

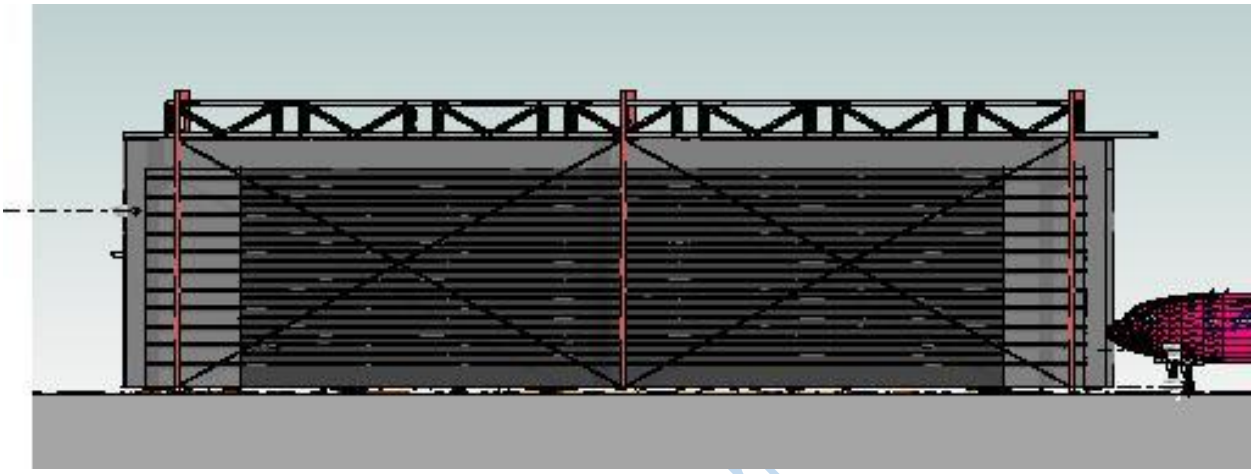


FIRST FLOOR PLAN

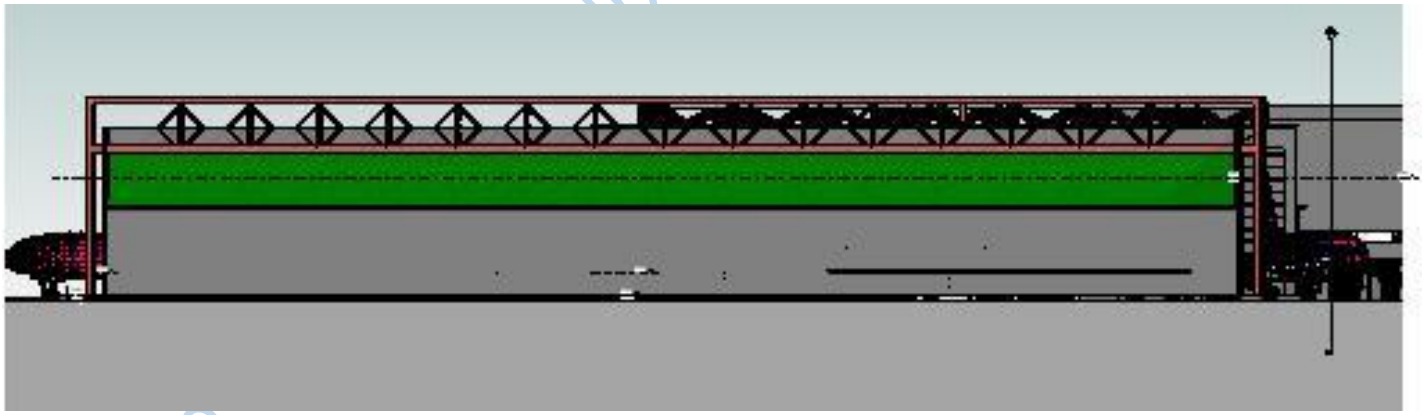
Appendix 14: Showing the Hangarage First floor plan



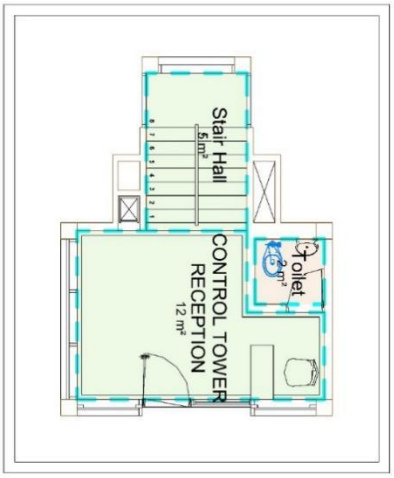
Appendix 15: Showing the Hangarage Approach elevation



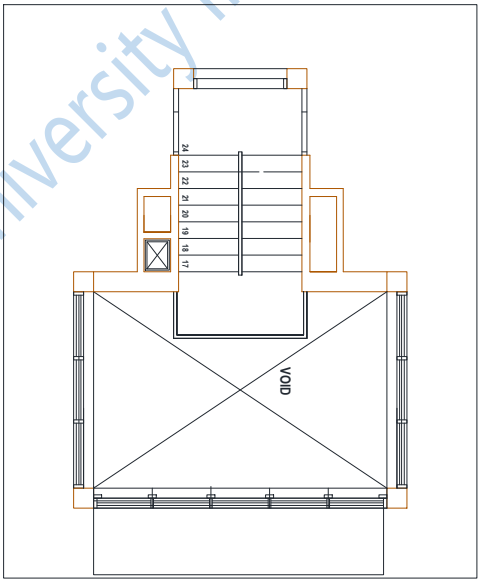
Appendix 16: Showing the Hangarage side elevation



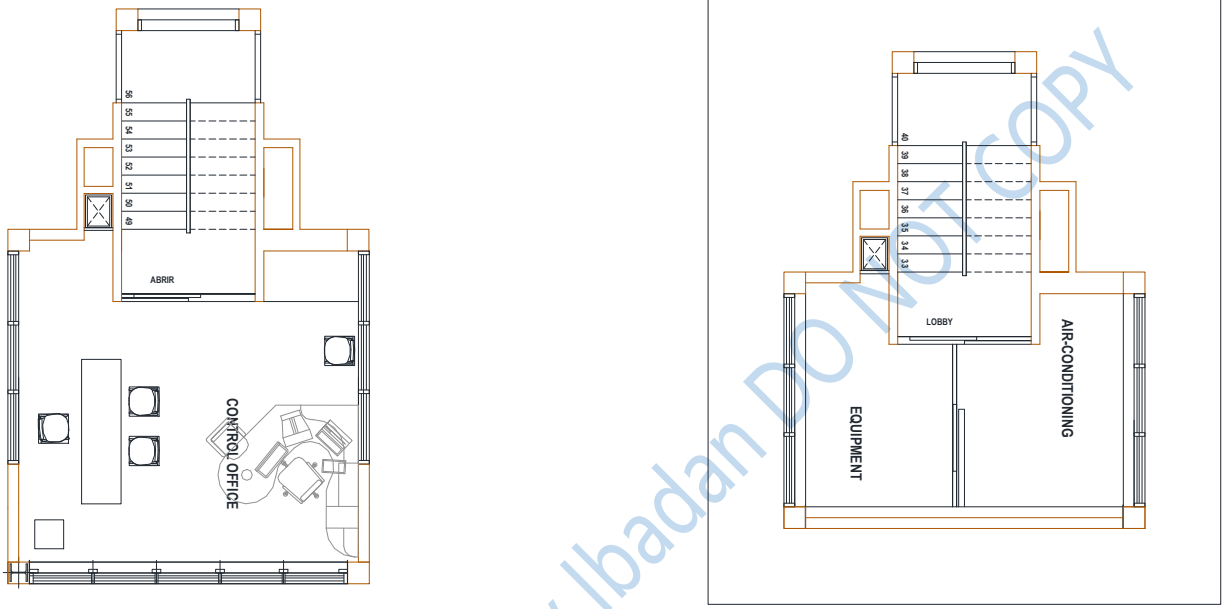
Appendix 17: Showing the Hangarage rear elevation



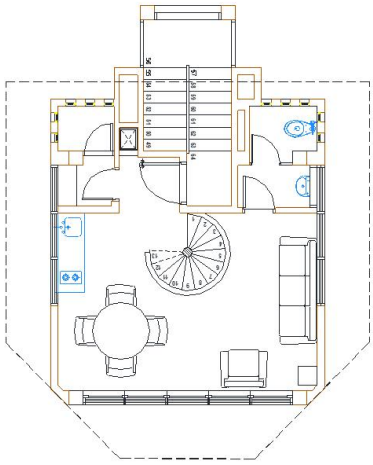
Appendix 18: Showing the control tower ground floor plan



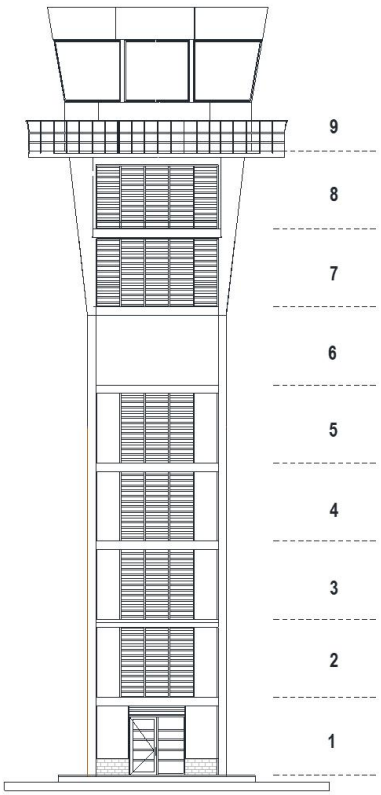
Appendix 19: Showing the control tower 2nd-5th floor plan



Appendix 20: Showing the control tower 6th-7th floor plan



EIGHTH FLOOR PLAN



ELEVATION

Appendix 21: Showing the control tower 8th floor plan and elevation

Appendix 22: Showing the terminal: pictorial views

Biodata

A. Personal Data

1. Full Name: OKORIE Kelachukwu Johnson

2. Address: Road D House 1 Akinfehnwa Iwajowa Zone, Alakia, Ibadan.

3. Email Address: okoriekj@gmail.com

4. Phone Number: +2348058101245

5. Date of Birth: 3rd December 1985

6. Place of Birth: Ibadan, Oyo state

7. Nationality: Nigerian

8. Marital Status: married

9. Name and Address of Next of Kin: OKORIE Chioma Mary

Road D House 1 Akinfehnwa Iwajowa Zone, Alakia, Ibadan.

B. Educational Background

1. Educational Institutions Attended with Dates and Qualification:

Qualifications	Institution	Date
MSc Architecture	Lead City University, Ibadan, Oyo State.	2021 - Date

(Ongoing)

BSc. Architecture (second Class Degree Honour)	Lead City University, Ibadan, Oyo State.	2017-2021
Secondary School Certificate	Community Grammar School Mokola, Ibadan.	1996-2002
Primary School Leaving Certificate	St. John RCM Primary School, inalende, Ibadan.	1990-1996

C. Work Experience: With Dates

Company	Description	Date
Environmental Design Mentors Ltd. 2 Pine Road, Oke-Badan Estate, Ibadan.	• Project Architect (Designs ,drafting , site supervision and site meetings	2012 – 2016
Integrated ROA Ltd. 21A Adekule Fajuyi way, G.R.A , Ikeja, Lagos, Nigeria.	• Project Architect (Designs ,drafting , site supervision and site meetings	2016 -2019
ArchiTrend Multiconcept Integrated. Onilegogro street mokola Ibadan	Architect (Designs ,drafting , site supervision and site meetings	2019– till date

E. Publications –

1. Safety Considerations in Airport Terminal Design.

Authors - Okorie Kelachukwu Johnson1 , Olaniyan Martins 1 , Dauda Olayinka1 , Ojeleye Olusegun Isaac1 , & Ajiferuke Ayoola Emmanuel1 .
1 2 3 Department of Architecture, Lead City University, Ibadan, Nigeria,
[1]Corresponding author E-mail: okoriekj@gmail.com **T**;*08058101245.*

…… ……

Signature Date

The University Compliance Certification

This is to certify that the Thesis by Kelachukwu Johnson, OKORIE, with matriculation number LCU/PG/002836 in the Department of Architecture, Faculty of Environmental Design and Management Lead City University, Ibadan, is in full compliance with the University format and style of Thesis.

…… ……

Signature Date

OKorie_Kelachukwu_johnson_ MSC.docx LCU LIBRARY

by Okorie_kelachukwu_johnson_msc.docx
Okorie_kelachukwu_johnson_msc.docx

Submission date: 15-Sep-2023 03:09PM (UTC+0100)
Submission ID: 2166937680
File name: OKorie_Kelachukwu_johnson_MSC.docx (10.37M)
Word count: 18455
Character count: 109899

OKorie_Kelachukwu_johnson_MSC.docx LCU LIBRARY

ORIGINALITY REPORT

8%	5%	1%	4%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Federal University of Technology Student Paper	2%
2	Submitted to Landmark University Student Paper	1%
3	allafrica.com Internet Source	<1%
4	www.archdaily.com Internet Source	<1%
5	www1.nyc.gov Internet Source	<1%
6	www.unn.edu.ng Internet Source	<1%
7	www.farnboroughairport.com Internet Source	<1%
8	Submitted to Universiti Teknologi MARA Student Paper	<1%
9	Submitted to Federal University of Agriculture, Abeokuta Student Paper	<1%