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The planning and design of Terminal buildings: a case study of Beirut international airport

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Abstract:

This report explores the fundamental design considerations and the evolution of Terminal architecture in a city. Terminals are critical nodes in the transportation infrastructure of a city, connecting various modes of transportation and serving as gateways for travelers. The report analyzes the key design principles and strategies that have influenced the evolution of Terminal architecture over time and examines their impact on the urban fabric.

This report explores the design aspects of Airport Terminals, which serve as iconic gateways to a city, representing its first impression to visitors. The Terminal building, as the interface between ground and air transport, involves diverse perspectives of analysis and understanding. The planning and design of Terminal buildings prioritize both form and function, as they are a city's pride and cater to visitors across cities and nations. With a life term of at least half a century and the potential for future expansion, the large establishments involve critical planning and management, prioritizing passenger comfort and safety, airline operational needs,

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airport management, safety and security, and community objectives. In Beirut, the increasing growth in air travel calls for a good experience at the Airport, prioritizing the "Green airports" concept, aligning with the social and environmental way of design and conceptualization.

Keywords: sustainability, Terminal, Airport, architecture, planning, design

Introduction:

Terminals are essential components of a city's transportation network, serving as hubs for the movement of people and goods. The design of a Terminal must consider a range of factors, from the needs of passengers and the characteristics of the transportation modes it serves to the surrounding urban context and environmental sustainability. This report examines the evolution of Terminal architecture in response to these design considerations.

An airport terminal serves as an intermediary zone that facilitates the transition between ground transportation and the infrastructure necessary for passengers to board and disembark from airplanes. This edifice contains all managerial and operational activities associated with the movement and actions of passengers before and after boarding flights. The terminal is a critical hub where air travelers purchase tickets, undergo security screenings, and interact with air management and administrative personnel. The concourse is the area within the terminal that houses gates that provide access to aircraft. At domestic airports, the terminal and concourse are often located in the same building. In contrast, at airports such as Denver International Airport, a single terminal accommodates multiple concourses.

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To ensure access, connectivity elements such as sky bridges, travellators, or subway paths are designed. Multiple terminals with their own sets of concourses are present in some international airports such as New York's La Guardia Airport and Dallas Airport.

The expansion of airports has become a necessary response to the growing demand for air travel. As a result, architects and urban planners have been challenged to design new terminal buildings that can accommodate increasing passenger numbers while addressing concerns of sustainability and community impact. This study will focus on the case of Beirut, a city that has experienced rapid airport expansion over the last few decades. The study will examine the basic design considerations for a terminal building and the evolution of terminal building architecture in a city. Additionally, the study will assess the impact of airport expansion on the surrounding community, including environmental concerns and traffic congestion. The report concludes with recommendations for architects and urban planners to mitigate the negative impacts of airport expansion and promote sustainable development.

In Beirut, air transportation has experienced significant growth in recent years, with numerous budget service providers entering the market alongside established airlines like Middle East Airlines. Air travel, once seen as a luxury, has become increasingly accessible to the general public. Passengers now expect a pleasant airport experience, which requires Terminal design to prioritize safety, security, and efficient circulation of multiple user groups and functions.

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The Directorate General of Civil Aviation (DGCA) regulates civil aviation and safety standards for both domestic and international transportation in Beirut. Beirut–Rafic Hariri International Airport (BRHIA) is managed and operated by the Directorate General of Civil Aviation (DGCA) of Lebanon, a government agency under the Ministry of Public Works and Transport established in 1927, making it one of the oldest civil aviation authorities in the world. The airport's day-to-day operations and management are overseen by the Beirut Airport Company (BAC), which is a public-private partnership between the Lebanese government and private investors established in 1994. BAC is responsible for the development, operation, and management of the airport, including its terminals, runways, and other infrastructure. This report will explore two key aspects of Terminal building design: the fundamental design considerations and the evolution of Terminal architecture in a city.

1. Literature Review:

Airport terminals are one of the most significant elements in modern transportation infrastructure, and they play a crucial role in shaping a city's identity and image. According to Koo and Kim (2019), airports and their terminals have become "destination facilities" that not only serve as transportation hubs but also provide a range of amenities, including retail, dining, and entertainment options. Therefore, the design of airport terminals has evolved beyond functional considerations to encompass broader social and cultural factors.

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In the past, airport terminals were typically designed as functional structures that prioritized efficiency and operational needs over aesthetics and passenger comfort. However, over time, this approach has shifted towards creating terminal buildings that serve as iconic gateways to a city and represent its culture, values, and aspirations (Ashford et al., 2011). Today, airport terminals are designed to reflect a city's identity and image, with attention paid to architectural form, materials, and colors.

In addition to aesthetics, sustainability is emerging as a critical factor in airport terminal design. With the increasing awareness of the impact of transportation on the environment, "green airports" are becoming the norm, with terminal buildings incorporating environmentally sustainable design features such as natural lighting, green roofs, and energy-efficient systems (Alqahtani et al., 2018). These sustainable features not only benefit the environment but also contribute to creating a more comfortable and healthier environment for passengers and staff.

Furthermore, the design of airport terminals is also incorporating public spaces, providing opportunities for passengers and visitors to engage in social and cultural activities. The integration of public spaces within airport terminals not only enhances the overall travel experience but also serves as a revenue-generating opportunity for airport operators through retail and dining options (Sereda et al., 2021).

In summary, the literature on airport terminal design highlights the evolution of terminal architecture from functional structures to iconic gateways that reflect a city's identity and values. With a growing focus on sustainability and the integration of public spaces, airport terminals are becoming more than just transportation hubs but also social and cultural destinations.

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2. Research Methodology:

This study employs a qualitative research approach, using a case study analysis of the Beirut-Rafik Hariri International Airport Terminal in Lebanon. The case study is based on a review of the existing literature on airport terminal design, with a focus on the fundamental design considerations and the evolution of terminal architecture in a city.

Data collection involves a review of academic journals, books, and industry reports related to airport terminal design, with a particular emphasis on case studies of successful terminal design that cater to both functional and aesthetic considerations. The study also relies on interviews with architects, airport designers, and airport operators to gain a deeper understanding of the design process and the challenges involved in designing successful airport terminals.

Data analysis involves a thematic analysis approach, with a focus on identifying the key themes that emerge from the literature and interviews. These themes include the evolution of airport terminal design, the balance between functional and aesthetic considerations, the integration of sustainable design features, and the incorporation of public spaces within airport terminals.

The findings of this study will provide insights into the design considerations involved in creating successful airport terminals that cater to both functional and aesthetic requirements while also incorporating sustainable design features and public spaces. The study will also identify the challenges involved in designing successful airport terminals and offer recommendations for future terminal design projects.

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3. Analysis:

4.1The significance of terminal building architecture in the context of airport design

According to recent studies, the architecture of terminal buildings plays a crucial role in airport design. As one of the most distinctive features of airports, terminal buildings have been designed in a variety of styles, ranging from plain functional to architecturally magnificent, representing indigenous cultures, or serving as structural marvels (Fjeld, 2019).

In today's world, many of the world's largest cities have multiple airports that cater to both domestic and international travel. This has raised questions about the appropriate size and design of airport terminals. Should terminals be massive, awe-inspiring, or intimidating, or should they be smaller in scale, designed to put anxious passengers at ease?

Recent research has shown that the design of terminal buildings can have a significant impact on travelers' experiences (Garcia-Rodriguez & Herrera-Franco, 2020). Innovations in terminal design over the past few decades have resulted in unique and creative terminal building designs that prioritize both function and aesthetics (Razavi, 2019).

In summary, terminal building architecture plays a crucial role in airport design, and recent innovations have resulted in unique and innovative terminal designs. As such, future airport design should prioritize the creation of functional yet aesthetically pleasing terminal buildings that cater to the needs of passengers while also representing the culture and character of the airport's location.

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4.2Basic Design Considerations for a Terminal Building:

Terminal buildings are the most identifiable components of an airport, as they represent the first and last point of contact for passengers and play a crucial role in shaping the overall passenger experience (Choi et al., 2021). Terminal buildings must be designed to provide a welcoming and functional environment that can handle high volumes of passengers. As such, basic design considerations must include passenger flow, flexibility, and sustainability (Bakhtyar et al., 2020).

- Passenger flow (Figure 1) is one of the essential design considerations for terminal buildings. Terminal buildings must be designed to ensure passengers can easily navigate through the building without congestion or delays. This includes areas such as security, check-in, boarding, and baggage claim (Bertolini & Spit, 2020).
- Flexibility is another crucial consideration for terminal building design. Terminal buildings must be flexible enough to accommodate changing operational requirements, including changes in passenger volumes, airline preferences, and security requirements (Choi et al., 2021).
- Sustainability is also essential in terminal building design. To minimize their impact on the environment, terminal buildings must be designed for energy efficiency, water conservation, and waste reduction. Incorporating sustainable design features and materials can play a key role in achieving these goals (Gonzalez-Longo & Agudelo-Vera, 2021).

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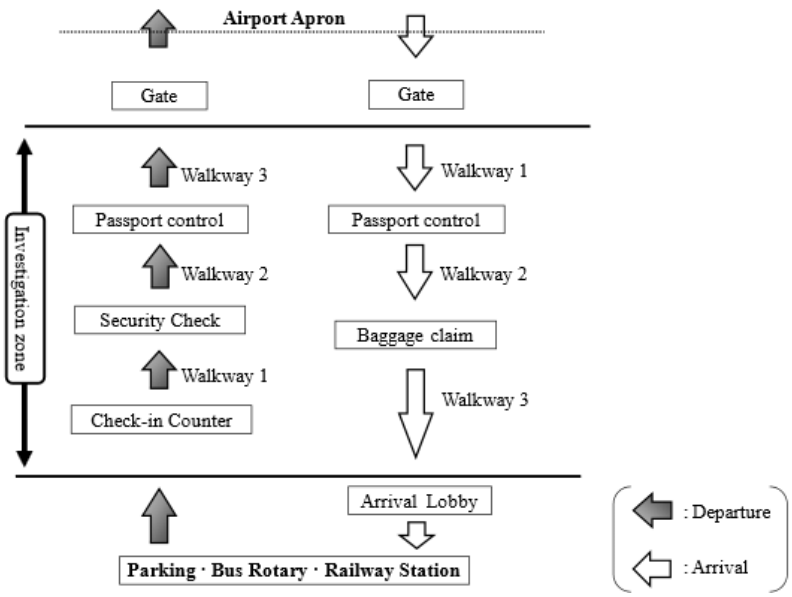

Figure 1 Passenger flow in airport terminals. (Juliater Simarmata 2018)

The architecture of terminal buildings is critical for several reasons. Firstly, it can significantly impact the passenger experience, shaping their overall impression of the airport and the city it serves. A well-designed terminal building can create a welcoming and positive experience for passengers, while a poorly designed terminal building can create confusion, frustration, and negative impressions (Saha & Ahmed, 2020).

Secondly, terminal buildings can contribute to the unique identity of the airport and the city it serves. They can become significant landmarks that represent the cultural, social, and historical context of the city and the region, playing a crucial role in shaping its sense of place (Ferreira et al., 2021).

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Thirdly, the architecture of terminal buildings is critical for addressing environmental concerns, as it can help minimize their impact on the environment. Incorporating sustainable design features and materials can play a crucial role in achieving these goals (Gonzalez-Longo & Agudelo-Vera, 2021).

In summary, terminal building architecture plays a critical role in creating a positive passenger experience, contributing to the unique identity of the airport and the city it serves, and addressing environmental concerns. Architects and designers must carefully consider these factors when designing terminal buildings to ensure they meet the needs of the airport, the city, and the passengers they serve.

Some examples of iconic terminal buildings that have been built by different cities:

- Denver International Airport (DEN) - Denver, Colorado, USA: The terminal building at Denver International Airport, designed by Fentress Architects, is a striking, tent-like structure that covers over 1.5 million square feet. The design was inspired by the snow-capped peaks of the Rocky Mountains, which can be seen from the airport. The terminal building is known for its expansive glass walls, which offer stunning views of the surrounding landscape.

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Figure 2 Denver International Airport (DEN) By AP, 2017

- Changi Airport (SIN) - Singapore: Changi Airport is known for its iconic terminal buildings, which have won numerous awards for their design. The newest terminal building, Terminal 4, features a unique, perforated roof that allows natural light to filter through, creating a welcoming and calming atmosphere for passengers.

Figure 3 Changi Airport (SIN) By Keith Jenkins, https://velvetescape.com/jewel-changi-airport/

- Hamad International Airport (DOH) - Doha, Qatar: The terminal building at Hamad International Airport, designed by HOK Architects, is a massive, wave-like structure that covers over 600,000 square meters. The building features a stunning, undulating roof that is covered in over 6,000 solar panels, which generate electricity for the airport.

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Figure 4 Hamad International Airport Passenger Terminal Complex, Doha, Qatar.(source : https://www.hok.com/projects/view/hamad-international-airport-passenger-terminal-complex/)

- Beijing Daxing International Airport (PKX) - Beijing, China: The terminal building at Beijing Daxing International Airport, designed by Zaha Hadid Architects, is a massive, starfish-shaped structure that covers over 700,000 square meters. The building features a stunning, vaulted roof that is covered in skylights, which allow natural light to flood the interior spaces.

Figure 5 Beijing Daxing International Airport (PKX) (Source: STR/AFP/Getty Images)

- Incheon International Airport (ICN) - Incheon, South Korea: The terminal building at Incheon International Airport, designed by Fentress Architects, is a massive, sweeping structure that covers over 5.4 million square feet. The building features a stunning, curved roof that is covered in over 33,000 panels of aluminum, which give the building a shimmering, metallic appearance.

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Figure 6 Incheon International Airport (ICN) (Source: © 2023 Skytrax)

These are just a few examples of the many iconic terminal buildings that have been built by cities around the world. Each building reflects the unique cultural, social, and historical context of the city it serves, and each has its own distinctive architectural style and features.

4.3Design objectives for terminals

The design objectives for terminals can vary depending on the needs of the airport and its passengers, but some common design objectives include:

- **Operational efficiency:** Terminal buildings must be designed to efficiently and effectively manage the flow of passengers, baggage, and aircraft. This includes designing for clear and logical circulation patterns, minimizing congestion, and providing adequate space for check-in, security, and boarding.

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- **Passenger experience:** Terminal buildings must provide a positive and memorable experience for passengers. This includes designing for comfort, convenience, and accessibility, as well as incorporating features that enhance the passenger experience, such as art installations, retail and dining options, and relaxation areas.
- **Safety and security:** Terminal buildings must be designed to ensure the safety and security of passengers and airport staff. This includes designing for effective security screening and surveillance, as well as providing clear and accessible emergency exits and evacuation routes.
- **Sustainability:** Terminal buildings must be designed to minimize their environmental impact and promote sustainability. This includes designing for energy efficiency, water conservation, and waste reduction, as well as incorporating sustainable materials and technologies.
- **Branding and identity:** Terminal buildings must be designed to reflect the unique identity and branding of the airport and the city it serves. This includes incorporating local cultural and historical references, as well as creating a distinctive architectural style and aesthetic.

Overall, the design objectives for terminal buildings must balance the practical needs of the airport with the desire to create a positive and memorable experience for passengers, while also addressing safety, security, sustainability, and branding concerns.

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4.4Site location requirements

The site location requirements for the construction of a terminal building can vary depending on several factors, such as the size and capacity of the airport, the surrounding infrastructure, and the local regulatory and environmental considerations. However, some common site location requirements for terminal buildings include:

- **Proximity to transportation:** Terminal buildings should be located in close proximity to major transportation hubs, such as highways, railways, and mass transit systems. This facilitates easy access for passengers and airport staff, as well as efficient movement of goods and supplies.
- **Adequate land area:** Terminal buildings require a significant amount of land area to accommodate the large number of passengers, aircraft, and support facilities. The site should provide sufficient space for the terminal building, runways, taxiways, aprons, and parking areas.
- **Level terrain:** The site for the terminal building should be relatively level to minimize the need for extensive grading and earthworks. This can help reduce construction costs and ensure the stability and safety of the building and its surrounding infrastructure.
- **Access to utilities:** Terminal buildings require access to a reliable supply of utilities, such as electricity, water, and telecommunications. The site should be located in an area with easy access to these utilities, either through existing infrastructure or through new installations.

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- **Environmental considerations:** The site location for terminal buildings should take into account environmental considerations, such as noise pollution, air quality, and impact on wildlife habitats. Environmental studies and assessments may be required to determine the suitability of the site for airport construction.
- **Safety considerations:** The site location for terminal buildings should also take into account safety considerations, such as proximity to hazardous materials, flight paths, and emergency response services. These factors can affect the safety of passengers, airport staff, and the surrounding community.

Overall, the site location requirements for terminal buildings must balance the practical needs of the airport with the desire to minimize the environmental impact, ensure safety and security, and provide easy access for passengers and airport staff.

4.5 Principles of passenger and baggage flow

The principles of passenger and baggage flow are important considerations in the design of airport terminal buildings, as they determine the efficiency and effectiveness of the airport's operations. Some of the key principles of passenger and baggage flow include:

- **Separation of flows:** Passengers and baggage should be separated into distinct flows throughout the terminal building. This includes separating arriving and departing passengers, as well as separating domestic and international passengers. Baggage flows should also be separated into checked and carry-on baggage.

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- **Streamlined processes:** Terminal buildings should be designed to streamline processes, such as check-in, security screening, and boarding. This includes designing for efficient queuing, minimizing bottlenecks, and providing adequate space for passengers to move through the terminal.
- **Logical circulation:** Terminal buildings should be designed for logical circulation, with clear wayfinding and directional signage. Passengers should be able to easily navigate through the terminal, from check-in to boarding, without confusion or delay.
- **Adequate space:** Terminal buildings should provide adequate space for passengers to move comfortably, without feeling overcrowded or cramped. This includes providing sufficient space for queuing, seating, and retail and dining areas.
- **Accessibility:** Terminal buildings should be designed for accessibility, with provisions for passengers with disabilities or mobility restrictions. This includes providing accessible routes, elevators and escalators, and accessible restrooms.
- **Baggage handling systems:** Terminal buildings should be designed to accommodate efficient baggage handling systems, such as baggage conveyors and baggage screening equipment. This helps to ensure timely and accurate delivery of baggage to the appropriate flights.

Overall, the principles of passenger and baggage flow are important considerations in the design of terminal buildings, as they help to ensure efficient and effective airport operations, while also providing a positive and memorable experience for passengers.

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4.6Configuration of terminal buildings

The configuration of terminal buildings can be categorized into two main principles: centralization and decentralization. Here are some examples of each:

A. Centralized configuration: In a centralized terminal configuration, all airline gates are located in one central building, which is typically connected to a single check-in area. This design is often used for smaller airports with fewer flights and airlines. Examples of centralized terminal configurations include:

- **Linear configuration:** This design features a long building with airline gates located on either side of a central concourse, connected to a single check-in area at one end of the building.
- **Pier configuration:** This design features a central building with airline gates located on a series of piers, which radiate out from the central building. This configuration allows for efficient use of space and can accommodate a large number of gates in a relatively small area.

B. Decentralized configuration: In a decentralized terminal configuration, airline gates are located in separate buildings or concourses, often grouped by airline or alliance. This design is often used for larger airports with multiple airlines and flights. Examples of decentralized terminal configurations include:

- **Satellite configuration:** This design features a central building connected to separate satellite buildings, each with its own set of gates. Passengers access the satellite buildings via automated people movers or underground trains.

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- **Remote configuration:** This design features separate terminal buildings located away from the central building, often connected by shuttle buses. This design is often used for low-cost carriers or airlines with fewer flights.

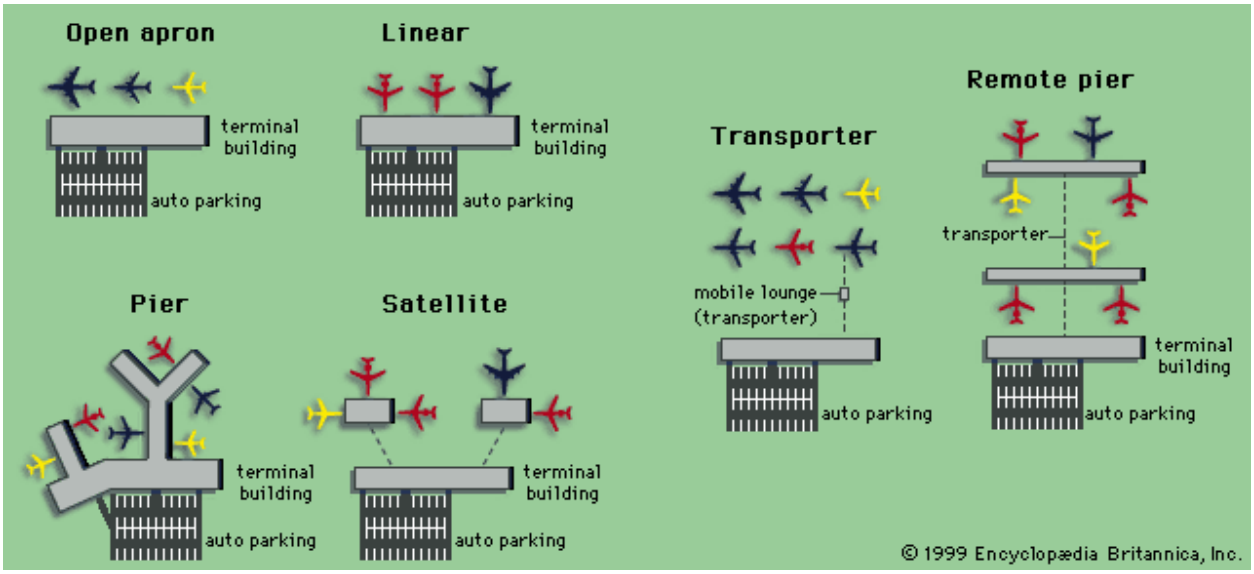

Figure 7 Configuration of terminal buildings (Source: Encyclopedia Britannica, 1999)

Overall, the configuration of terminal buildings depends on various factors such as the size and capacity of the airport, the number of airlines and flights, and the desired level of passenger convenience and efficiency. The choice of configuration can have a significant impact on passenger and baggage flow, as well as overall airport operations.

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4.7Relevance and Evolution of Terminal Building Architecture in a City:

The development of terminal buildings in airports can be traced back to the early days of aviation when airports were primarily utilized for military and mail transportation (Golob, 2018). In the 1920s and 1930s, airports began to serve a growing number of passengers, and terminal buildings began to take on a more prominent role in airport design. The evolution of terminal buildings over time reflects changes in technology, architectural trends, and societal values, as well as the growing importance of air travel in modern society (Mallach, 2015).

In the early days of commercial aviation, terminal buildings were often small and functional, with minimal amenities. Passengers typically boarded planes directly from the tarmac (Golob, 2018). As air travel became more popular, terminal buildings began to incorporate more elaborate and decorative features, inspired by the Art Deco movement, in the 1930s (Mallach, 2015). Notable examples include the TWA Terminal at JFK Airport in New York, designed by Eero Saarinen, and the Marine Air Terminal at LaGuardia Airport, also in New York, designed by William Delano and Chester Holmes Aldrich.

With the advent of jet travel in the 1950s and 1960s, terminal buildings began to take on a more streamlined and modern look, with larger open spaces and greater use of glass and steel (Golob, 2018). Examples include the iconic TWA Flight Center at JFK Airport, and the Terminal 1 building at Los Angeles International Airport.

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In recent years, there has been a growing emphasis on sustainable design in airport terminal buildings, with a focus on energy efficiency, natural light, and the use of environmentally friendly materials (Mallach, 2015). For instance, the Indianapolis International Airport designed by HOK uses a geothermal heating and cooling system, while the Terminal 3 building at Changi Airport in Singapore, designed by Skidmore, Owings & Merrill, incorporates a rainwater harvesting system (Kaiser, 2019).

Furthermore, terminal building architecture must respond to various aspects, including context, iconography, and technology. Terminal buildings must reflect the cultural, social, and historical context of the city and the region they are located in. They should be visually distinctive and memorable to create a unique and memorable iconography that represents the city. Terminal buildings should also incorporate the latest technologies to improve passenger experience and operational efficiency, such as advanced security systems, efficient baggage handling, and smart building management systems (Kaiser, 2019).

In conclusion, the evolution of terminal buildings in airports reflects the changes in technology, architectural styles, and societal values over time, emphasizing sustainability and the incorporation of advanced technologies. Terminal building architecture also serves as significant landmarks in a city, making a lasting impression on visitors.

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4.8The Terminal architecture in Lebanon

The Beirut Rafic Hariri International Airport (BRHIA) in Lebanon has undergone several expansions and renovations over the years, resulting in a mix of architectural styles and designs. Here are some notable features of the terminal architecture in Lebanon:

The original terminal: The airport's original terminal building was designed by the French architect André Leconte in the 1950s. It features a modernist design, with a simple rectangular shape and a façade of concrete and glass.

Figure 8 Beirut Airport late 1950s. The image was obtained from the oldbeirut.com website Image Library.

On 23 April 1954, Beirut International Airport (BIA) was inaugurated, replacing the smaller Bir Hassan Airfield. The terminal building at the time was considered to be very modern, and it included a spotter’s terrace with a café, which was highly appreciated by aviation enthusiasts. The airport was initially equipped with two asphalt runways: runway 18/36, measuring 3,250 meters (10,663 ft) in length, was primarily used for landings from the 18 end, while runway 03/21, measuring 3,180

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meters (10,433 ft), was primarily used for take-offs from the 21 end and from the Sami end. This marked a significant step forward in the development of airport infrastructure in Beirut, as the previous airfield lacked modern amenities and was not suitable for the growing demands of commercial aviation.

The airport facilitated international companies and four Lebanese companies - Middle East Airlines (MEA), Air Liban (which merged with MEA), Trans Mediterranean Airways (TMA), and Lebanese International Airways (LIA) - until an Israeli commando attacked on December 28, 1968, destroying 13 planes from three of the Lebanese companies.

Figure 9 Beirut International Airport [1960- 1970s], The images were obtained from the oldbeirut.com website Image Library.

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- During the fifteen-year-long civil war from April 1975, the airport was operational only during periods of calm, and incidents such as the Israeli forces destroying the newly renovated terminal in 1977 and a suicide attack in 1983 were recorded. In 1994, a ten-year reconstruction program was launched, including the construction of a new terminal, two new runways, a new fire station, and other facilities.
- The new terminal was inaugurated in 2002 and can accommodate 6 million passengers per year with an expected capacity of 16 million passengers per year in 2035. To accommodate larger aircraft like the Airbus A380, a new runway, 16/34, was built, which is 3,395 meters (11,138 feet) long and built on the sea. In 2006, during the Israeli-Lebanese conflict, the airport was bombed and closed until August 21, 2006. The airport suffered substantial damage due to the explosions at the port of Beirut on August 4, 2020, but it remained operational.

Figure 10 An aerial picture taken on March 7, 2020, shows a view of Rafik Hariri International Airport in Beirut. (Credit: Patrick Baz/AFP)

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Criteria for a successful Hub:

Lebanon's advantageous position, robust financial and service sectors, rich cultural heritage, and proficient labor force render it a highly coveted destination for international businesses and tourists. In 2009, Airtrax magazine ranked Beirut Rafic Hariri International Airport (BRIHA) as the second-best airport and aviation hub in the Middle East, trailing only Dubai International Airport. However, for BRIHA to attain and maintain its status as a competitive and successful international hub, it must fulfill specific criteria expounded upon in the subsequent sections.

- Right Geographical Location: The BRIHA's geographical location is a prime attribute for its status as a hub airport, providing an optimal point of connection. From a macro perspective, it is strategically positioned at the intersection of Europe, Asia, and Africa, allowing it to serve as a central hub for transit traffic between these regions. Moreover, its location facilitates the origination and destination of traffic, serving as an ideal entry and exit point. It is conveniently located 9km south of the Beirut City Center, ensuring swift accessibility within 15 minutes via economical ground transportation.
- Highly Developed Airport Facilities and Infrastructure: BRIHA boasts modern and sophisticated airside and landside facilities, including a passenger building a decade old. The airfield comprises three concrete runways, designed to accommodate a high volume of aircraft landing in a short duration and minimize runway occupancy time. The two primary runways, 16-34 and 03-21, are equipped with an Instrument Landing System (ILS) CAT II and configured in an open V layout. Operations predominantly occur in a north-to-south direction, enabling the two runways to converge. Runway 16-34 serves as the primary landing runway,

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while Runway 03-21 is designated for takeoff. The length of Runway 03-21 is 3,800m, sufficient to accommodate the A340-600, an aircraft that necessitates a long runway. To mitigate aircraft noise and enhance safety, Runway 16-34 extends 1,900m into the sea, enabling the airport to operate 24 hours a day without noise curfew. In addition to the three runways, BRIHA features an extensive taxiway network serving the runways and aprons, as well as a ground service equipment road network, firefighting and rescue facility, equipment and ULD staging areas, stormwater drainage system, primary radar, airfield lighting, airfield marking and signing, meteorological equipment, and navigational aids.

- Configuration: The passenger terminal building at BRIHA features a pier configuration, with two fingers perpendicular to the main building. The east finger accommodates twelve contact gates, while the west finger comprises nine contact gates and two bus gates. Six of the twenty-one contact stands are designed for wide-body aircraft with an ICAO Code E. Additionally, the airport has two remote aprons, one for three ICAO Code D aircraft and the other for ICAO Code E aircraft. However, the limited number of wide-body gates poses a challenge, given that MEA plans to expand its fleet with at least four A330 aircraft. The west finger primarily serves MEA and its alliances, such as Air France, while other airlines utilize the east finger. This configuration minimizes delays and ensures reliability, facilitating passenger connections with ease. However, in rare cases where a transfer occurs between MEA and another airline parked in the east finger, the passenger must undergo security checks at the departure level to catch their flight in the east finger, which presents a disadvantage. To mitigate passenger confusion and minimize walking distances, ATC must efficiently schedule transfer gates.

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Figure 11 3D model of Beirut-Rafic Hariri International Airport and its surrounding area based on GIS data (December 2019) -Metaa Group

The architectural design of the main building of BRIHA consists of four levels with a basement that is connected to a three-story visitors' car park with a capacity of 2,350 parking spaces. The ground and first floors are occupied by the arrival and departure levels, respectively. The departure level has a duty-free area that is conveniently located between the two boarding fingers after immigration, three business class lounges, cafes, restaurants, and a bank. Additionally, the Civil Aviation Authority offices are housed within the main building. To streamline the check-in and transfer processes and ensure reliable passenger data transfer, the airport has adopted the CUTE (Common Use Terminal Equipment) system, which has been operational since 1998.

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The airport is conveniently linked to Beirut through a dual three-lane highway, facilitating access and efficient transportation for the passengers. Although there is currently no organized public transportation service available, plans are in place to introduce regular scheduled bus services from the airport to Beirut and other locations across Lebanon. The curbside layout of the airport has already been designed with the provision of such services in mind. Meanwhile, the airport is well-served by a fleet of comfortable and reliable taxis operated directly by the airport, providing passengers with convenient and seamless ground transportation options.
In 2005, a modern General Aviation terminal was inaugurated along with its dedicated facilities, making it one of the most advanced in the Middle East. Since its opening, it has been highly successful in providing state-of-the-art amenities to its patrons. The MEA Flight Training Center, which was established in 1960 but was inactive during the civil war, is currently undergoing construction. Upon completion, this center will serve the aviation industry in Lebanon and the surrounding region.

- Sufficient Demand and Available Capacity: The airport has been experiencing a steady growth in passenger traffic since 1997, with an average annual increase of 6.75% up to 2002. In 2003, this growth accelerated sharply by 19.59%, attributed to the Lebanese government's implementation of deregulation and an open skies policy. However, due to political instability and the assassination of Prime Minister Rafic Hariri in 2006, passenger traffic decreased by (-)1.5%. Additionally, the July 2006 war and the Israeli blockade further reduced traffic by (-)1.22%, resulting in levels comparable to those in 2002 and just above 1975 traffic levels. The airport's passenger traffic made a robust recovery in the following years, with annual growth rates ranging between 16% and 25%.

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- Presence of a Strong Airline: The presence of a strong airline is a critical factor in the success of an airport as it establishes the dynamics of air service. Merely constructing an airport does not guarantee its transformation into a successful hub.

- Possibility for Expansion: The Beirut Rafic Hariri International Airport (BRHIA) has set ambitious plans for expansion to handle 16 million annual passengers by 2035. The expansion plan not only aims to increase the passenger capacity but also includes the development of a Free Zone, a four-star airport hotel, cargo handling buildings, and twelve hangars for the general aviation terminal, and seven new gates for wide-body aircraft such as the A380. An economic feasibility study for the Free Zone and the A380 operations is underway as part of the airport's Development Plan. However, these plans face several constraints, including limited land for expansion, constrained airspace due to the surrounding high mountains, and the need for substantial improvements to the airfield and terminal building to accommodate the A380.

The expansion plans may require expropriation of land, most likely in the area between runways 16-34 and 17-35, which is already heavily populated. Moreover, building a new passenger terminal or concourse may involve relocating some airport facilities, such as part of the cargo terminal in the east side or the air force base in the west side. To receive the A380, the airport needs to widen at least one runway, selected taxiways, taxiway intersections, increase separation distances between runway and its parallel taxiway, and secure an aircraft stand large enough for the A380 to park.

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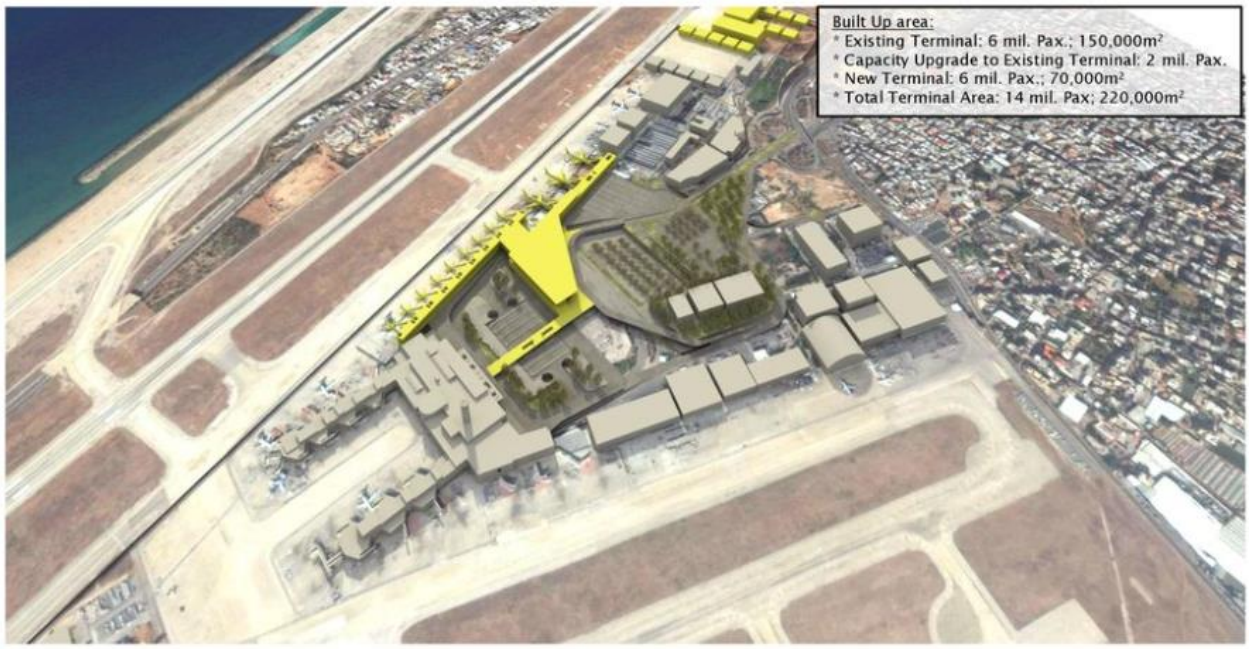
Airport Expansion Project:

This project includes 2 Phases, which will be executed as follows:

- First phase is to add a new terminal to the west side of the airport with a capacity of 6M pax.
- Second phase includes the construction of a new terminal east side of the airport with a capacity of 6M pax, where the total capacity will be more than 20 million passengers.



New Terminal Phase 1 – Construction

Built Up area:

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- Existing Terminal: 6 mil. Pax.; 150,000m2
- Capacity Upgrade to Existing Terminal: 2 mil. Pax.
- New Terminal: 6 mil. Pax.; 70,000m2
- Total Terminal Area: 14 mil. Pax; 220,000m2

New Terminal Phase 2 – Construction

Built Up area:

- Existing Terminal: 14 mil. Pax.; 220,000m2
- New Terminal: 6 mil. Pax.; 75,000m2
- Total Terminal Area: 20 mil. Pax.; 295,000m2

Figure 12 Plans and perspectives from the Directorate General of Civil Aviation presentation, 2018

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- Aside from the BRHIA expansion plans, the government is also studying the development of other airports and Free Zones in Qlayaat in the north and Riyak in the east.

Lebanon's economy has long been based on a free-market system, and the country's rich cultural heritage and diverse attractions make it a popular destination for tourists from all over the world. However, political instability and security concerns have taken their toll on the aviation industry, which is viewed as a "Disrupted Venture." This has kept major international players from entering the Lebanese market, but there is hope for change.

If Lebanon is able to achieve relative peace and stability, the Beirut Rafic Hariri International Airport (BRHIA) has the potential to once again become a successful regional hub, serving the tourism industry, business interests in the Middle East, and the large Lebanese diaspora. Despite its many attractive features, such as its location, modern infrastructure and facilities, abundant capacity, and liberalization laws, it may not serve as a transfer hub in the near future.

To become a transfer hub, BRHIA needs a strong airline that can compete in a regulated and subsidized market and is willing to transform the airport. However, given the few published expansion plans by MEA and the negligible number of transfer passengers they carry, it is unclear whether MEA will be the strong airline at BRHIA in the future. In addition to a strong airline, there must be political will and commitment to enforce liberalization laws to promote competition at the airport.

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This can be accomplished by removing MEA's exclusive rights to transport air passengers and eliminating the airport's monopoly. However, before doing so, the government must ensure that MEA will not be disadvantaged when entering other local markets in Europe and the Arab world.

The potential benefits of expanding the airport are numerous. Airports are increasingly viewed as incentives for local economic development, and airport expansion has a ripple effect, promoting growth in tourism, financial services, wholesale and retail. Moreover, the expansion of BRHIA will require a commitment to high standards of corporate governance. The expansion is a unique opportunity for investment in improving the local environment, generating employment, and driving improvements in public transport and road networks. Overall, the expansion of BRHIA is an important step towards the sustainable development of Lebanon's aviation sector.

4. Results:

The results of this study demonstrate that the design of airport terminals is a complex process that involves multiple considerations. The study identified the following key findings:

- Functionality and aesthetics are both critical considerations: The study found that the most successful airport terminals strike a balance between functional and aesthetic considerations. While the functional requirements of the terminal, such as efficient passenger processing and aircraft operations, are essential, the aesthetics of the terminal play a significant role in creating a welcoming environment for passengers.

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- Sustainable design features are increasingly important: The analysis revealed that sustainable design features are becoming increasingly important in airport terminal design. These features can include energy-efficient lighting and HVAC systems, the use of renewable energy sources, and the incorporation of green spaces within the terminal.
- Public spaces are integral to successful airport terminals: The study found that successful airport terminals incorporate public spaces such as lounges, restaurants, and retail areas, providing a positive experience for passengers and creating a sense of place for the local community.
- Terminal design must consider community objectives: The study highlights the importance of considering community objectives when designing airport terminals. Airports are representative of a city's pride and must be aesthetically appealing while also contributing positively to the surrounding community.

Overall, this study demonstrates the need for a comprehensive and holistic approach to airport terminal design that considers both functional and aesthetic requirements, incorporates sustainable design features, and includes public spaces that benefit both passengers and the local community. These findings can inform future airport terminal design projects, helping designers and operators create successful and sustainable airport terminals that meet the needs of all stakeholders.

5. Conclusion:

In conclusion, this study explored the fundamental design considerations and evolution of airport terminal architecture in a city, including the evolution of terminal design, the balance between functional and aesthetic considerations, the incorporation of sustainable design features, and the importance of public spaces.

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The study highlighted the importance of a comprehensive and holistic approach to airport terminal design that considers both functional and aesthetic requirements, integrates sustainable design features, and creates public spaces that benefit both passengers and the local community. Such an approach can lead to successful and sustainable airport terminals that meet the needs of all stakeholders.

Terminal buildings have evolved over time, from basic functional structures to elaborate and iconic designs that reflect changes in technology, societal values, and architectural trends. There are two main terminal building configurations: centralized and decentralized, each with its own advantages and disadvantages. As airports continue to expand and evolve, the architecture of terminal buildings will continue to play a key role in shaping the future of air travel. The findings of this study have implications for airport terminal designers, operators, and policymakers, informing their approach to future airport terminal design projects and leading to the creation of more efficient, sustainable, and welcoming airport terminals.

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