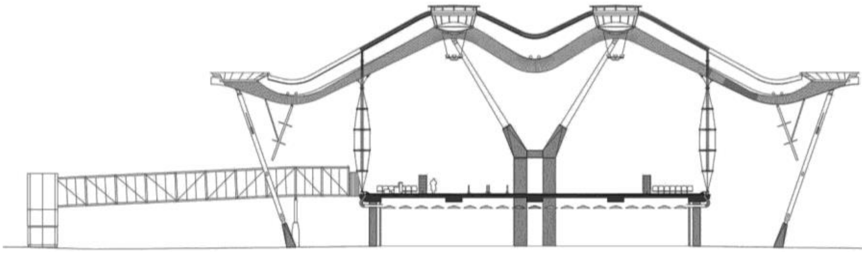

DOI: 10.21005/pif.2020.41.B-06

TECHNOLOGY AS PRINCIPAL IN FUNCTIONAL PLANNING AND ARCHITECTURAL DESIGN OF SMART INTERACTIVE TERMINALS

Qasim Mohammed Basim
Phd student
Author's Orcid number: Org/0000-0002-3223-646x

Kiev National University of Construction and Architecture
Faculty of Architecture
Department of Architectural Basis and Architectural Design

ABSTRACT

This article deals with the design of new generation of airports terminals using the concept of smart interactive terminal and presents its main functional zones and technologies. In addition, adoption of technology as symbolic expressive tool in the architecture of airports terminals. Problem of the research is lack of approach and practice of smart interactive terminals functional planning and organization, the previous researches about this type of buildings are dealing with the influence of technology on one functional zone inside the terminal, not taking all functional zones inside it. The aims of research are presenting the influence of technology on all functional zones inside the smart interactive terminal and understanding the connection between them, this study will look also at the transformation of airport terminal interior design in relation to technology and automatic passengers processing systems. additionally, introducing the functional planning of smart interactive terminals buildings and its architectural design features. The results of developing a smart integrated terminal are presented. A comparative functional analysis was done of the proposed terminals as well as its design and technology.

Keywords: Smart interactive terminal, future airports, terminal design, airports technology, terminal architecture.

1. INTRODUCTION

Airport is one of the most uniquely designed buildings of the 21st century. Today the airport has evolved into a new generation state of the art hybrid full technical building with multifunction. Since the design of the first airports, a lot of transformation and evolution have taken place in the form, image, character, spatial design, materials and technologies which used in airport terminals. Airports are mega transport hubs, their design and technology should stand through the time to be appreciated by past, current and future generations. Airport terminal is the central processor of the airport system. Its architecture reflects the beauty, scale and technological prowess of this fast-growing industry (Ahmed, 2015). As air travel become more popular and accessible, airport has assumed greater importance as a fundamentally new challenging building. It is a miniature city reflecting the values and aspiration of the society. Nation prosperity and its technology image is reflected more directly in the design of airports than in any other building type.

Modern airports are big complicated complexes reflect the cultural and the architectural heritage of communities and countries, the terminal building can be considered as an architectural symbol of technology which used to achieve the efficiency of the operational process and integration in functions with design and architectural planning.

Terminal building can be defined as the main facility in the airport used for processing passengers and luggage, it can be considered as very complicated functional building because of the number and the quality of the functional processes inside it, it has to contain passengers, visitors and staff movement, luggage processing etc. In general, there are main functions inside terminal building: Transporting, processing passengers and luggage from land to airside and conversely, controlling the country or state borders, providing waiting and entertainment areas for passengers (Lokshin, Soghomonyan, Berlin, 1966).

In addition, technology and flexibility are playing a major role in making terminals as hi-tech modern buildings which can contain and process the increasing numbers of passengers. It reflects the development of human civilization and show the unique identity of nations and countries. By the beginning of the 21st century, architecture of the airports entered a new era and many new technologies had been applied in airports design and architecture. (Qasim, Semka, 2019)**.**

Technology is moving so fast that it's hard for all of us to realize all the effects, it is affecting on the shape and appearance of airports, what we are about to see is the modernization of screens and interactive devices in almost all airports. There is potential for all types of interaction with the passenger of the future. The changeable nature of the construction materials which will be used to build future facilities and buildings is another factor that could potentially have a significant impact on the appearance of tomorrow's airport (Palmer, 2006). Materials that repair themselves when damaged and surfaces that clean themselves are some of the most daring innovations that can actually become a reality in the not too far future.

The problem of the research is dealing with lack of approach and practice of smart interactive terminals functional planning and modern technological trends in design concepts, the previous researches about this type of building are dealing with the technology that applied on the one functional zone or on the structural, operational systems inside the terminal, not presenting the influence of technology on all functional zones inside the smart interactive terminal and its design as integrated building. it's also didn't deal with the relationship between technology as an impact factor and terminal architecture as a result.

The aims of research are showing the role of technology as deep impact factor in the architecture of next generation terminal buildings and its influence on the iconic and symbolic form of terminal building presenting all functional zones inside the smart interactive terminal and understanding the connection between them, additionally introducing the features and aspects of smart interactive terminal design.

Methodology of the research: The used methods in the research divided to: **theoretical method** by presenting a theoretical approach for smart interactive terminal function zones, technologies and adoption of technology as symbolic expressive tool in its architecture. **Applied method** by applying the theoretical form of the research in chosen international airports projects and make a review on the new technologies have been applied in these projects and give the final conclusions.

The importance of the research: Unveiling a new smart interactive generation of terminal building using the technology as main principle in its architecture and give a design model in the integration of technology systems with the function in terminal building to become more efficient and hence giving the passengers a unique experience with technology through the airport terminal.

2. ADOPTION OF TECHNOLOGY AS SYMBOLIC EXPRESSIVE TOOL

A) Tectonic as symbolic expressional architectural language

Many architects consider the expression by the technological language as moral task and they see the environment of airports and its architecture is a perfect place to test their ideas and thoughts, where the structural process as well the comprehensive concept is adopted and promoted by "tectonic" language. "The tectonic is the gestalt of the age and the terminal is the perfect vehicle for its expression" (Edwards,2005). Airport terminals buildings are using all structural possibilities to create wonderful shapes and unique tectonic ideas where the structural system works on minimize the apparent weight of the building, reduces the effect of gravity to seem as floating on a surface. Tectonic architecture reflects the rhythm of parts and detailed elements which is the most important aspect of expression. It uses the joints, light, materials and lines instead of heavy elements like walls and columns, the angles are disappeared with the curved floating roofs and the floors are presented as horizontal light plains.

The tectonic expression can be seen as architectural idea of the terminal building as Charles de Gaulle International Airport terminal 2 or only in some parts of the building, for example the roof design of Kansai International Airport. The roofs are considered clear mirrors reflect the impact of tectonic architecture in terminal building, these roofs can be seen with wide spans with curved shape and have an expression of aerodynamic and aircrafts shapes or integrated with nature and environment (Blow,1996).

Fig. 1. Charles de Gaulle international airport terminal 2. Source: (Charles de Gaulle 2020)

Fig. 2. Kansai International Airport roof. Source: (Osaka 2020)

B) Compatibility of Environment and Technology in terminal building architecture

The integration of building design with external environment can be achieved by using environmental technologies and integrating the design idea with all operational systems and functions in efficient non-energy consuming concept achieved by technology as a tool of implementation and expression (Bachman, 2013).The architectural design of terminal building external can be integrated to the environment by:

1. Using the smart materials in windows and roofs to reduce the environmental influence inside the building, like using the infrared absorbent glass (Kansai International Airport) or double glass which can be cooled by air conditioning system between the sheets of the glass (Munich International Airport).
2. Using of natural lighting in the roofs and natural construction materials and plants to create an integrated artificial environment inside the building, the natural light will be integrated with the constructional system and glass for example Jewel Changi Airport.
3. By applying structural details that respond to the factors of the nature, like the extension joints in the structural system of the building in Kansai international airport, these joints absorb the retraction and the extension of the building which caused be the difference of temperature degrees. Other example is the green modern architecture of Inchon air transportation center as a solution of design a building in hot environment areas, the building designed by Terry Farrell &partners and used a smart solution to reduce the energy consumption by orientation of the building according to the sun and using the natural ventilation systems (Edwards, 2005).

3. THE INTEGRATION OF DESIGN SYSTEMS IN AIRPORT TERMINALS BUILDINGS

Every functional building contains a group of structural systems to achieve the physical shape of it, this research presents the main systems of the building and the role of technology to achieve the integration with other systems to reach a highly efficient smart building adoptable with the external environment. The role of technology can be seen in:

A) Structural systems and external shape of the terminal building

Airports are considered the most important gates of country, as well as being modern building have special functions, so it's important to give the attention to the airport buildings and its architecture, and the choice of suitable structural system to achieve: a special unique architectural form, high functional performance with flexibility, fast construction period considering airports are mega structures and need a long time to build (Blow,1991).

The airport terminal today is a center of many human activities like travel, shopping, work and acquired a complicated character, the structure elements like columns, bridges and aches have essential role in organization of internal spaces so it create activity and dynamic inside spaces, help passengers to realize the orientation of movement, show the functions of the space (Edwards,2005).

The airports structural systems are characterized as mega structure to contain the diversity of the function and provide a long span spaces inside terminals, these structures can be defined as wide-span structure, membranes tension structure and space structure (Sebestyen,2003).

Including the main structural system of the building with its horizontal and vertical elements (columns, spans, walls, etc.). These elements reflect the orientation of the movement and the gradient of spaces. That can be seen in the vertical section of many modern terminal buildings' plans, it presents the movement of passengers between levels and floors inside the building and the nature of space function where passenger goes through it, also presents the main zones of passengers centralization inside the building in the land and airsides like departure and arrival halls (Dempsey,1999).

B) Internal space system of the terminal building

Terminal is a functional building and architecture of modern terminals buildings is an example of " Spaceless Architecture", as a result the internal space must have a harmony between the main features of the space and the nature of functions which supports to achieve a high level of functionality in the building and dealing with internal design with simple language to orient the passengers easily " way finding" by integrate the design elements like: (Palmer, 2006)

– **Internal physical objects**

The physical objects and main elements of terminal internal design are waiting zones, information desks, duty free zones and circulation units (passengers' paths, elevations and lifts). These zones are considered as movement orientation elements create a path for passengers to the main functional zones like (check in counters, passport and customs control) (Edwards,2005).

– **Lightening**

Light is considered as tactile element in the internal design of terminal building. The natural and artificial lights are playing an important role in the organization of internal spaces and in the orientation of human movement inside it, in additional the difference between lightening levels helps to understand the nature of functions inside the space and increases the realization of human to the building (De Neufville,2003).

Light presents the aesthetic adjective of the internal design, by controlling the levels of natural and artificial lights inside the space we can increase or decrease the complexity, ambiguity and stimulation level of space structure. The light also helps to emphasis on function, feel the volume the space and creates a space with high level of transparency and clearance (Edwards,2005).

4. TECHNOLOGY OF FUNCTIONAL SYSTEMS IN THE TERMINAL BUILDING

As usual, passengers have to come to the airport before the flight time by 3-4 hours, because there is an image in the passengers' minds of the long boring waiting lines in every procedure inside the airport, so the passenger must go through several procedures or processes before getting on the plane, the main reasons of long passengers processing time are:

1. The increasing numbers of air transport passengers generally and the flights between countries.
2. Receding of the land and sea transport in front of air transportation
3. Increase of passenger's security checking procedures because of the security threats in the airports specially after 9/11 attacks.
4. The large area of the terminals building so the passenger has to across a long distance inside the terminal or between the terminals and the concourses to reach the plane.

Passengers waiting lines in the airports became too long and unbearable, starting from check-in to the boarding gates coming through passport and security control. It became urgent need to find a solution decreases passenger waiting time inside the airports terminals and reduce the time to get into or from the plane to the landside.

One of these evolutional solutions is the Smart interactive Terminal, the concept of the smart interactive terminal is a full automatic passengers processing terminal where the technology is taking place of human and functioning the spaces and zones by the designer or the architect to be independent and doing its function without human involvement, the passenger goes through it smoothly and quickly to be processed. As a result, decrease the passengers waiting time inside the airports. In general, the features of the smart interactive terminal are:

1. Minimizing the waiting time inside the airport
2. Increasing the efficiency of passengers and luggage processing systems.
3. Minimize the airplane waiting time in the airports and that will decrease the costs of airplanes delaying flights.
4. Increasing the transporting numbers of passengers, luggage and goods by the airport.
5. Using the latest technology in passport and customs control systems so that will minimize mistakes and oversight rates.
6. Low operational cost of the terminal because of low number of working staff inside it.
7. The free open-space terminal zones which can be used or reused in different kinds of functions.

8. Centralization of terminal control and monitoring.
9. Energy conserving and using the sustainable energy, working by Sustainable Architecture principles.
10. Connecting the airports and its terminals with the cities by the different kinds of land transportation by using the (Transport hub) concept.

The smart interactive terminal design has two main aspects: Increasing terminal efficiency and minimizing the passenger waiting times by using the technology and artificial systems in passenger / luggage processing processes, so the terminal will be a self-integrated operated building, the passengers will go through next several zones in the smart interactive terminal:

1. Automatic check-in (bag drop)

Check-in is the first processing zone where passengers are accepted by airlines in the airport. Airlines typically use service counters are found at terminal building. Passengers usually hand over any baggage that they do not wish or are not allowed to carry in to the airplane's cabin and receive a boarding pass. Usually in the airport there are 50-100 counters to receive the passengers' baggage and these counters occupy a large area in the terminal.

In the concept of Smart Terminal, it has an automatic check-in system, where the passenger scans his passport, visa (If needed) and enter the destination with the flight number, puts the baggage on the self-check-in counter to weight it and hands it over, the system will process all passenger data with luggage weight and gives the passenger boarding pass and baggage label and hands over the luggage to a moving belt. (Fig-4) As for travelers without baggage they can just do (self-check-in) and get the boarding pass to the plane.

Fig. 3. Automatic check-in system. Source: (SELF SERVICE 2019)

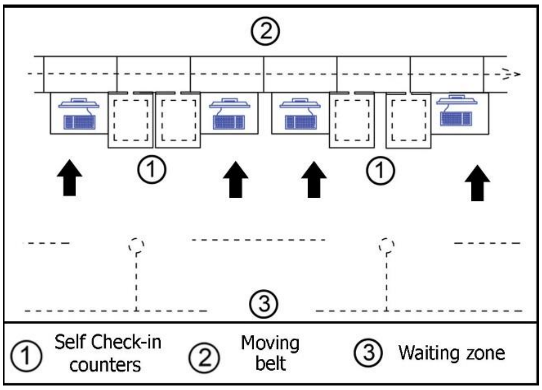

Fig. 4. Proposed typical plan of Automatic check-in area. source: Source: (Arthur)

2. Passengers and luggage Security screening

The second important functional zone after handing over the non-carry-on luggage in the self-check-in system, the passenger and his carry-on luggage goes through security screening, the X-ray scanner will scan the luggage to make sure there are no not allowed items inside it and passenger goes through metal detector and X-ray scanner that detect a hided weapons or metal items in the clothes or inside the body, after that the passenger takes his luggage and goes on to the passport control. If the X- ray scanner detects unusual item so it will beep and passenger will be taken by the aviation security or customs officers for individual check. (Fig-6)

Fig. 5. X-Ray body scanner. Source: (Japan, 2020)

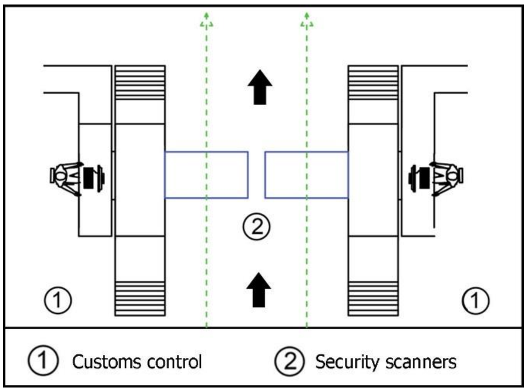

Fig. 6. Proposed typical plan of customs control. Source: (Arthur)

3. Passport control

One of the most important procedures in the airports, border control officers will check passengers ID, details by their passports and the ability to reach the destination where they want to fly, immigration officer checks all the details and gives the passenger permission to exit the country. Passport control and checking time are increased in the airports because of the security threats so passengers have to wait in long lines. In the Smart Terminal, passport control process is automatic using:

E-passport gates: Passenger goes through these gates to a small chamber and scans his passport, fingerprints and visa, enters the destination, the system will take a picture of passenger, processes and analyses all the passenger's data, the system will put stamp on passport as a permission to exit the country, and chamber's door will be open to the airside area. If there is something wrong with the passenger's documents and the system couldn't identify the documents or the passenger, a side door will be open toward passport control officer and the officer will check passenger's documents manually. (Fig-9). The average hourly passenger traffic in one direction throw E-Gates can be determined by the formula:

$$E = \left(G\,\frac{3600}{T}\right) - U \qquad \text{............ (1)}$$

Where: (E- Hourly passenger traffic throw E-Gates, G- Numbers of E-Gates, T- E-gate processing time in seconds, U- Passengers with unrecognized documents by E-Gates).

Fig. 7. E-Passports gates. Source:(ePassport, 2020)

Fig. 8. Smart tunnel. Source: (Dubai, 2018)

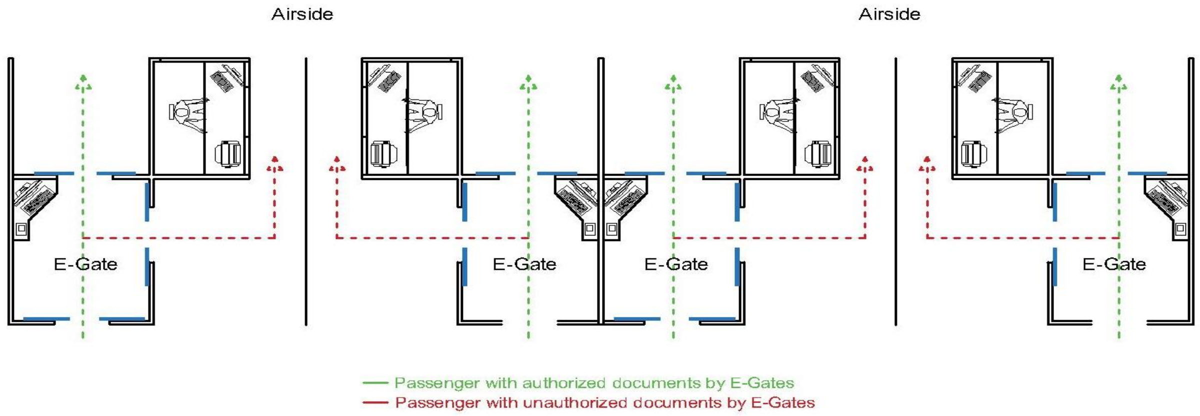

Fig. 9. Proposed passengers' path through E-Passport gates configuration. Source: (Arthur)

Smart Tunnel:

Smart Tunnels were first unveiled by Dubai Airports at GITEX Technology Week event 2017. Using facial recognition, the tunnel's technology will allow the traveler to complete the passport control procedure within 15 seconds, recognizing passengers as they walk through a tunnel with no human intervention or passport stamping needed for the standard passenger. The tunnels are not enclosed and resemble a longer version of the e-gates, and come fitted with more than 80 hi-tech cameras, the cameras can identify the passenger and perform 'full body scan searches. Smart Tunnel uses the data of passengers and self-learning techniques to ease and expedite their movement across the passport control area at the airport without the need to use any travel documents including passports, ID cards or boarding passes, as is the case with E-passport gates. (Fig-7,8) (Al Shouk, 2017).

The average hourly passenger traffic in one direction through Smart Tunnel inside the terminal can be determined by the formula:

$$R = (S * 240) - U \quad \ldots\ldots\ldots\ldots (2)$$

Where: R- Hourly passenger traffic throws Smart tunnels, S- Numbers of Smart tunnels, 240: A determined value by dividing the number of seconds per hour on the smart tunnel passenger processing time which estimated 15 sec., U- Passengers with unrecognized documents by Smart tunnels.

Security at passport control desks has to be maintained rigorously. All such as security check points, including those designed for people with reduced mobility gate taxis and the transit of goods, have to be easy and safe to use. Swing doors and tripod barriers provide the ideal solutions to guide and control the flow of the passengers at the passports control desks. Double swing doors are ideal for access points intended to be used by gate taxis and for the goods and can be only be activated by the airport staff.

- Stylish, transparent design
- Access for the people with reduced mobility
- Easy passage thanks to power-assisted drive
- Opening time and angle adjustable.

The hourly passenger traffic through Smart terminal processor can be determined by this formula:

$$P = E + R + M \quad \ldots\ldots\ldots (3)$$

Where: P - Total hourly passenger traffic through Smart terminal processor, E - Hourly passenger traffic throw E-Gates, R - Hourly passenger traffic through Smart tunnels, M - Proceeded passengers by manual passport control.

4. Self-boarding gates

It the last procedure in the terminal building for the departures, usually passengers are boarding in the concourses. The airline staff checks passenger's document and boarding pass to let him getting on the plane, in the Smart Terminal passenger can scan his boarding pass by a scanner in front of self-boarding gates and the system will take a photo of passenger and analyses his data to give him the permission boarding on the airplane. (Fig-10) shows the self-boarding gates.

Fig. 10. Self-boarding gates. Source: Source: (Self boarding, 2019)

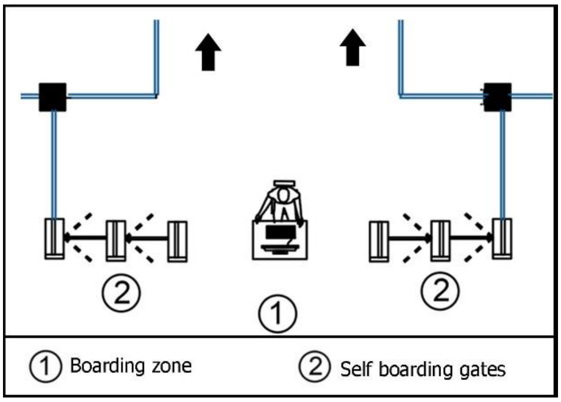

Fig. 11. Proposed typical plan for Self-boarding gates.Source; (Arthur)

Passengers' flow can be improved by automatic boarding pass control as passengers enter the departure zone and proceed towards security screening.

Boarding pass control gates support airport staff in checking passengers' boarding passes more efficiently. In turn, this reduces queues at the departure hall entrance, eliminating congestion and making it easier for the airport security units to stay in control. Half-height sensor barriers with automatic swing panels, an integrated boarding pass reader and a display for passenger information.

5. Arrivals

All arrivals must go through the passport control before crossing the borders and getting in the country, passengers go through the E-passport gates or smart tunnels in a similar procedure for the departures to get the permission and enter the country.

The architectural design of smart interactive terminals should take into account the particularities of creation unique passengers' aviation control zones, these zones must ensure the effectivity of control and comfort for passengers. The new technology has to be implemented effectively within the building environment and applying the new technical solutions might improve passengers experience and increase the security levels in the airports. The architecture of smart interactive terminal building will guide and assist passengers to check-in areas and find passport and custom control points. All passengers processing operations can be remotely operated. There will be an approach to treating passengers as a human factor which have an important influence on the design of the airport. The space provisions, functional zones distribution and layouts may change, but the aspects of good smart interactive terminal design will remain, including:

- Fast passengers processing to eliminate the waiting lines
- Smooth safety and security systems
- Simple design, clearance of space function and organization
- Applying easy wayfinding and paths inside the terminal
- Minimize walking distances.
- Flexibility to re-zone areas as processes change and edibility for future expansions.

Jewel Changi Airport – Singapore

Routinely ranked as the best airport in the world, Singapore's Changi Airport is no stranger to innovation, efficiency, and passenger satisfaction. It's now trying to end one of the biggest annoyances for travelers and airlines: flight delays due to late passengers. Changi is testing facial recognition for finding passengers whose flight is about to leave, searching for them around the terminals in case they lost track of time. Changi Airport's Terminal 4 has a facial recognition system that will capture a passenger's photo at different stations, centralized security screening, as well as start-to-end self-service options for check-in and other processes. (Kaur, 2017)

Terminal 4 designed with high ceilings and open spaces; it projects a modern, clean look. Highlights include a Peranakan - themed heritage zone featuring a six-minute cultural show and a 70m by 5m wall showcasing Singapore's skyline and Asian landmarks, as well as a whimsical animated clip on suitcases being screened before a flight.

The Terminal has seven check-in rows. Rows 1 to 3 has 42 conventional check-in counters. There are 65 automated Check-In kiosks and 50 automated bag-drop machines equipped with a Facial Recognition system from Rows 4 to 7.

Passengers have to scan their passport by the Automated Check-In Kiosks and enter their booking reverence and print the boarding pass and bag tags. Passenger photo will be captured and matched against the photo in passport before luggage is accepted in the Automated Bag Drop system.

There are 18 Automated Immigration Gates in the Terminal 4 available to Singaporeans, Permanent Residents and passengers who have registered with the Immigration and Checkpoints Authority. Passenger must scan his passport in the passport scanner and scans bar code on his boarding pass at the boarding pass scanner and wait for his photo fingerprints to be taken. The Automated Immigration Gate uses a dual facial and thumbprint biometric recognition system. The captured photo will be matched with the passport photo. Next scan the bar code on your boarding pass at the boarding pass scanner above the passport scanner. Once it is accepted, the gantry will open so you can proceed.

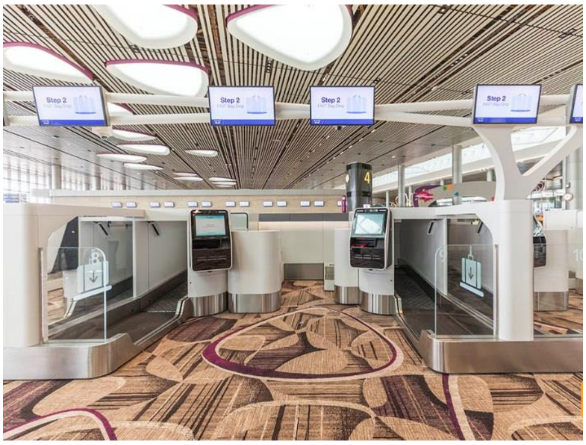

Fig. 12. Fast check-in technology system at Jewel Changi Airport. Source: (Adrian, 2017)

Fig. 13. Facial recognition system in Terminal 4 Source: (Adrian, 2017)

Dubai International Airport – UAE

Dubai International Airport's main goal in its "smart" journey has centered around improving efficiency at passport control in terminal building and increasing the number of processed passengers. The plan: instead of waiting in line to be checked by migration officers, passengers would walk through a smart tunnel instead. The tunnel uses artificial intelligence and a biometric system to identify passengers as they walk. There'll be no need for people to show their passports, or do anything else. Instead, passengers will initially stand in front of the tunnel for iris scanning, with face recognition technology doing the rest as they walk through the tunnel.

Dubai International airport also launched smart gates in 2017, the airport now has a total of 112 smart gates including 30 in Terminal 1, 18 in Terminal 2, 64 in Terminal 3, The number of passengers using the smart gates increased to 2.63 million in the first five months of 2019, compared to 2.16 million during the same period last year.

A total of 18 new smart gates have been launched at Dubai International Airport's Terminal 2 aimed at enabling passengers to pass through immigration quickly, the new gates – including 10 at the arrivals area and eight at the departures area, will allow passengers to clear the immigration process in between seven to 10 seconds. The gates use face-sensors to scan and identify travelers and indicators guide them through the steps required to complete the process.

The main features of Smart gates in Dubai international airport are:

1. Passengers process works on the face recognition technology and biometric data allows the them to simply walk through the gates and finish the entire procedure within 7-10 sec.
2. The used space for this technology is relatively small and there are no lines of passengers waiting in front of the smart tunnels, this space can be reused according to principle of flexibility in terminal building design because there is no fixed walls and partitions.

Barajas Airport – Madrid

Terminal 4 was designed by a consortium of Richard Rogers Partnership, Estudio Lamela and engineering firms TPS and Intec. It was opened in 2006, and is Europe's fourth largest airport. The building was designed with four key design principles in mind:

- Integration into the landscape taking into account the topography of the local area.
- Energy conservation, and the use of passive environmental systems where possible.
- Spatial clarity in the form of a clear progression of spaces for passengers' movements.
- Flexibility with the potential for future building extensions.

The design process focused on creating an "attractive, peaceful atmosphere. This led to the utilisation of materials and finishes which would convey a sense of calm." The inside of the modular curved roof is lined with bamboo strips that help create a comfortable atmosphere that has a more natural feel than steel structures, and better acoustic properties. The buildings undulating shapes have reference to the surrounding hills of the area and have been described as emulating the forms of a seagull in flight. A bird like symbolism that is synonymous with airport design since Eero Saarinen first designed the TWA terminal at the JFK airport in 1968. (Ahmed, 2015).

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

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

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

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

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

Fig. 14. Skylight and structure inside terminal Source: Adolfo Suárez, 2019

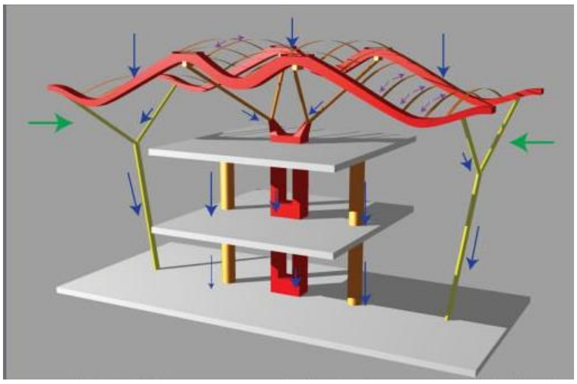

Fig. 15. Elements of the structural system Source: Structure, 2019

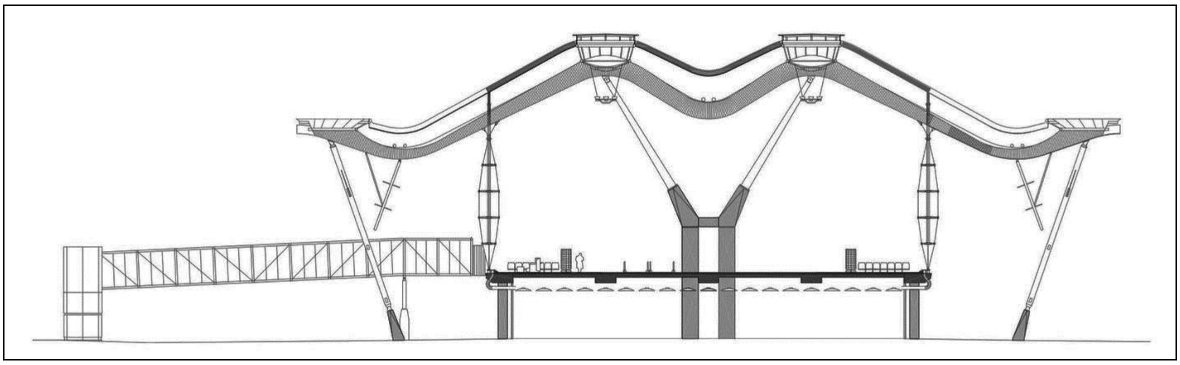

Fig. 16. Section of the terminal building. Source: (Santibañez, 2018)

Kansai International Airport

Airport terminal was designed by Renzo Piano and Arup engineers, and built on a manmade island off the coast of Osaka Bay, Japan in 1994. Measuring 1.7km in length along the main concourse. "Aesthetic, practical, economic and technical considerations combined powerfully in the design engineering of the Kansai main terminal building". Piano's elegant, flowing design was driven by his belief that the building itself, the refraction of light through it and even the movement of air within it should reflect passengers' movement from landside to airside, with a visual connection between the two." The building's sweeping form was also reminiscent of two long wings of aeronautical imagery; with an aerofoil shape tapering in height from the central hub to the outer edges, in order to help with sightlines from the control tower to the planes. Piano's intention was that of a simple building to navigate, that was light, bright and spacious, built with low energy consumption in mind, as well as structural strength against the earthquake and typhoon prone region. (Kansai, 2019)

1. The Wing runs the entire 1.7 km span of the structure. This is the side that faces the sea, and therefore receives the blunt of the high force winds during storms.
2. The wing has a separate structural system from the main terminal building. The truss changes to a single tubular steel member supported by tension cables.
3. Another roof form generating idea was the desire to condition the passenger terminal without a clutter of ductwork hanging from the exposed trusses. This was done by blowing a jet of air from the landside and let it be carried against a ceiling that would be shaped to follow the natural curve of the decelerating air.
4. A continuous secondary structure spans across the primary trusses Built out of standard I-sections with traditional cross bracing Designed to absorb lateral forces generated by earthquakes Also helps restrict potential buckling of the primary trusses Gable ends of main terminal are double bow trusses Used to avoid complexity of joining a truss and glazing..

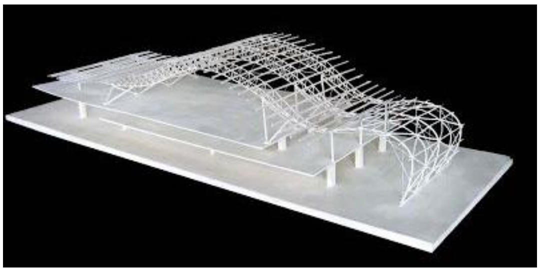

Fig. 17. Kansai International Airport Truss Model Source: (Kansai, 2020)

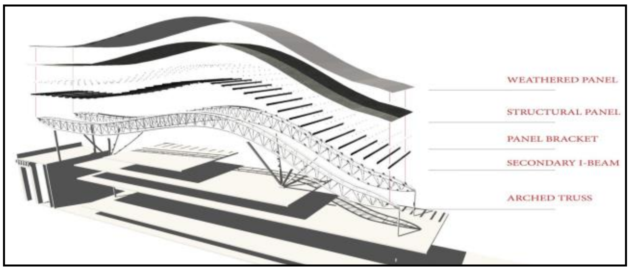

Fig. 18. Details of terminal building structure Source: (Resultado, 2020)

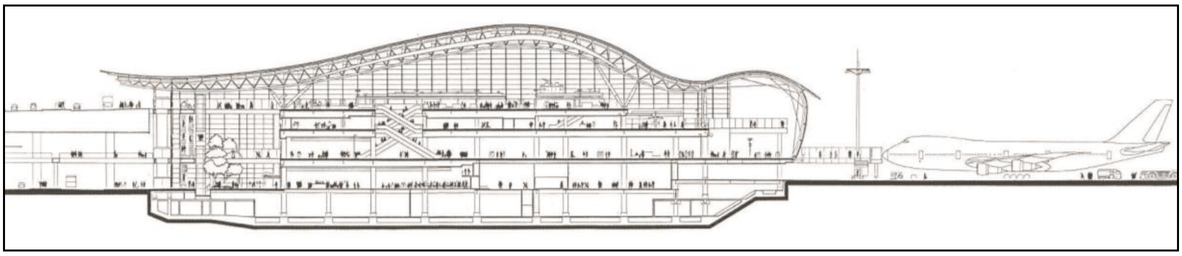

Fig. 19. Section of the terminal building. Source: (Kansai, 2019)

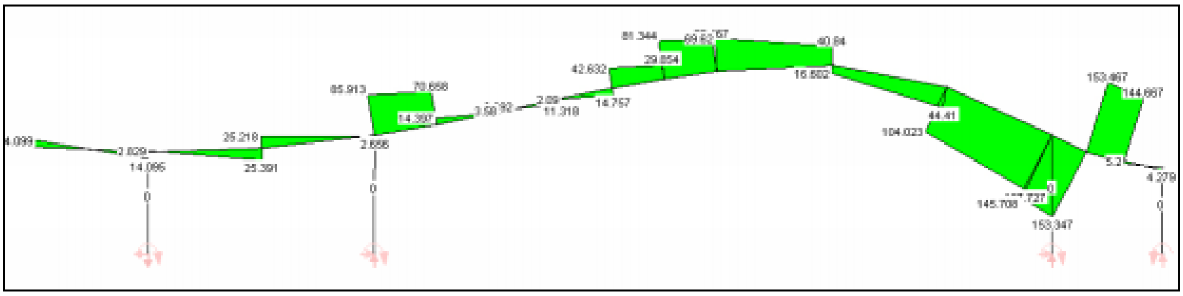

Fig. 20. Shear diagram of the terminal structural system. Source: (Kansai, 2019)

9. FINAL CONCLUSIONS

1. Architecture of terminal building can reflect the technology of construction more than any other kind of functional buildings and the tectonic architecture is one of the expression tools in terminal building architecture where the technology level of terminal building can express the advanced technology of aviation industry in the country.
2. Airports terminals buildings are considered a place of meeting all modern technology possibilities and technologies of air navigation and aviation, adopted by the designers ideas in dramatic expressive language to create a new generation of tectonic terminals which responds to the environmental factors and integrates with it, with internal spaces where the light is interacted with the structural systems.
3. Technology presents the expression language of modern terminals buildings and involves with its design process, the role of technology in that process can be seen by the capability of expansion and growing, respond to the internal and external changes, flexibility in planning and functional organization, as a result technology became a special feature in modern terminal building architecture.
4. The increased numbers of passengers and flights using airports and spread of air transport worldwide showed the needs to redesign the terminal building for the new century

requirements and apply the latest technology and security systems in it and how to integrate the building with functional and operational system to create a dynamic environment to be a revolution in airports design, as a result will be a vital new generation of terminals make the world more connected.

5. Compatibility of technology with environment can be achieved by the integration of design systems and elements like the shape of the structure and its refection of surrounded environment, the details of the structure and its respond to the climate conditions, applying of physical laws to create the shape of the roof, using of smart materials and technologies to protect the externals and facades, taking the advantage of clean and sustainable energy systems. The compatible technology with environment works on integration the internal environment of the building with its external environment, creates high efficiency, energy saving building and achieves the ultimate level of harmony between all systems and technologies inside it.
6. The structure of terminal building in last decade depended on static structural systems which considerate only the function of the building, not presenting the nature of the main event "Aviation". In the architecture of modern terminal buildings, technology can be considered as symbolic expressive tool in the architecture of new generation of terminal buildings where all physical, technological possibilities and aviation technology can be applied, using a special structural systems with high level of expression like (tectonic systems), these systems can be defined as "the science or art of construction " and present the expressive, functional, symbolic language of the building.
7. According to the priority of technology, technological and space-planning solutions in the terminal building are unified schemes and typical space-planning solutions. New technologies have an impact on the formation of space-planning decisions in international terminals and subsequently can completely change the space and configuration of buildings. The architecture of modern terminals is (Spaceless architecture) where many functions taking place in one internal environment, the perfect environment of internal space can be achieved by the integration of physical elements of interior, structural systems details and light.
8. The principle of technology and flexibility are playing a big role in the formation of internal environment in terminal building. Principle Flexibility is to create free space that can be changed quickly, which is very convenient to create spaces for different functional processes and apply the new technology solutions which in the terminal building.
9. The concept of smart interactive terminal is a fully automatic passengers processing terminal where the technology is taking place of human, functioning the spaces and zones by the designer or the architect to be independent and doing its function without human involvement, passenger goes through it smoothly and quickly to be processed. As a result, decrease passengers waiting time inside airports. The smart interactive terminal design has two main aims: Increasing terminal efficiency and minimizing the passenger waiting times by using the technology and artificial systems in passenger / luggage processing processes.
10. Smart interactive terminal general design aspects can be used as guidelines to develop principles of new generation of smart interactive terminals buildings architecture such as, simple design, clearance of space function and organization, easy wayfinding and paths inside terminal, minimize passengers processing time and walking distances, flexibility to re-zone areas as processes change and edibility for future expansions and creating a self-integrated operated building. The integration of systems in smart interactive terminals buildings depends on the principle of technology to reach a high level of efficiency.

BIBLIOGRAPHY

Aarti Nagraj, New smart gates opened at Dubai airport's Terminal 2 to cut queues. https://gulfbusiness.com/new-smart-gates-opened-dubai-airports-terminal-2-cut-queues/, access: 03.06.2018.

Adolfo Suárez Madrid–Barajas Airport. https://en.wikipedia.org/wiki/Adolfo_Su%C3%A1rez_Madrid%E2%80%93Barajas_Airport access: 11.12.2019

Adrian Eugene, Guide to Changi Airport Terminal 4. https://supertravelme.com/flying/changi-airport-terminal-4/, 2018. access: 06.09.2017

Ahmed M. A., Airport- terminal building. Hargeisa, ADMAS University, 2015.

Airports solutions. Kyiv, KABA group. 2011.

Al Shouk A., 'Smart tunnels' to speed up airport checks in Dubai. Gulf news government. https://gulfnews.com/uae/government/smart-tunnels-to-speed-up-airport-checks-in-dubai-1.2102412, access: 08.10.2017

Bachman, Leonard. Integrated Buildings: The Systems Basis of Architecture. Hoboken, John Wiley and Sons, 2003.

Blow, Christopher. J., Airport terminals. 1st Edition, Oxford, Butterworth Architecture., 1991.

Blow, Christopher. J., Airport terminals. 2nd Edition, Oxford, Butterworth Architecture.,1996.

Buchanan, P. Renzo Piano Building Workshop, Complete Works Volume III. New York: Phaidon Press Inc., 1997.

Charles de Gaulle airport terminal 2 F building interior with steel and glass roof Paris France Europe EU. https://www.alamy.com/stock-photo-charles-de-gaulle-airport-terminal-2-f-building-interior-with-steel-14682292.html. access: 02.02.2020

Dempsey P. S., Airport planning and development, 1st Edition, New York, McGraw-Hill., 1999.

De Neufville, R., Airport system: planning, design, and management. New York, McGraw-Hill , 2003

Dubai airport trials 'Smart Tunnel' that allows passengers clear passport control in 15 seconds. https://www.arabianbusiness.com/transport/406044-dubai-airport-trials-smart-tunnel-that-allows-passengers-clear-passport-control-in-15-seconds access: 11.10.2018

Edwards, Brian, The Modern Airport Terminal: New Approaches to Airport Architecture. Second Edition, London, Taylor & Francis, E & FN Spon, 2005.

E - Passport gates. https://en.wikipedia.org/wiki/EPassport_gates. access:02.02.2020

Japan may test airport body scanners this year. http://www.securitytoday.in/international-news/japan-may-test-airport-body-scanners-this-year/. July 2015. access:02.02.2020

Kansai International Airport Terminal Bay of Osaka, Japan 1988- 1994 http://faculty.arch.tamu.edu/anichols/courses/applied-architectural-structures/projects-631/Files/kansai.pdf. access: 11.12.2019

Kansai International Airport Truss Model. http://rosabellepangilinan.blogspot.com/2007/06/kansai-international-airport-truss.html. access:02.02.2020

Kaur K., Changi Airport to open Terminal 4. https://www.straitstimes.com/singapore/changi-airport-to-open-terminal-4-on-october-31-after-more-than-100-trials. access: 06.09.2017

Lokshin V., Soghomonyan N., Berlin U., Airports terminals, Moscow, Transport, 1966.

Santibañez D. , Madrid-Barajas Airport Terminal 4 / Estudio Lamela & Rogers Stirk Harbour + Partners. https://www.archdaily.com/805964/madrid-barajas-airport-terminal-4-estudio-lamela-plus-richard-rogers-partnership?ad_medium=gallery access: 10.07.2018

Osaka, Japan - April 2016: Interior shot inside passenger departure terminal, Kansai International Airport, Osaka, Japan – Stock Editorial Photography. https://depositphotos.com/152694772/stock-photo-osaka-japan-april-2016-interior.html . access: 02.02.2020

Palmer, S. 10 Airports: Fentress Bradburn Architects, Los Angles, Edizioni Press. 2006

Qasim M.B., Semka S. V. The involvement of structural systems in airport terminals forming and architecture. Space and Form journal Vol. 38. Szczecin. 2019.

Resultado de imagem para kansai international airport truss model. https://www.pinterest.com/pin/789889222123103970/?lp=true access: 02.02.2020

Sebestyen, G., Pollington, C., New Architecture and Technology, London, Architectural Press, 2003

Self-Boarding is becoming more widespread. https://www.resa.aero/what-about-self-boarding#prettyPhoto. access: 11.12.2019

SELF SERVICE HYBRID BAG DROP. https://www.matteograssi.com/en/products/te-products/self-service-hybrid-bag-drop. access: 11.12.2019

Structure + Force Diagram | Madrid Barajas Airport terminal, Spain . https://www.pinterest.com/pin/373095150359558661/?lp=true access: 11.12.2019

Super Structures of the World: Kansai International Airport. Videotape. Unipix, 2000.

AUTHOR'S NOTE

Qasim Mohammed Basim, an Iraqi architect based in Ukraine, holds a Master degree in Architecture from Kiev National University of Construction and Architecture 2014. Currently he is a PhD student in Architecture of buildings and structures in the same university since 2014. Previously he got his diploma in architecture form Al-Nahrain University, 2010, Baghdad- Iraq. He worked as an architect in water treatment plant project construction (2011-2012) and as engineer assistant in construction projects contracts achievement, importation and exportation of construction materials (2009-2011). Member in Iraqi Engineers Union since 2010. His PhD thesis “Principles of airports terminals architectural planning and organization, for example airports of Iraq” covers the fields of airport terminals architecture and design of smart interactive terminals and transport hub. He has been disseminated through various local and international articles publications in Ukraine and Poland and several international conferences in Ukraine. Research interests: Airports terminals design and architecture, smart terminals design.

Contact | Kontakt: qasim.m.qaisi@gmail.com