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Indiana Harbor International Airport

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INDIANA HARBOR
INTERNATIONAL AIRPORT

CONTENTS

ABSTRAKT

Die Flughäfen von Chicago besetzen riesige Landstriche in der Mitte der sehr großen Vorstadtgebiete. Seit die Flughäfen konzipiert wurden hat niemand jemals gedacht, dass der Großraum Chicago über diese Flughäfen hinaus wachsen würde. Die Flughäfen, die Chicago im Moment primär dienen, heißen O'Hare und Midway. Mit vereinten Passagierzahlen in der Höhe von fast 86 Millionen im Jahr, sind die Flughäfen vielleicht einer der größten Arial-Kreuzungen in Nordamerika. Da diese Flughäfen sich in der Mitte der vorstädtischen Gebiete befinden und immer noch expandieren, wächst die Besorgnis über Lärmbelastung und erhöhten Verkehr in diesen Bereichen. Vielleicht noch mehr hinsichtlich der Tatsache, dass die Flughäfen selbst schon altmodisch geworden sind und immer unpopulärer werden aufgrund ihrer Passagierunfreundlichkeit.

Diese Diplomarbeit beschäftigt sich mit der Konzeption und dem Bau eines neuen internationalen Flughafens in Chicago und sollte auch der umliegenden Mid-West Region der Vereinigten Staaten dienen. Der gewählte Standort für den neuen Flughafen ist eine Region beim Lake Michigan der als Indiana Harbor bekannt ist und besteht aus zurückgewonnenem Land ca. 25km südöstlich der Innenstadt Chicago (etwa die gleiche Entfernung wie O'Hare). Der Ort, in seiner jetzigen Form, ist die Heimat einer rückläufigen Stahlindustrie, welche ihre Geschäftstätigkeit auf neue Märkte wie Indien und China verlagert.

Der neue Flughafen soll die Architektur Chicagos reflektieren und sollte für mehr als 100 Millionen Passagiere pro Jahr Kapazität schaffen und soll in Zukunft erweiterbar und anpassungsfähig sein. Durch das Ersetzen der alten Flughäfen von Chicago mit diesem zentralen Flughafen, ist zu hoffen, dass viele der Fragen im Zusammenhang mit Flughäfen in dicht besiedelten städtischen Umgebungen vermieden werden und auch in der Zukunft verbessert werden können.

ABSTRACT

The airports of Chicago occupy huge swaths of land in the middle of very large suburban areas. As the airports were conceived nobody ever thought that the metropolitan area of Chicago would grow beyond these airports. The airports that serve Chicago at the moment are primarily O'Hare and Midway International airports. With combined passenger numbers totalling nearly 86 million a year, the airports are perhaps one of the largest Ariel crossroads in North America. As these airports are in the middle of suburban areas and as the airports continue to grow, there has been an evermore growing concern about noise-pollution and increased traffic in these areas. Perhaps even more concerning is the fact that the airports themselves have become outdated and unpopular due to their passenger unfriendliness.

This master thesis concerns itself with the design and construction of a new international airport serving Chicago and the surrounding mid-west region of the United States. The chosen location for the new airport is a region, reclaimed from Lake Michigan, known as Indiana Harbor and is 25km southeast of downtown Chicago (approximately the same distance as O'Hare). The site, in its current form, is home to a declining steel industry which continues to shift its business to new markets such as India and China.

The new airport should reflect the architecture of Chicago. It should cater for over 100 million passengers a year and be expandable and adaptable in the future. By replacing the old airports of Chicago with this centralised airport, it is hoped that many of the issues tied to airports in dense urban environments can be avoided and be improved upon in the future.

Fig.1. The skywalk boarding pier at La Guardia Field, 1939

HISTORY

1903–2015

Fig.2. Flagman at Newark Airport, 1929

Foreword

This master thesis concerns itself with the modern building phenomenon known as the airport. In this thesis I will be looking back at the history of airports, looking at trends and attempt to peer into the future of airport design. After looking at the history and trends of today's airports I will be designing and planning a new airport for the city of Chicago, Illinois. Using all the information gathered I will be creating a modern airport, based on future needs, which will be the first completely new airport designed for the US since 1995. Understanding why that is, is a question of history, economics and outside influences. Charting the events of the last 100 years will uncover all the information required to design a truly modern and nearly future-proof airport.

Early aviation history

Over the course of history a lot has happened concerning the history of airports and aviation. As both go hand in hand their history is automatically intertwined and inseparable. People have always been fascinated by flight. In China kites and hot-air balloons were already being made as early as the 4th century BC. These were the first man-made aircraft. During the renaissance Leonardo da Vinci designed many flying apparatus such as ornithopters, fixed-wing gliders, rotorcraft and parachutes[1]. Many of the ideas were theoretical but proved that many of the ideas of flight were already around at that time and are by no means truly modern inventions. The very first manned flight occurred in 1783 in Paris. The Montgolfier brothers had previously created unmanned hot-air balloons but this was to be their first attempt at a manned flight. On the 19th of October the aviators Jean-François Pilâtre de Rozier, Jean-Baptiste Réveillon, and Giroud de Villette were launched on a tethered flight. On the 21st of November the first untethered flight was undertaken and the balloon drifted for around 8km. Later the first controllable balloons known as dirigibles were created and the first non-rigid airships were designed and flown. Alberto Santos-Dumont, a Brazilian aviator, successfully combined a balloon and a combustion engine. His flight in 1901 with "Number 6" rounded the Eiffel Tower and he subsequently won the Meurthe Prize. Rigid airship design was pioneered by Ferdinand von Zeppelin. The first Zeppelin flight occurred in 1900 but only lasted for 18 minutes. The subsequent future of lighter-than-air craft would be overshadowed by the development of heavier-than-air craft and to this day the technology has never really progressed.

Heavier-than-air craft were starting to be pioneered in the mid to late 19th century. During this time gliders were starting to be developed and theories on flight, in particular by Sir George Cayley, were being devised. Cayley wrote the first books on the underlying physics behind manned and powered flight and formed the bedrock of everything we know today about the physics of flight. During this time many gliders were being made and being flown by men such as Boit, Massia and Lillienthal. Toward the end of the 19th century Samuel Langley started a serious investigation into[1] powered and manned flight and on May 6th 1896, Langley's "Aerodrome No. 5" made the first successful sustained flight of an unpiloted, engine-driven heavier-than-air craft of substantial size[1]. Over many years Langley attempted to scale up his designs and introduce suitable motors for a manned flight. However after two attempts and two crashes, funding dried up and Langley gave up. Only nine days later, on the 17th of December 1903, the Wright brothers made their first sustained, powered and manned flight at Kill Devil Hills, four miles south of Kitty Hawk, North Carolina. The era of manned and powered flight had begun and soon places where these aircraft could be flown and landed were needed.

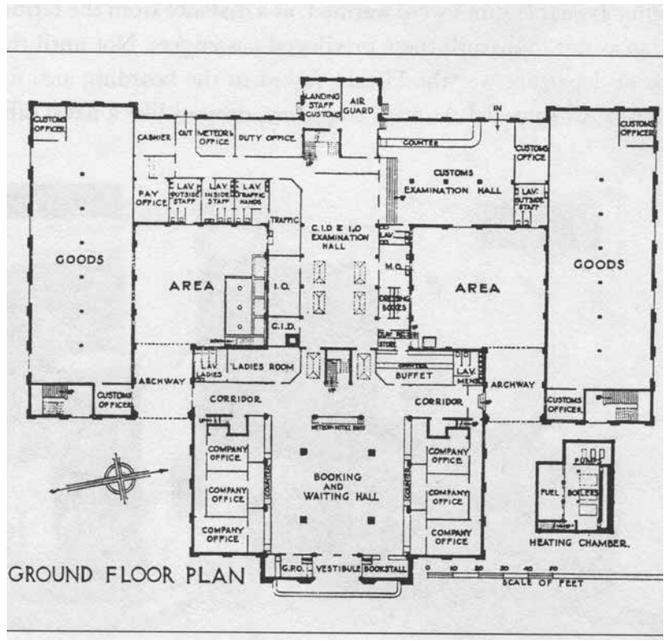
"[Architecture is, simultaneousley, an] expression of a utopia and instrument of a convenience."

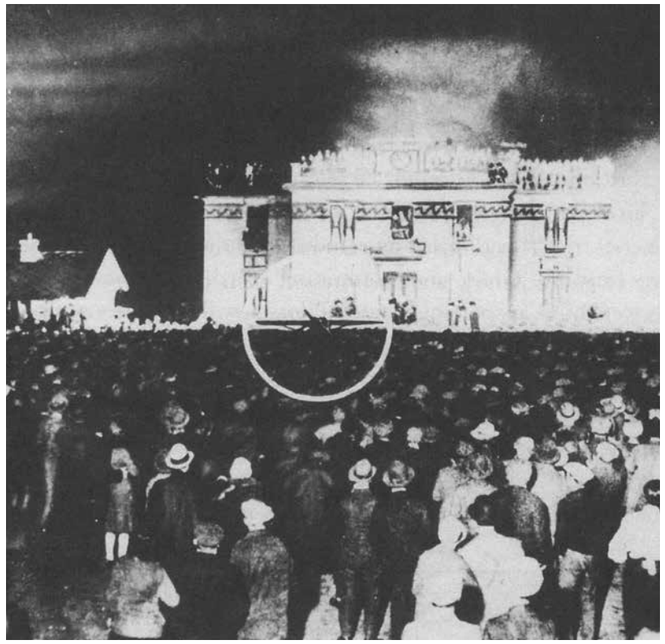
Roland Barthes

During the next two decades aviation technology would explode. During a time known as the pioneer era (1903 to 1914) many flights would be taken as flying technology became evermore advanced. Aviators such as Viua and Voisin all produced aircraft capable of the same feats of the Wright Brothers in 1903 and in 1908 Louis Bleriot achieved the first flight across the English Channel. The first military use for an airplane was in 1911 when an aircraft was used as a bomber in the Italian-Turkish war (1911-1912). The First World War introduced the first concepts of planes shooting at one another when Frenchman Roland Garros mounted a machine-gun at the front of the plane. The war created many legends such as Manfred von Richthofen and Rene Paul Fonck. The first true fighter aces. In 1915 Hugo Junkers, a German aviation enthusiast, created the first all-metal aeroplane, only 12 years after the Wright Brothers made their famous flight. Many feats in aviation would be gone on to be made but the advances that the First World War brought would shape the history of airports as we know them today. During the war the images of flight and pilots who flew the airplanes were regarded as the modern gladiators. There was something wildly fascinating maybe even romantic about the thought of what could be done with flight. At the end of the war many of the places where these products of war were landing, known as aerodromes, needed a new use. And so the first commercial airports were born.

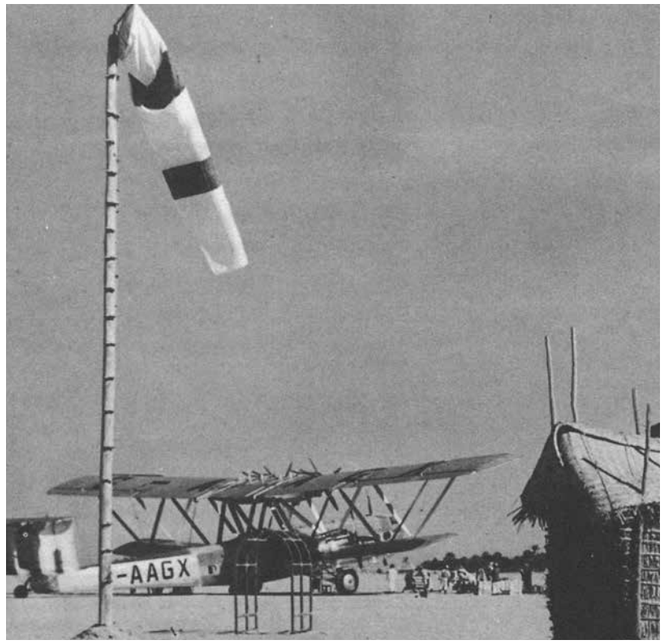
First attempts: 1924-1930

Airports had many names around the world; airport, air-station, air depot, aerogare, Flughafen, aeroporto, stazioni aeroplane and aerodrome. They all meant the same thing and simply meant a place where airplanes could land, unload and load the wares and fly away again. Airports in Europe and the US however, had decidedly different origins. Whereas the airports in Europe all grew out of WW1 airfields and air stations their American equivalents had no such thing, as mainland America had no need for them. Instead locations for airfields arose out of sporting venues such as race courses and race tracks, simple open expanses where planes could land and takeoff. The first true aerodromes in the world were to be found in Hounslow, England and Le Bourget near Paris, France. On August 25th, 1919 the





▲ *Fig.3. Ground floor plan of Croydon Aerodrome, 1928*
◄ *Fig.4. Charles Lindbergh arriving at Le Bourget, 1927*
► *Fig.5. Desert airport in Bahrain, 1934*



first international commercial scheduled flight took off from Hounslow Aerodrome to La Bourget. Hounslow at that moment became the first British land-locked customs post as all previous importation of goods were done by ship. The planes used in these international flights at the time all tended to be converted WW1 bombers. Conditions during the trip were extremely harsh and there was also no guarantee of actually arriving. Air travel was reserved for the rich and made quick trips to Paris a reality. A flight to Paris would take around 2.5 hours whereas the same journey by train and ship would take close to 9 hours. Hounslow however, was not to be the future of british commercial aviation. Although the British government had no airport development plans in place for the future it was decided that Croydon Aerodrome would be the future airport for London and the British Empire and therefore all services were moved from Hounslow to Croydon.

Croydon Airport, in the south of London, opened in 1920 and boasted the first air terminal building in the UK and the first air traffic control systems in the world. The terminal building itself would be the earliest example of airport circulation known. The terminals ground-floor plan was symmetrical. In the centre were progressive steps through the booking and waiting hall. Passengers then moved on to the examination hall and then on to their plane. Passengers arriving would enter through another door, move through customs and then leave the terminal through the front entrance. Freight was stored on either side of the terminal and away from paying passengers. The waiting hall was naturally lit through a domed skylight and contained a bookshop, a restaurant and a reading lounge. The airport also had a 50-room hotel and many new hangers able to store and service aircraft. The airport became the centre of all air travel through the British Empire and naturally became the home of the national carrier: Imperial Airways. Around Europe many nations started to build airports. The Netherlands for example build a purpose built airport on reclaimed land, 13ft under sea-level, at Schiphol. The airport would become one of the most important crossroads in Europe. In Germany, meanwhile, due to the restrictions imposed upon them by the Versailles settlement where they were unable to build up any military force, and in particular an air force, invested all their money in Civil Aviation. Germany built many airports such as those in Königsberg and Hamburg but the airport in Berlin would be the finest of them all. The Tempelhof airport, designed in the fashionable Bauhaus style designed by Kosina and Mahlberg, would become the “finest commercial aerodrome in the world”. Its distinct oval airfield with concrete aprons were to be unmatched by anything in the world.

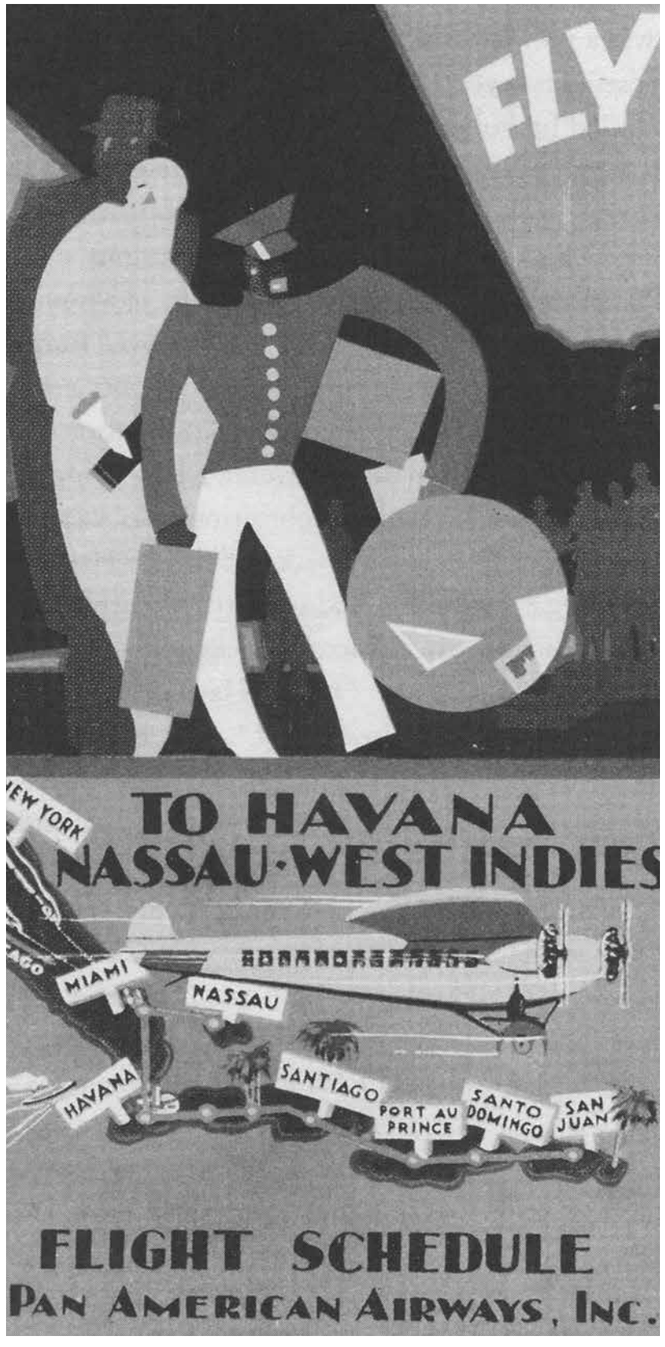
In 1927 Charles Lindbergh completed the first non-stop solo flight across the Atlantic after flying from New York to Paris. By this time all the cities in Europe were connected by Airports and Airlines. Air travel became fashionable and the airline industry was booming. When Charles Lindbergh landed in Paris and saw the Airport with its terminal, and subsequently many airports in Europe, he couldn’t help but realise that American airports were lagging very far behind and described them as “cow-pasture” aerodromes. When he returned to the United States he was seen as a hero and became an instant celebrity. Before Lindberg’s flight, the only type of Commercial Aviation that was taking place was that of the US Postal Service. A string of airfields were being used around the country to ferry mail from A to B but no true commercial passenger facilities were available. The airfields were simply used to unload and load mail and refuel the aircraft. In 1926 the US Government passed the Air Commerce Act which ushered in controls of the registering of pilots, aircraft and civil airways. The act however prohibited the direct government sponsorships of airports. This meant that all airports had to be run as businesses and effectively weren’t allowed to make losses. The airlines were in a similar situation. Where in Europe Airlines and Airports were nationalised their counterparts in America were all privately owned. In the future the privatisation of Airlines would become the norm whereas the future of airports was decidedly unknown. Even before the Air Commerce act and Lindbergh’s flight, cities across America were already buying land in anticipation of the air travel boom. Boston had already purchased land in 1923 in East Boston to make way for the future airport and is a site which is still used to this day. Other cities such as Buffalo, San Francisco (which also boasted the first airport hotel in the US) and Dearborn all followed suit and purchased land to build new airports.

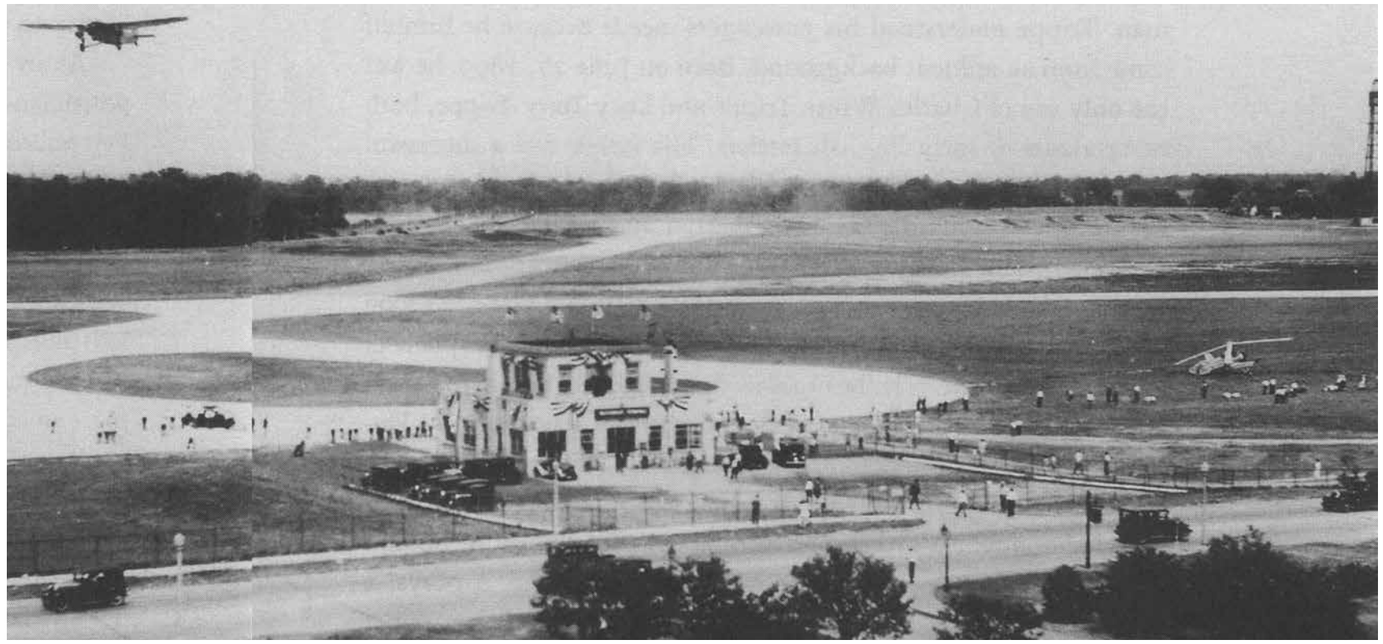
When Lindbergh returned from Europe forty days after his historic flight he embarked on a whirlwind tour across the United States championing commercial aviation. Travelling more than twenty-two thousand miles and having been seen by more than thirty million people Lindbergh inspired people across the US and his tour fostered in a new kind of awareness that commercial aviation was extremely important and that the entire nation should be connected in a “modern, air-age union”. Within one year of Lindbergh’s tour there were more than 425 municipally owned airports and passenger numbers quadrupled. However, even then the airports were still horrendous containing grass-strips, shoddy hangars and sheds that were considered as “terminals”.

Even then the building of an airport posed huge problems. Huge expanses of flat land were required along with facilities for passengers, drainage systems and hangers for the storing and maintenance of aircraft. Some of the first major purpose built airports were those in Chicago and Dearborn. The Curtiss Airfield in Chicago, part of the Curtiss-Wright Airport Corporation that built twelve airports across the country, was one of the first airports to have a purpose built terminal for paying passengers. The airport also generated extra revenue by accommodating paying spectators (up to two-thousand at a time), by building restaurants and gift-shops and by hosting air-shows. All this was done to keep the airports out of debt. It would be the start of a new business type that went hand-in-hand with commercial aviation; consumerism. By 1929 there were already sixty passenger airlines in the US and the first cross-country service was inaugurated in July.

“There are those airports which make you feel better, and there are those airports that, when you go there, your heart sinks: you can’t wait to get out of there. They both function as airports, but it’s the things that you can’t measure that make them different.”

Lord Norman Foster





▲ *Fig.6. Ford Airport in Dearborn, Michigan*
◀ *Fig.7. Pan American Airways brochure in 1928*

The airport in Dearborn, Michigan was to be one of the first and most forward thinking airports in the US. Henry Ford, creator of the Model-T and pioneer of the assembly line already saw the potential of aviation much earlier than most. By 1926 he was constructing tri-motor all-metals airplanes and by 1929 he was building around twenty-five per month. Ford however, realised that he could build as many planes as he wanted but without reliable airports, airlines and passengers the airline business and subsequently the airport business would never get off the ground. His first task was to instil confidence in people that flying was as safe as driving or travelling by train (in 1928 around fourteen-hundred passengers flew commercially, and fourteen of those died). Flying at the time was a dangerous affair and Ford did this with targeted advertising campaigns in popular magazines but nothing would instil more confidence than people actually seeing how safe it really was by experiencing it for themselves. His airport in Dearborn would be purposely built for safety in mind and included paved runways, paved aprons, floodlights, the first radio systems, a hundred-room hotel and a freestanding terminal. All amenities were designed to relax and calm the passengers. In 1927 over nineteen-thousand people visited the airports and undertook short flights over Detroit. These flights were taken to show people how safe flying really was and not one fatality was recorded. Dearborn was essentially the first comprehensively planned airport in the US.

At the time most of the passengers were business executives, politicians or people in the entertainment business. The main draw to flying somewhere would be to save time over other conventional methods of transportation such as car, train or ship. The benefits therefore outweighed the risk that flying brought but nevertheless the “normal” person would not be flying anywhere for some time. A man trying to change this notion was a young affluent man named Juan Trippe.

Juan Trippe understood better than most what affluent people wanted. He himself came from that very background and wanted to take commercial aviation to the next level. Where Ford saw an airport as an assembly-line Juan Trippe saw it as an exclusive Country-Club. When his first aviation venture (Long Island Airways) failed he founded Colonial Air Transport and later invested in a small upstart called Pan American Airways. On the 19th of October, 1927 Pan American Airways flew the first international mail route outside of the US from Key West, Florida to Havana, Cuba. In 1928 Trippe negotiated an exclusive twenty-five year flying agreement with then president Morales which allowed only Pan American to fly to Cuba. With prohibition in effect at the time in the US many used the opportunity to fly to the short route to Havana to circumvent the regulations. Because Pan American had exclusive rights business exploded. Wealthy socialites and even mobsters such as Al Capone were flying to Cuba for the unrestricted alcohol and gambling. Cuba however, wasn’t enough for Trippe. He wanted to expand his air routes into Central and South America. Soon Trippe would be negotiating with governments of many nations, something actually not allowed by the US government, about routes and locations for airports. Soon airports were popping up from Argentina to Mexico. These airports were becoming outposts for economic and geopolitical expansion by Pan Am and in turn the US. Countries were bribed and leaders were deposed all to further the expansive nature of the US. They weren’t expanding their influence by war but by economic suffocation. In Europe there was a different situation. European airlines were usually nationalised, flag-bearers of a nation and were building airports for different reasons: they had empires to take care of. In the case of the British their Empire, at its height in 1922, encompassed 458 million people (a fifth of the world’s population at the time). It stretched from Canada in the west, to India and to Australia in the east. The Airports that had to be built to connect this huge empire were used as stops to refuel and feed passengers. Airports sprung up in places such as Basra (now Iraq) and Karachi. These were the first tastes of exotic locations that people could now travel to in a short amount of time.

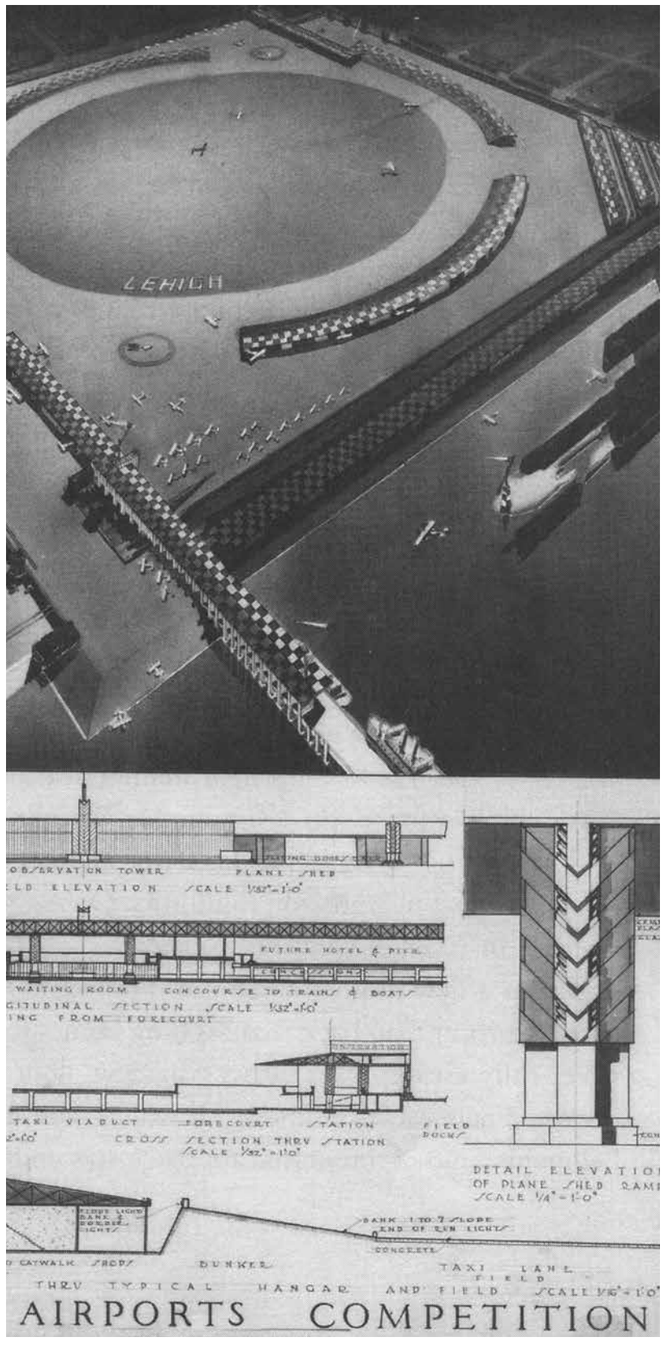
By the end of the 1920’s airports were becoming common-place amongst communities across Europe and America. Airport design at the time was a new problem for architects. It was a completely new type of building with its own specific and unique requirements. No-one really knew what an airport should look like. In Europe the first airports were being built like many other public buildings in sort of historical themes such as Palladian Manor or Petit Palais. The theme of neo-classicism would also influence American airports such as Boston which built an airport with a grand neo-classical entrance. Early airports built after 1927 all followed the example of Dearborn’s symmetrical facade and depot-style interior. They contained a waiting hall, ticketing office and often other amenities such as bookshops and restaurants. In this short time between 1927 and 1928 one could say that American airports had caught up with their European counterparts. However, as airports in America progressed the airports in Europe stood still. The likes of Croydon and La Bourget would stay unchanged till after the Second World War.

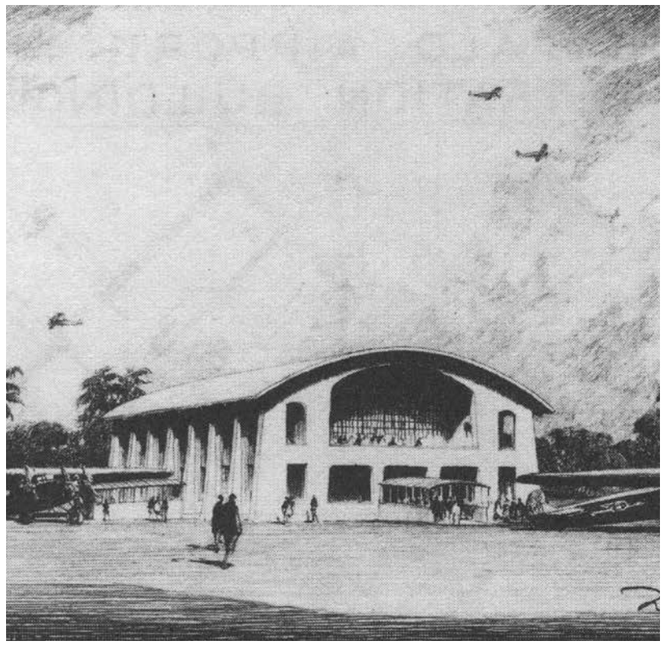
Juan Trippe believed the airport “should set the stage for the adventure of flight” and therefore required its own type of architecture. One of the first examples of this effort to form an own identity was a Terminal building in Miami commissioned by Trippe and designed by Delano and Aldrich in 1928. Whereas most airports of the time were somehow alluding to classical themes used on many other public buildings, the airport in Miami mirrored the planes themselves. The building was looking to the future with the curve of its roof complimenting the planes perfectly. Balconies for spectators and a waiting hall flooded with natural light seemed to be the way a terminal should be designed. By the end of the 1920’s there was a concentrated effort to determine the appropriate style of airport architecture. In 1929 a national design competition was held to determine airport style. Many architects entered and proposed radical solutions

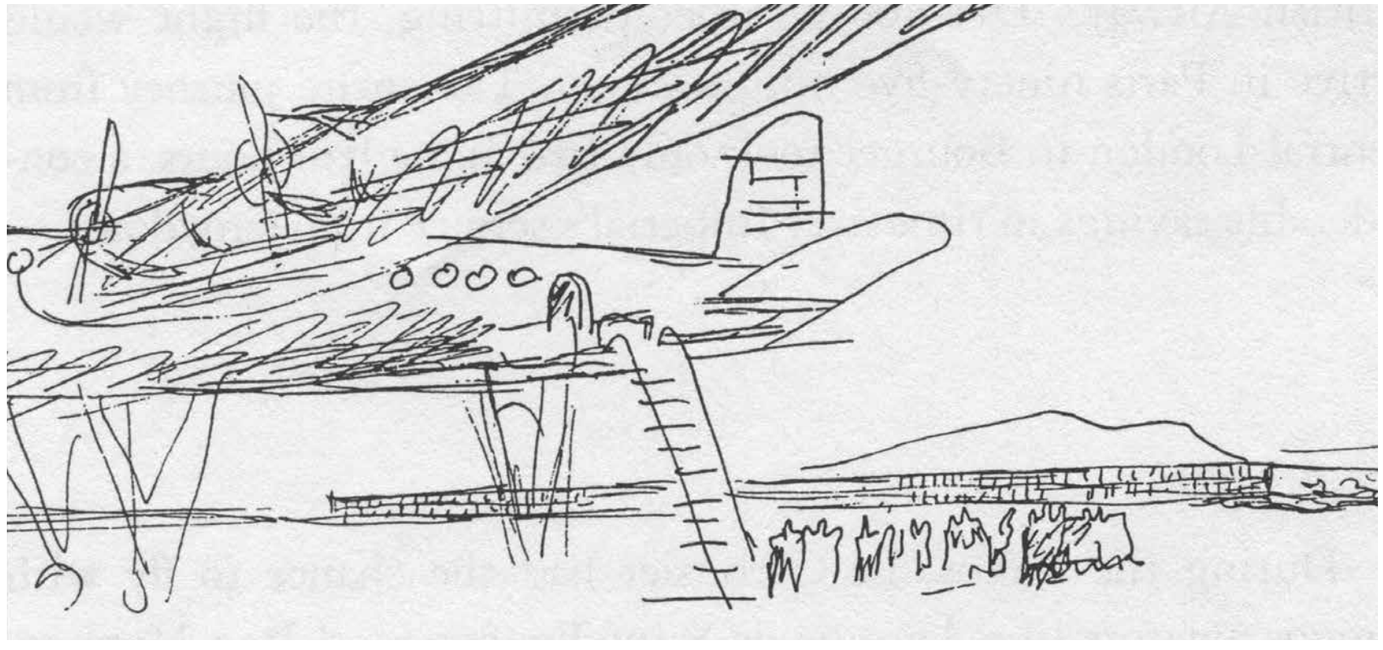
“The airport is bound to no architectural traditions.”

Wyatt Brummitt, 1929

◄ *Fig.8. Entry into Lehigh Airport Competition by Lloyd Wright*
▼ *Fig.9. Le Corbusier's sketch for a naked airport, 1946*
► *Fig.10. Delano and Aldrich, Pan Am terminal, Miami, 1928*







where some were more absurd than others. But what crystallised out of the competition was that airports should look to the future and be cutting-edge in terms of design. The winning entry by Zimmerman and Harrison was one of the few designs which focused on logical organisation and innovative boarding system which led passengers through a tunnel to a star shaped pavilion (a precursor to the modern day satellite). An entry to the competition which wasn't even given a mention by the jury was that of Lloyd Wright, Frank Lloyd Wright's eldest son. The design had no hints of the past, it was a design influenced by Wright's influences from his father and his experience designing flying boats. The hangars and terminals were all unified in a singular gesture and there was no ceremonial entrance. Even though the design was ignored the design "foreshadowed the hyper extended architecture of the future".

By the end of the 1920's many milestones had been reached. The foundations for future commercial air-travel had been laid. Night routes were being expanded and air travel was considered so safe that taking-off and landing and night were deemed to be extremely normal. By the end of 1929 two hundred and seventy five airports in the US had been equipped for night flying. Also, in 1928 the first in-flight movie was shown on a flight in a Ford Tri-motor. This showed people were already considering air travel as a normal method of travel and were looking for things to do to relieve their boredom on long flights.

Around 1930 the chosen design for new airports was to be Art Deco. It was a design and style which was influenced by and embodied aviation. Everything was given the "aerodynamic treatment". Even though Art Deco was the mainstream choice at the time many airports decided that they would mirror the architecture of their regions. In the golden age of Hollywood many set-designers, not architects were being commissioned to design airports. The style of pseudo-Moorish or Spanish monasteries was carried in many airports in the west of America (Burbank, California) but they were not trying to be historically accurate. Instead they were creating a fantasy of the future. A future where people could experience what they saw in the movies. They could perhaps be considered "themepark-esque". Mines Field in Los Angeles, designed by Lloyd Wright, also adhered to a Spanish mission style theme (however determined by his roots in organic architecture) to help "promote an image of eternal sunshine and unbridled opportunity". In the southern states airports were designed in an Antebellum or Plantation theme. They were also not accurate representations of the past but a fantasy where the old south met the new south. Already, airports were trying to form an identity for themselves by selling their looks to the masses and drawing people to them.

"An airport, should be naked."

Le Corbusier

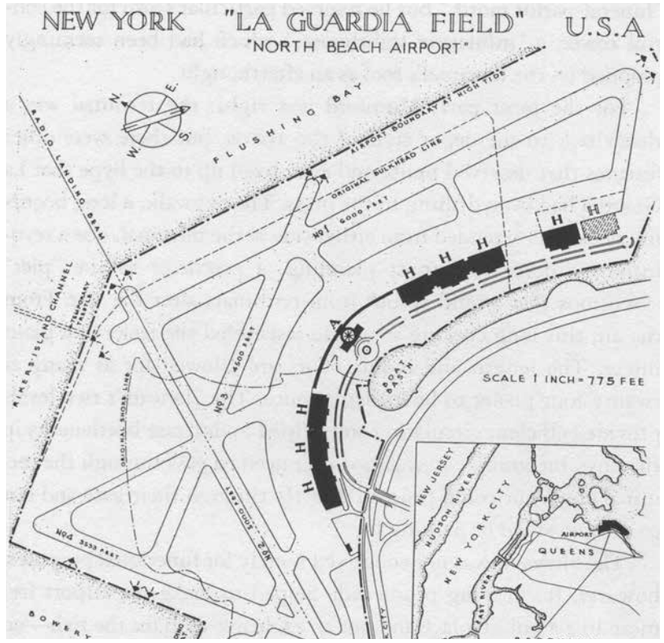
Naked Airport: 1930-1940

Air travel, by the end of the 1930's and indeed even before that, promised to shed new light on how humanity viewed the world. Architecture in particular was in for a rude awakening, because air travel opened up a third dimension in travel, one where we would now be able to view buildings and even entire cities from above. The architects of the age now had to consider every aspect of the building: the top, bottom, sides etc. They were no longer able to only consider the facade but had to give equal thought to the roof and rear of their buildings. The new facade was the roof. In terms of urban planning many city planners only discovered through aeroplanes how cities worked and how they were failing. This also led to a new era in city development where the third dimension became vital.

At the beginning of the 1930's airports were becoming common-place amongst urban environments. Many architects and urban planners who were trying to envisage the modern cities of tomorrow saw airports as integral parts of a city's core elements. Le Corbusier had a design in 1922 for a city for three million inhabitants called Une Ville Contemporaire where the central element was an air station flanked by four skyscrapers. There were also other radical designs such as the Stazioni Aeroplane for the centre of Milan in 1912 by Antonio Sant'Elia. But was the idea of placing an airport in the centre of a city a good idea for the future? At the time airports were also starting to gain importance and were no longer seen as a passing fad. Robert Mallet-Stevens stated that airports should be "a bold new entry point" and also condemned nostalgic forms. The point about the airport being the entry point to a city was extremely important and has an extreme bearing on today's airport architecture as well. As the ideas of airport architecture progressed the ideas of how airports of the future should look like continued to be discussed. The future of airports seemed to be away from city centres where wide-open spaces were available and the disturbance to people could be minimised. By now the rate at which airports were being used exploded exponentially. Airports were processing ever more numbers of passengers and it became apparent that the way airports looked may not be as important as how they worked internally. In Hamburg Dryssen and Averhoff designed an airport based entirely on functionality. The different floors of the airport were divided into different functions such as areas for ticketed passengers, baggage handling and non-travelling passengers. The airport was also connected by a dual-carriageway and tramline to the city. If this was the birth of functional airports then Le Corbusier gave birth to the way of thinking how airports should look like when complimenting these functional attributes. Le Corbusier said: "An airport, should be Naked". His idea seemed to be that the airport should not be seen and posses no architectural style whatsoever. The focus should be on the passengers and the aircraft themselves. These were the first truly modern notions which seemed to be the birth of the steel and glass facades we see on today's airports. However, as we know today, the style which wanted to be invisible has turned out to be an architectural style in its own right.

By the mid 1930's the "old" European airports such as Croyden, La Bourget and Schiphol were all becoming outdated. Out of all the airports only La Bourget received a

◀ *Fig.11. Delano and Aldrich, Dinner Key Airport, 1934*
▼ *Fig.12. Master plan for LaGuardia Airport, 1939*



"Speed and fluidity in the transition from air to ground is what is needed more than a grand court d'honneur in front of an airport."

Richard Neutra

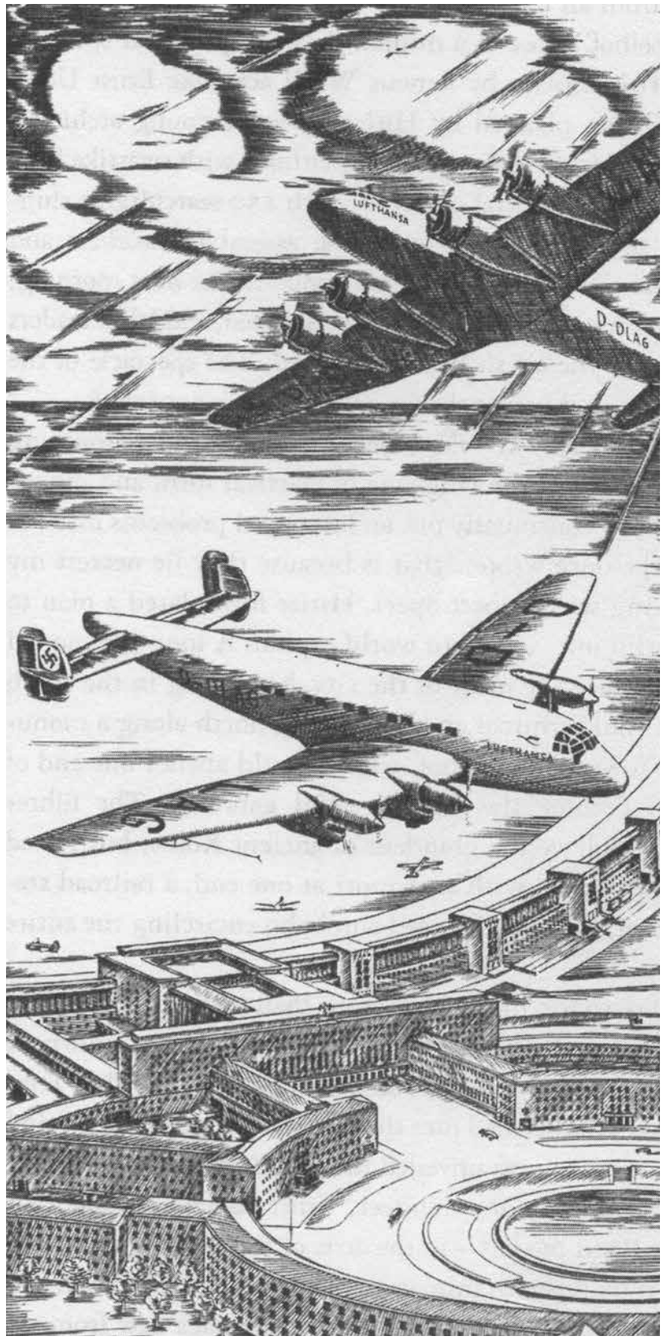
new terminal in 1937. The high-point of airport design at the end of the 1930's was Kastrup Airport designed by Vilhelm Lauritzen. The airport, in Copenhagen, was perhaps the first example where a truly efficient and functional airport was coupled with a beautiful design. Columns were set-back which allowed tall glass facades to allow copious amounts of natural light to flood into the main booking hall. Wall coverings were made from birch to dampen noise and create a rhythmic sense of movement. This was the first truly modern airport and maybe a design from which all of today's design stem from. Little would be known that these airports would soon no longer be used for commercial air travel again until after the Second World War.

Pre-war era: 1933-1941

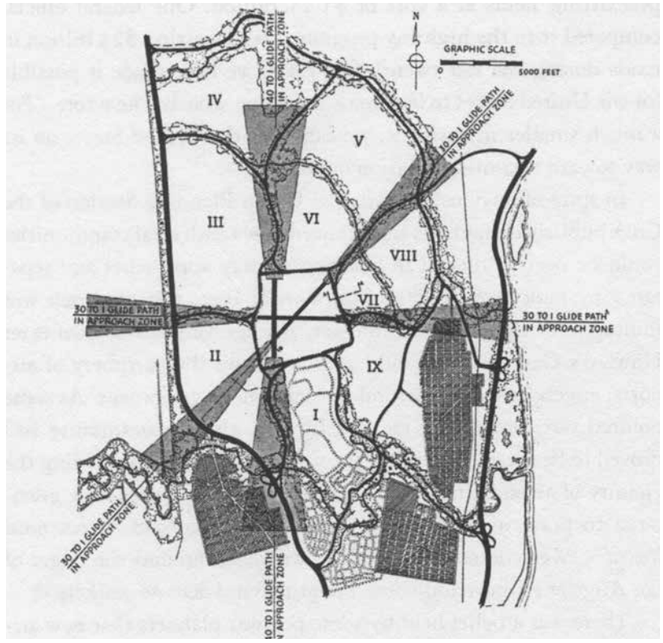
Across the Atlantic however, American airports were blossoming even though the economic situation was somewhat precarious and slowed down the expansion of commercial air travel. In 1929 the stock market crashed on Wall Street. The world entered a "Great Depression". Spending on everything had to be curbed and the aviation industry suffered greatly. Private investments in airports dropped from $35 million in 1930 to $1 million in 1933. During this period, due to a lack in investment, terminals and runways were desolate, unmaintained and fell into terrible disrepair. In 1933 when Franklin Delano Roosevelt (FDR) started his first term as President of the United States he pledged to bring America out of the depression by investing in programs which would give people work and jump-start the US economy. The programs were part of what would be known as FDR's new deal. In this new deal programs called the Works Project Administration and the Civil Works Administration were implemented to expand the civil aviation network by upgrading existing airports and building entirely new ones. In 1933 $11.5 million was invested into the construction of new airports. The programs also brought their own style of architecture with them. The buildings erected tended to be non-descript modern, faux Tudor and neoclassical; styles which had been done already and were not too overbearing or risky. They also tended to encompass materials which were local and readily available. By designing airports this way the government was able to quickly establish an upgraded commercial air travel network quickly and easily whilst also finding work for the millions of unemployed. One of the examples of WPA architecture which didn't follow the aforementioned trend would be the new terminal at Newark Airport, New York. The new terminal was designed in the Deco style of the depression era and was connected with a new elevated highway which allowed people from all over New York to reach the airport quickly. The airport hosted over 200,000 passengers and was, at the time, the busiest airport in the world.

During the depression however, not everyone was saving money. The only airline to grow and expand during the depression era was Pan American. Due to Juan Trippe's negotiating and exclusive (virtual monopoly between 1930 and 1934) deals on overseas routes, Pan American enjoyed the best years of their lives and was the "tentacle of Yankee Imperialism". In the same time Trippe wanted to expand his own facilities and built a luxurious flying-boat airport designed by Delano and Aldrich in Biscayne Bay, Florida. The Airport would be the centre for Pan American's Sikorsky S-40 flying boats. There were new hangars and a beautiful new terminal which was once again nothing like the WPA airport architecture of the time. Throughout the time of the new deal the old ideas of airport planning were being challenged. Speed was becoming the primary goal and the ways passengers were transferred, baggage was handled and systems of boarding and de-boarding passengers were becoming ever more important. The importance of the design was slipping into the background. Richard Neutra, the Austrian born architect said: "Speed and fluidity in the transition from air to ground is what is needed more than a grand court d'honneur in front of an airport." John Walter Wood, an architect and inspector of airports in the 1930's, concurred and said and airport should be operated "like a smoothly functioning organism, providing a steady and fluent movement of aircraft, passengers, merchandise, mail and surface vehicles." Systems to enhance this efficiency started to appear and the move from an attractive airport to a functional airport had begun. Bel Geddes' systems to board aircraft were some of the first ideas to increase efficiency where aircraft and passengers were completely separated and worked like Ford's assembly lines. Although the idea was never implemented it led to the development of air traffic control as we know it today.

Towards the end of the 1930's and new deal era the then mayor of New York; Fiorello La Guardia, wanted to bring New York into modern age with a brand new airport. Many opposed him and asked why he wanted to invest $50 million in a new airport when there was a perfectly good airport at Newark. He wanted "an airport for New York, not New Jersey" and proceeded with the planning. The site was an area of reclaimed land in the north of Queens. The airport which was constructed in-time for the 1939 World Fair ended up costing nearly $100 million. It was however the most forward thinking airport to date and encompassed a new terminal in a totalitarian look, the longest runways at the time (6000ft) and a control tower. By 1940 the airport was the busiest in the world and around 250 landings per day were taking place. The last airport of the new deal era to be constructed was the new airport in Washington DC (built on the banks of the Potomac), known as Washington National, and built under executive orders from FDR; it boasted the most modern baggage system in the world and rotating turntables in the apron to quickly turnaround aircraft. The facade of the airport was not ignored like it was at La Guardia and once again evoked classical themes (perhaps justified as Washington DC is the capital of



◄ *Fig.13. Ernst Sagebiel, Tempelhof Field, 1936*
► *Fig.14. Postwar plan for suburban development*



"Wartime demands have accelerated the trend toward concrete as a medium of design."

Advertisement for the Lone Star Cement Corporation, 1943

the US and home to government). What the airports of the new deal era didn't do was set the tone for how airports of the future should look like but what they did do was set the tone for airports which were ambitious in scale and focused on efficiency. What they also achieved was the clarification that airports of the future could no longer be build in urban centres but had to be built on the outskirts of cities. They defined new peripheral zones on the outskirts of cities where the airports could continually expand and serve their cities in the most efficient of ways. Washington National and La Guardia would serve as the examples for post-war airports where the new urban space that airports required would be horizontal and sprawling rather than vertical and dense.

War and post-war: 1939-1957

During the Second World War civil aviation suffered a serious downturn due to conflict. No civil airports were built outside of Germany during the war and inside Germany they were primarily used to project the might of the Third Reich upon other nations. The architecture that was prevalent in airports constructed tended to be boiled-down classicism such as the Reich's aerial gateway at Tempelhof Airport. All Germany wanted was to show how mighty it wanted to be and classicism in that respect always tended to be the architecture of choice. The airplanes themselves were also used as propaganda tools. When Hitler flew around Germany rallying supporters, he was always filmed arriving in his Junkers Ju 52 Tri-motor plane. It showed him as this all-powerful leader coming down from the sky.

At the same time in America, commercial aviation came to a grounding halt. No Airports were being built and no airlines were flying anywhere. During the war the commercial airlines and airports were being used to ferry around equipment and personnel in aid of the war. Pan Am were even paid $12m to build twenty-five land and nine seaplane bases in fourteen different countries around the world as part of the Airport Development Plan (ADP). This wasn't a bad deal as Pan Am was granted exclusive use of these airports straight after the war and for long periods thereafter. Once again showing how Trippe and his Airline could get their own way by influencing politics.

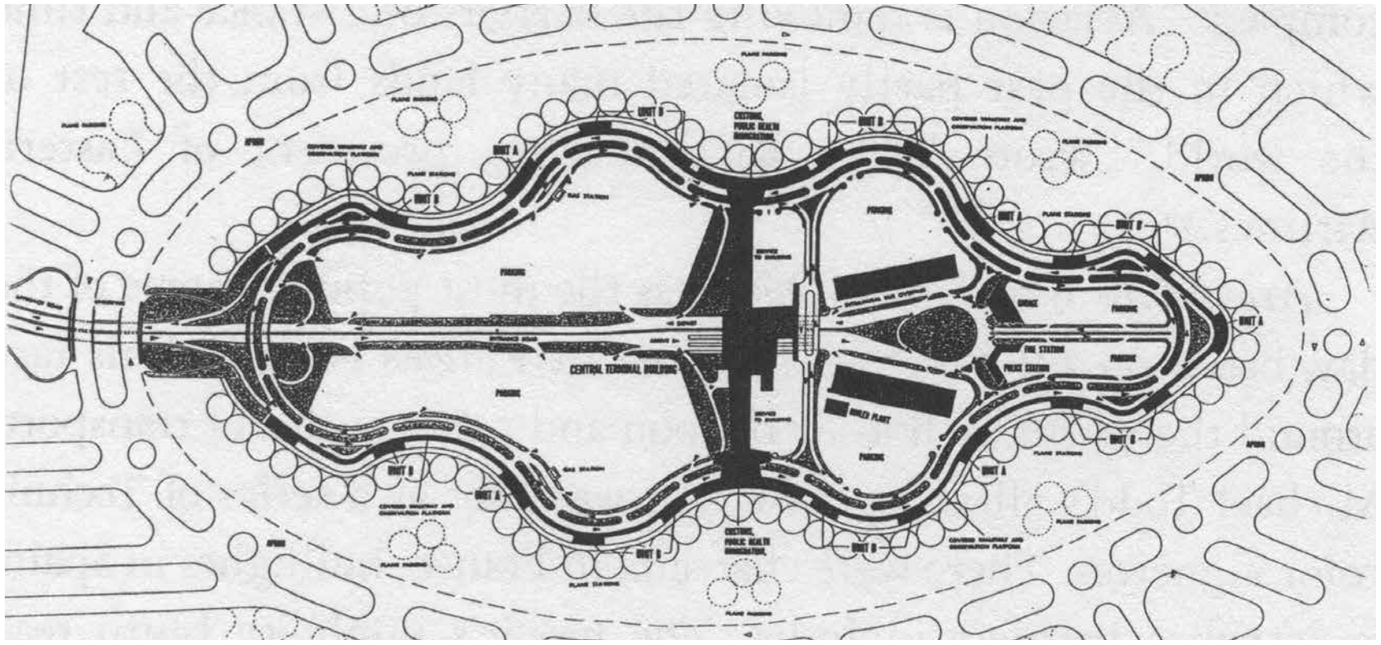
The war itself progressed technology massively. It is said that war is the mother of invention and this war definitely progressed the field of aviation by leaps and bounds. New faster and stronger aircraft were by-products of the fighters and bombers developed during the war. Those planes that were used in the war were (such as the B-29 Superfortress converted to the B-377 Stratocruiser) then also converted for civilian purposes after the war. Radar's introduction helped to increase safety and efficiency in the skies and in terms of architecture the major development was the use of concrete.

The introduction of concrete as an airport building material after the war was logical. It was a cheap material, was easy and fast to work with, was extremely strong and durable, and many forms could be designed with it. During the war one of the pioneers of concrete construction was an Italian called Pier Luigi Nervi. His concrete hangars during the war and buildings after the war were to be some of the most interesting and ground-breaking uses of concrete in history straight after the Pantheon in Rome.

Once the restrictions on air travel were lifted, after VJ Day on the 2nd of September 1945, commercial air travel was poised to explode. In 1945 over 6.7 million passengers travelled with American airlines and in the following nearly doubled to 12.5 million passengers. Airlines responded with cheaper tickets, bigger airplanes and clever marketing gimmicks enticing people to fly with their airlines to the far-flung nations that had previously been torn apart by war. The emergence of package holidays and the cheaper "coach" or economy fares were allowing every level of society to travel by air. The era of mass transit had begun and by 1955 more Americans were flying than travelling by railroad. By 1956 there were 40 million passengers travelling with American airlines.

As passenger numbers were exploding and airlines expanding the airports were standing still. Not much had changed in regards to airport design since before the war and with the explosion in passenger numbers, due to bigger aircraft and cheaper fares, the airports were no longer able to cope. Many runways were too short, landing systems were obsolete and baggage handling was archaic (usually all baggage was thrown on a heap). Because of these shortcomings airplanes were often found in holding patterns around the airport and added hours to some journeys. There are even accounts of planes running out of fuel and having to be diverted. All this caused the public opinion towards airports to drop and many publications started the golden-era of airport bashing. Terminals were described as slums and were criticised for the way they handled passengers in all aspects of their journey. Planes also always seemed to be crashing just short of runways into residential areas and killing not only the passengers but also people on the ground. The consensus was that new airports were needed away from urban centres.

In 1954 the turning point had come. After a day known as "Black Wednesday" where more than forty-five thousand passengers were delayed across America due to fog in the New York area, a safety commission led by James Doolittle concluded that building next to airports posed no great risk and that the risk must be tolerated as a part of modern urban life. The commission did however persuade the President (Truman) to enforce no-build zones half a mile from the end of runways so that construction of houses could no longer be undertaken in the approach zones to airports. The president also increased funding for safety measures including: airport safety, pilot examinations, air traffic control improvements and navigational aids for aircraft. There was also a $1.25 billion investment for new and existing airfields from the Civil Aviation Authority (CAA) which improved many run-down sites. Not one fatality in connection with commercial air-travel was recorded in 1954.



▲ *Fig.15. Master plan for Idlewild Airport, Wallace Harrison*
◀ *Fig.16. Greater Pittsburgh Airport Terminal, 1952*

Airports were requiring more and more space. The old ideas that airports could be close to the centre of cities were no longer feasible. The new trend was to move new airport sites away from city centres and move them into unpopulated areas and then connect them to the urban centres via new infrastructure. After the war and as passenger numbers were exploding the notion of new airports outside of city centres was being considered. One of the first new sites was to be the location of the O'Hare International Airport in Chicago. The new site would 15 miles north-west of the city centre and be connected via new highways and a subway line. Another example would be the site of the new airport for New York upon the old Idlewild golf course near Jamaica Bay. The new airport, to be called Idlewild Airport, would be designed by Delano and Aldrich in a classical design wanting to evoke the ancient past. The idea was quickly shelved as it wasn't seen as a forward thinking approach. Another architect called Wallace Harrison took over and proposed a truly modern design for the airport. It was an oddly baroque shaped master plan where a two-mile long peripheral terminal building would be connected by a highway and had space for eighty-six boarding positions. Custom designed buses would move along their own road to all the boarding positions and is perhaps the first early reference to the modern day people mover now seen in all of today's modern airports. However, as was often the case, this proposal was also too forward thinking and as a result was also shelved. Once again another architect, called Thomas Sullivan, took over and proposed a modified version of Harrison's design and the resulting master plan is the one we see today at JFK International airport.

As empires around the world were crumbling, America was forging their own empire, through air-travel across the globe. As more and more Americans were using the airports as "gateways to the wide world", American was expanding its influence everywhere. Every overseas airport became an outpost for American foreign policy. By 1947 retail was accounting for a third of airport revenue and hotels, shops and restaurants were all common-place amongst airport scenery. Gone were the days of exclusive bars and high-class restaurants. American culture and the influx of the "normal man" would bring fast-food restaurants which everybody could afford. Hotels were also becoming part of the airport landscapes. In 1946, Juan Trippe established the Intercontinental Hotel Corporation which he established at airports where Pan Am flew to. This allowed him to offer some of the very first package holidays and made flying even more affordable for everyone. By this time around 538,000 Americans had been abroad. By 1950 it would be over a million. In 1954 the very first airport hotel was opened at Los Angeles International Airport by the Hyatt Hotel Chain. Soon every airport would have at least one hotel.

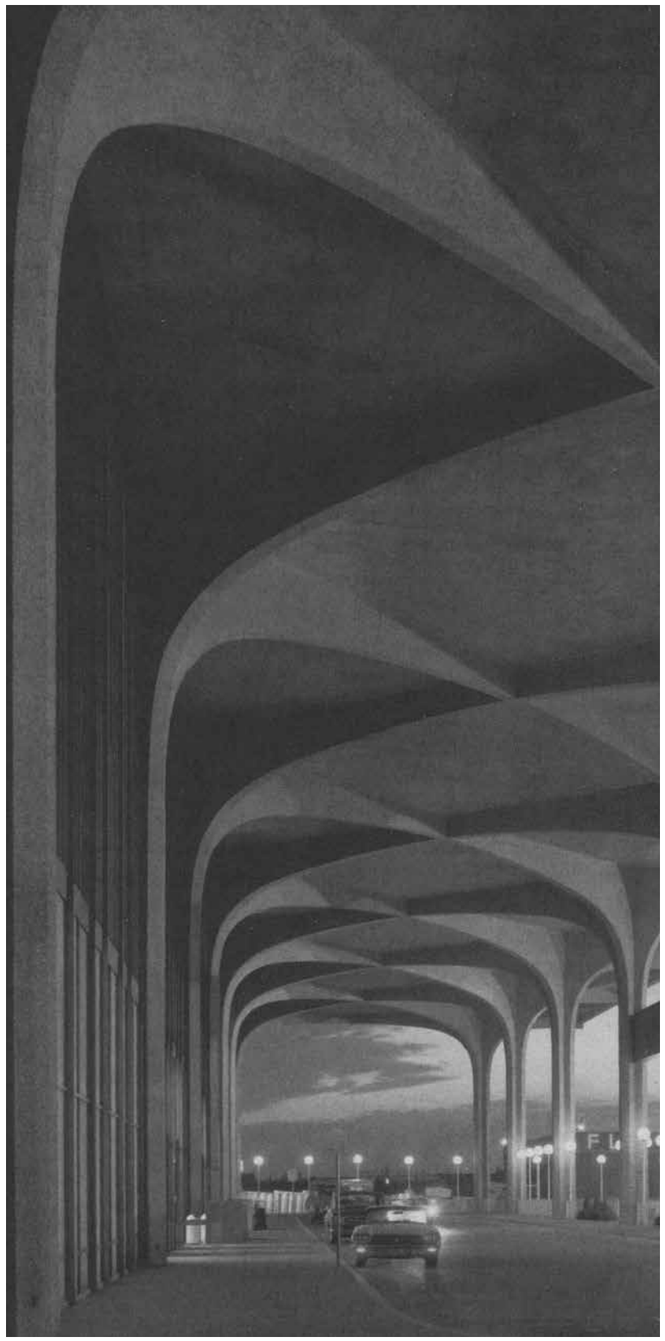
In Europe however, airports were in dire positions because of the war. Many gleaming pre-war terminals had been destroyed and as a result commercial air-travel in Europe suffered heavily. Europe was lagging behind and the busiest airport was Heathrow in the west of London. In 1946 it became new paved runways but the first permanent terminal building wouldn't be built till 1955. As a result of strict rationing and economic austerity tents and make-shift buildings were used as the main structures at many airports across Europe. The first new terminal building in Europe was built at Kloten Airport in Zürich in 1953 by Alfred and Heinrich. It boasted lounges with showers, playrooms for children and good restaurants for waiting passengers and was seen more as a deluxe hotel than an airport.

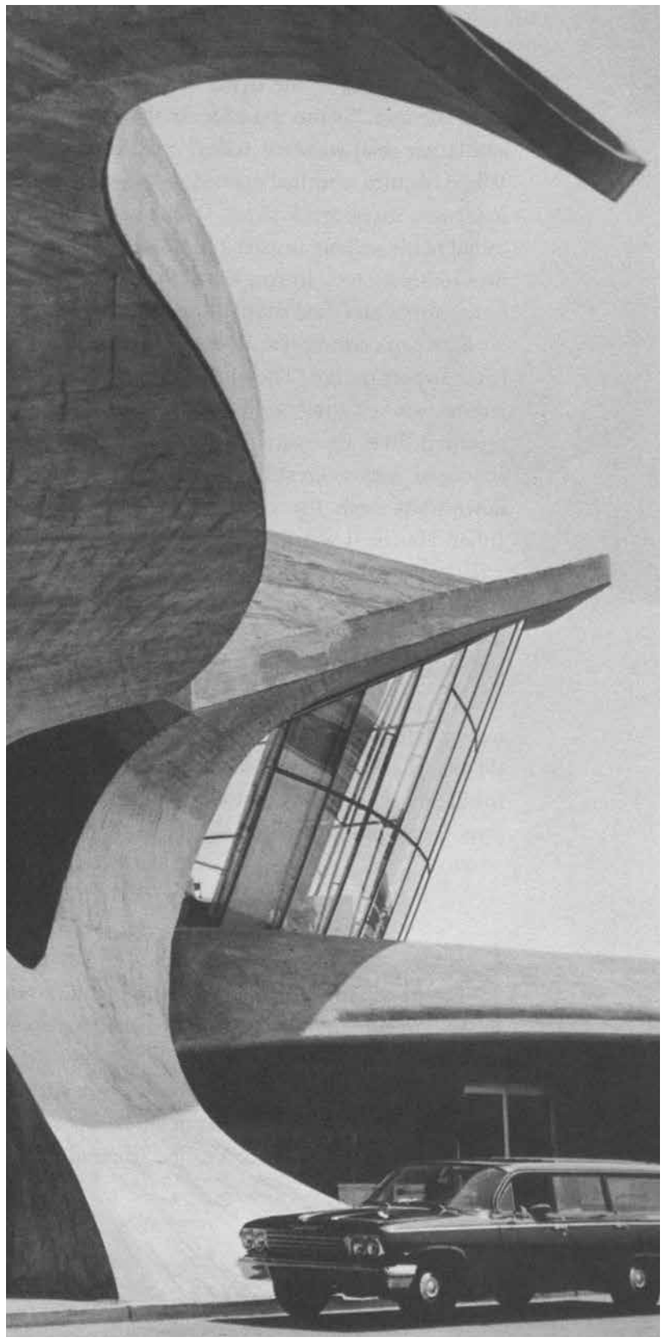
By 1956 the introduction of the Douglas DC-7C allowed airlines to fly non-stop across the Atlantic. This, in one fell swoop, made hundreds if not thousands of small airports used as stops along long routes redundant. As the smaller airports were no longer being used, the larger "hubs" were gaining evermore passengers and importance. As the airports were becoming larger they started "sacrificing character for largeness". Airports were still using classical monumental styles as the airport architecture of choice but as airports grew the classical style could no longer be scaled correctly. A few airports did however challenge the normal conventions such as the new "battleship terminal" designed by Joseph Hoover in Pittsburgh or Friendship Airport in Baltimore. Behind the facades the airports were growing in every direction to service the larger aircraft that were being developed. Soon piers or fingers were becoming longer than the actual terminals themselves and the airport could no longer be seen as a singular entity. Heino, the chief architect at United Airlines said the "airport should be treated as a functional machine, not a civic monument".

At this time many considered that allowing architects to design airports was the wrong decision and perhaps allowing engineers, with a more pragmatic approach, to plan airports would be a better idea. Soon engineers would be devising formulas and devising new ways to get people quickly from their cars to the planes. The Holy Grail for airport planners therefore was how to move large numbers of people between terminal and plane and get the plane back in the air as quickly as possible. A reaction to this was the concept of the "Unit Terminal". The unit terminal at the time was a structure of necessity and housed many of the same functions as the next unit. It was a scheme used to process many passengers very quickly to maximise profits by turning around aircraft at high rates. As these new units were being devised new technologies such as air bridges were being implemented to save even more time. Their introduction would mean that no passenger ever had to be outside whilst travelling from terminal to terminal. One of the best examples of this new type of efficient architecture was a new boarding pier at Gatwick airport built by Yorke, Rosenberg and Mardall architects in 1957. It was a slender steel and glass pier, around 300m long, that "possessed a functional purity" and a quality which the architecture critic Kidder-Smith called "Airport-ness". He wrote: "One is architecturally, indeed physically, projected onto the field and made part of its excitement, for no solid wall ever rises between the passenger and his aerial transportation". The

> *"One is architecturally, indeed physically, projected onto the field and made part of its excitement, for no solid wall ever rises between the passenger and his aerial transportation."*
>
> *G.E. Kidder-Smith*

◄ *Fig.17. St. Louis Airport, Minoru Yamasaki, 1956*
► *Fig.18. TWA Terminal, Erro Saarinen, 1963*





"[What is wanted] is a building that starts your flight with your first glimpse of it and increases your anticipation after you arrive. The spirit of flight, inside and out, and nothing less will do."

TWA's president, Ralph Damon.

quote rings back to Le Corbusier's concept of the "Naked-airport" but fundamentally it changed the perception of airports in general and would shape airport architecture in the future. Airports, as of that moment, "owed nothing to the past". They would embark upon their own new style of "airportness".

Jet-age: 1957-1970

The advent of the Jet-era was ushered in towards the end of the 1950's with the British De Havilland Comet and Americas Boeing 707. Two airplanes that redefined commercial air travel. Both aircraft were able to cross the Atlantic non-stop and in record times. The Comet won the accolades as the first commercial jet-aircraft to cross the Atlantic non-stop but there were major caveats in its design. The main problem was the amount of passengers it could carry; the comet could carry a maximum of around eighty passengers whilst the 707 could carry nearly two-hundred. Along with that the Comet had a number of fatal crashes attributed to the design of its windows. The Comet had therefore won the short-term success but it was to be the 707's long-term success that made it into a money spinner for many airlines.

If the Jet age did anything for air travel then it was the way it made people disregard how fantastic flight actually was. The days where people were able to look out of the window and obtain awareness for the landscape and architecture of the places they flew over were gone and everything in a jet basically looked the same. But with the advent of the Jet-age, airplanes were all about speed and for passenger's time was the only thing important to them. People were getting bored of flying and airlines responded by giving them in-flight entertainment. Movies were shown, music was played and bars were offered on-board to allow people to mingle as they would anywhere else.

The terminals of the day were however becoming ever more important. The focus was being taken away from the aircraft and being put on the terminals as the places where people were starting and ending their journeys. The journey between the terminals was essentially becoming a nuisance. The terminals being built during the 1960's wanted to evoke the spirit of flight and adhere to their own new type of "naked" architecture. Adjectives used to describe the type of architecture were word such as: "winglike", "birdlike", "soaring" and "swooping". What was wanted "is a building that starts your flight with your first glimpse of it and increases your anticipation after you arrive. The spirit of flight, inside and out, and nothing less will do", said TWA's president, Ralph Damon.

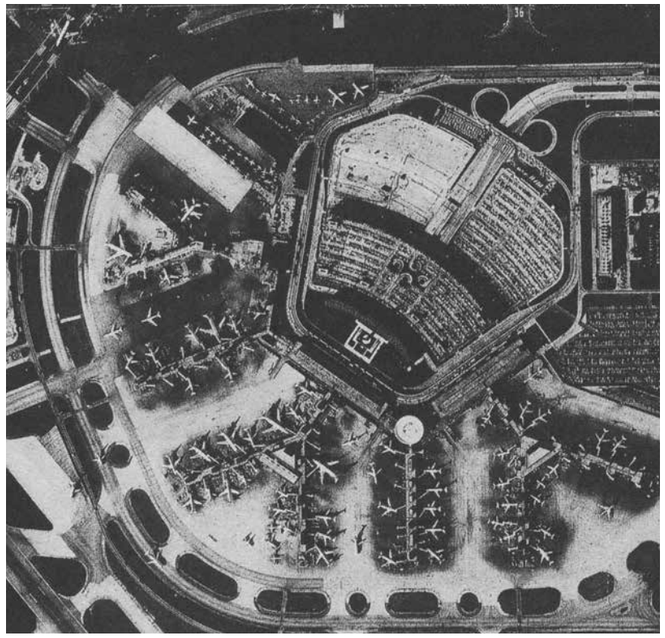
One of the first examples of this new type of architecture was the new terminal at Lambert Field, St. Louis. Designed by Minoru Yamasaki "wanted the roofs of his terminal to soar rather than anchor themselves to the earth". The main design features were three cross-vaulted spaces connected to form a type of concourse. It prompted a "feeling of being suspended" as one critic wrote.

Airports as a whole were becoming self-contained urban-nodes where everything a person would require would and could be found inside. Airports were also becoming gateways for foreign travellers. As Ellis Island, New York had been before the era of affordable air-travel, the airport was becoming the immigration gateway of a nation. What airports now required were their own versions of the Statue of Liberty. An iconic gesture to give immigrants hope and visitors who came through the airport a sense of what that nation was actually all about.

The airport was now evolving into a huge beast and passenger numbers were still increasing. The Idlewild Airport in New York, now known as JFK International, was one of the first airports to decentralise its Terminals. The idea behind this was to allow the airlines to control their own terminals and thereby stimulate competition amongst architects to produce the finest terminals in the world. At JFK the idea was to have an area in the centre of the airport, not for cars, but for pedestrians. The area would be come to be known as Liberty Plaza. Designed on ideas of the gardens of Versailles, the antithesis of democracy, it wanted to represent American democracy and the values of capitalism which were trying to be spread around the world. The Plaza however, would soon fall prey to the rise of the automobile and would become centralised parking for all the terminals. The terminals would be come to be known as the "seven wonders". Designs for Pan Am by Walter Prokosch and the National Airline Sundrome by Pei were all beautiful examples which promoted the new and dynamic architecture of the age and also adhered to the "naked" style of airportness.

There was however one terminal which, to this day, still shows and exemplifies the dynamism of the Jet-age. Eero Saarinen's TWA Terminal at Idlewild in 1962 would be the pinnacle of Terminal design in the Jet-age. It was exactly the type of terminal which mirrored the fantastic feeling of flight in its design. Its beautiful use of concrete to create acrobatic and free flowing forms is perhaps still to this day an un-matched feat in terminal design. Many purists in airport design were offended by the flamboyance and impracticality of such excess. But the architecture speaks for itself and although passenger numbers have outgrown the terminal in its first state, people are still drawn to it as it simply mirrors the spectacle of flight in building form. Saarinen would go onto design another terminal at Washington-Dulles airport which also become a classic in itself.

One thing that came out of the Jet-age was the airports allegiance to the automobile. In America and Europe airports were being designed with the car as the first priority. Many airports in the US were expected to follow the "architectural zoo" of Idlewild where the car was the most important thing to the airport and that people could drive from their homes directly to the terminal and hop on their flight and vice versa. O'Hare, was connected to Interstate 90 in 1963 to



◀ *Fig.19. Chicago O'Hare, Stanislav Gladych, 1963*
▼ *Fig.20. Introduction of Boeing's 747 in 1970*

allow a direct and fast connection from the city. LAX also developed into the “Unit Terminal” design where cars were the highest priority at the airport. In Europe, the Leonardo da Vinci airport, built in 1960 in Rome, was connected to a high-speed highway. At London’s Heathrow Airports, its early design constraint of building in the centre of the airfield meant the road connection had to be through a tunnel underneath the runways. For the second busiest airport in the world a lot of terrible planning had occurred and the idea there of the “Unit Terminal” concept led it to become “a hopeless Jungle”. But putting the automobile at the forefront of their expansion philosophies many of these airports have become terrible messes. The ideas of in airport design of concentration, consolidation and connection were thrown out of the window. The priority was getting people to the airports in the cars en masse and what happened with those people at the airports was of secondary importance.

What defined the Jet-age was of course the introduction of the Jets but perhaps more important was the explosion in mass-market travel where over four million Americans had already been abroad. By this time air travel was considered the normal way to travel across the globe and travellers had become the “new race of nomads”. Airports though were once again not able to cope with the continuing growth in the airline industry. Even though the Jet-age gave us the “Seven Wonders” and a new beautiful type of architecture, the terminals of the time could, by 1970, once again no longer cope with the appetite for commercial air-travel and the introduction of even bigger and faster aircraft.

Modern times: 1970-2015

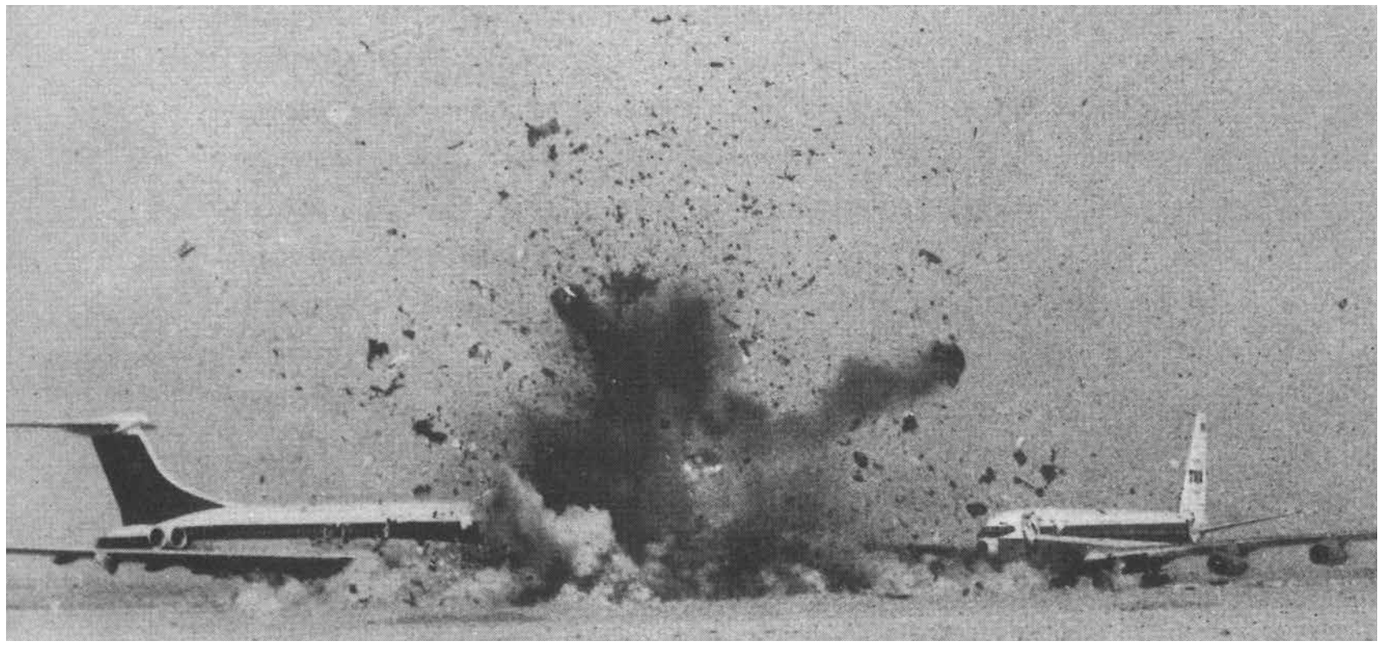
Once again a new era in airport and aviation history begins with the introduction of ground-breaking aircraft. The era to be known as the “Jumbo-era” was ushered in with the introduction in 1970 of Boeing’s 747. It was a huge step-up in passenger capacity and rendered all other aircraft useless in terms of size and range. During the Jet-age (pre-1970) passenger traffic rose dramatically due to the leap forward in aircraft design and the affordability of air-travel. In the US passenger traffic rose from seven to thirty-two million from 1955 to 1972. Airports being built at the time were then already out-of-date by the time they opened and as soon as the 747 arrived hardly any airports were designed to handle it. Due to the problems caused by the 747 such as an increase in passengers, more baggage, more catering and higher loads on runways, many airports were forced to upgrade and adapt to the new aircraft. The issue in 1970 though, was that many experts didn’t really believe in what the 747 brought to the table. They saw a bigger future for supersonic air-travel rather than the slow mass-travel. In 1969 Concorde flew its first flight and was brought into service in 1976. Concorde was seen as the future and the 747 was simply a passing fad. During this time many different Supersonic planes were being proposed. Even Boeing, creators of the 747, was actually betting most of their money on their supersonic plane but that would never see actual service. In fact, the 747 was such a runaway success that variants are still being produced to this day along with its new competitor from Airbus, the A380. As many airports were caught off-guard by these aircraft the situation at airports started to enter the “dark-ages”. Atlanta’s new jet port was already out-of-date even before it opened, Chicago’s O’Hare became the busiest airport in the world and, somehow, passenger numbers actually decreased at New York airports because people wanted to avoid them.
In terms of airport typologies the “finger” perhaps became the most used during the Jumbo-era. Terminals wanted to shelter their passengers from the outside world, perhaps even restrict them. Glazing reduced the noise from jet-engines and the view on to the airfield was also reduced in order to force people to orient themselves to the insides of the terminals where retail would be the main focus of their attention. The “finger” typology would allow all or many aircraft to seamlessly connect to the terminal via Jet bridges, thereby allowing passengers to never walk upon the tarmac as had been the norm during the Jet-age. However, the biggest draw-back of the “fingers” was the distances passengers had to cover in order to get to their planes. O’Hare became known as “cardiac alley” due to the humongous distances which passengers had to cover. In some ways this typology was mirroring the aircrafts themselves with their long thin aisles where there was one entry point which also doubled as the exit point. The “fingers” led to the development of moving walkways and other aids such as visual information systems to reduce the strain on passengers.

“In the end nothing is ever going to be totally secure, and in that sense you could say that is the eventual, absolute capitulation if the airport becomes the windowless, underground atomic bunker.”

Lord Norman Foster

Many airports responded to the new aircraft, not by building new airports, but by expanding and adding to existing facilities. Airports were like “demented amoeba” growing recklessly out of control. Airports such as Heathrow were simply adding to facilities which led to a chaotic assembly of terminals and caused passengers to fear and regret having been to such an airport. Because of this general situation at airports, during the 1970’s the first signs of anti-airport sentiment were starting to emerge. No longer was air-travel a luxury or even fun. It became a chore and most people simply looked forward to getting to their destination.

However, what would really shape the airports of the jumbo-era and even airports of today would be the advent of global terrorism. During the 1970’s there was to be an escalation in International Terrorism whereas before terrorism had largely limited itself to ethnic nationalism. During the 1970’s The Popular Front for the Liberation of Palestine and other Palestinian groups fighting for independence emerged as a serious terrorist threat and perpetrated many hijackings and committed their greatest act of terrorism at the 1972 Munich Olympic games where the group “Black September” murdered eleven Israelis and a German police officer. From that moment on International Terrorism was a problem which all governments had to deal with and of course one of the first reactions was to change the way airports were being designed and used. The many hijackings and events such as “Revolution Airport”, Munich and the Lockerbie



▲ *Fig.21. First security measures at airports, 1973*
◀ *Fig.22. Destruction of four airliners in Jordan, 1970*

bombings would cause many if not all passengers in the future to be anxious about flying. What is interesting to note is that in 1970 there was no such thing as airport security. Passengers simply moved freely from outside the airport to the aircraft, but it was never considered that aircraft would or could be used as targets for terrorism.

But the stark reality is that the aircraft and the airport have become symbols of modernity and a modern lifestyle, something which many terrorist groups have resented cultures in the west for and therefore, for terrorist groups, the fastest way to garner international attention was to commit airline terror.

After the events from 1968 to 1972, security at airports entered a new era. From this moment on, all airports were to screen passengers before they boarded the planes. American airports were the front runners introducing metal detectors and x-ray machines to screen people and check baggage. All other airports followed suit and in essence the passengers were guilty until proven otherwise. By adopting this methodology the number of aircraft hijackings (successful and failed attempts) fell abruptly. However, the terrorist then turned to new ways to commit their atrocities and soon bombs were being used (Lockerbie) and even the aircraft themselves (September 11th).

In terms of architecture airports had to change dramatically. The airports that pre-dated this era (essentially all of them) all had to adopt these new security measures. The over-stretched and congested airports now obtained large choke points where passengers were being pressed through like cattle. Airports were losing their fluidity and internal zones began to emerge. The sterile and non-sterile zones were before and after security and signalled the change in a passenger's status as being "suspicious" or not. The buildings themselves started to obtain a defensive new style. Concrete was used to create bunker like forms. Unlike the sleek concrete structures of Saarinen, these new buildings were large, bulky and defensive looking buildings. The use of glass was discouraged as glass equalled transparency and for security purposes transparency tends to be a liability. In a way airport architecture followed the style of brutalism with Le Corbusiers La Tourette being a good example of how airports were starting to look. The cold, cheap concrete structures, that were staples of brutalist architecture, would become the norm for nearly two decades in airport design and construction. As time went by and anti-terrorist measures were becoming ever more complex, the digital revolution became firmly embedded in airport design. The airport became an electronically controlled environment where everyone and everything was electronically screened and controlled. The comparisons to a maximum security prison could be made and perhaps the only difference was the time of the stay / incarceration.

In the aftermath of airline deregulation in 1978 there was an explosion in passenger numbers and the number of new airlines that emerged and went bankrupt (including stalwarts such as Pan Am and TWA). Deregulation brought cheaper fares and many new budget airlines. Aviation was no longer about fancy high class flights but more about getting the cheapest economy fare to as many destinations as possible. The increase in passengers and the high-flow of new aircraft that would be taking those passengers to their destinations would mean new airports would be needed and the ones constructed to date would no longer be suitable. The first offspring of deregulation were airports in Dallas and Atlanta. Decentralisation was a key design goal for Dallas whereas in Atlanta the idea was to shift as many people as possible in cheap, no-frills terminals. What was clear was that the airport experience had to be better than before and that the airports had to return to the excitement and freedom of the past. Airports had to adapt. The brutalist structures were no longer viable and would no longer be accepted by paying customers. If airports, no being run to be profitable, wanted to make money they would have to give passengers the best service possible.

In the mid 1980's the opportunity arose to change airports and their designs for the next decades. In the wake of the explosion in budget airlines, the decision was taken to expand an airport on the outskirts of London; Stansted. Norman Foster, the architect, wanted to bring the joy back to flying. The ideas of Le Corbusier's "naked airport" should also make a comeback and airfield operations and aircraft should be seen and not be kept out of sight. The light airy roof and the elimination of unsightly utilities allowed Foster to create a terminal which was flooded with light and easy for the passengers to navigate. It would provide the blueprint for all future airports. However, Stansted was an exception in the western world. Airports only expanded and no new ones have been built or are being planned. In the UK the only major expansion was at Heathrow with its Terminal 5 in 2008 and in the US no new airport has been built since Denver's in 1995. There have been many discussions where expansions or new airports could happen (Thames estuary / Boris Island) but governments tend to be extremely hesitant on the matter. In contrast to the Gulf States and emerging economies such as China, Brazil and India - new airports have been sprouting up everywhere. The airports being built in these places have easily overtaken those in Europe and the US. Along with the airlines with the highest customer satisfaction, international passenger numbers at airports such as Heathrow have been losing passengers to new hubs such as Dubai at an extremely high rate. If western airports want to keep-up they need to rapidly change their strategies in terms of expansion / new builds.

As architecture was returning to airport design in the 1990's with designs from Foster, Jahn and other architects it was clear that the priority for airports was shifting. Airports, now being mostly privately owned and profit driven, no longer wanted to shift passengers quickly like the airlines. Airports now wanted to keep passenger in their terminals for as long

"The finger, or variations thereof, became the panacea for all forms of airport chaos."

Alastair Gordon

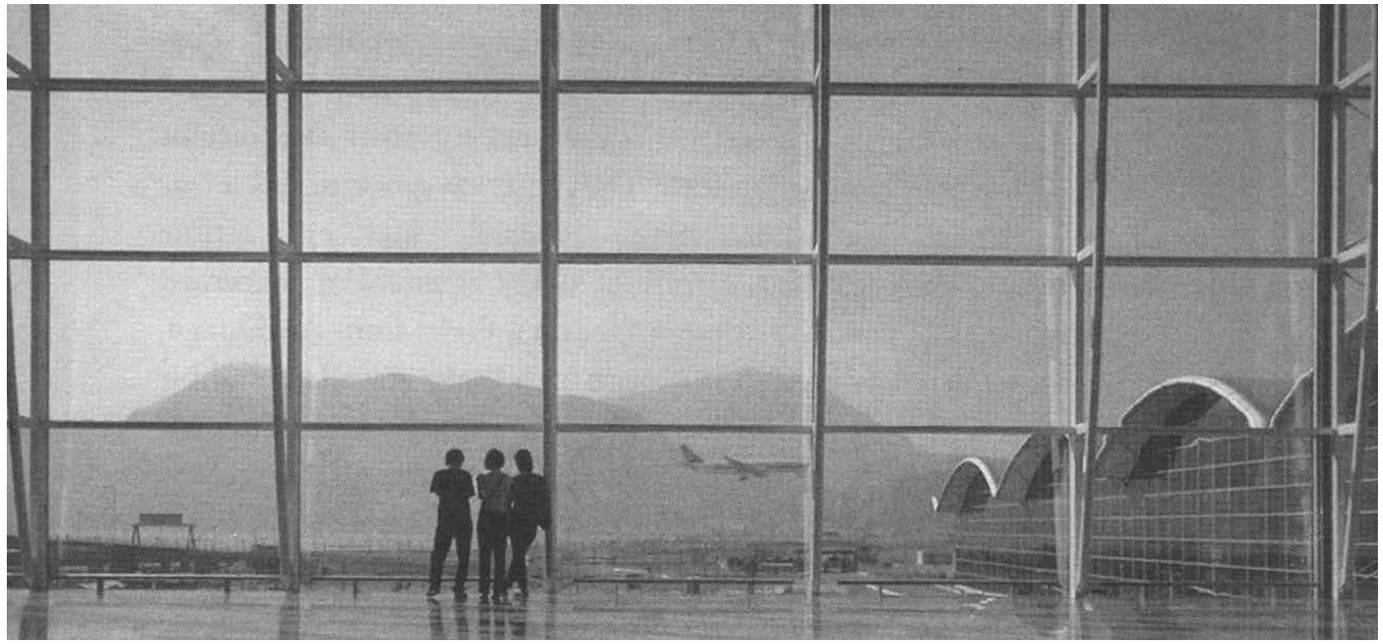


Fig.23. Foster's Chek Lap Kok AIrport, Hong Kong, 1998

as possible. The main reason for this was that airports were turning into shopping malls accounting for nearly two-thirds of airport revenues with airplanes leaving from it. Along with new shopping possibilities airports are attracting more business minded customers with conference centres and hotels allowing business to be conducted at all times and without the need to leave the airport. Newer airports have even started to introduce “green” aspects such as health spas and massage parlours in order to offer passengers an even deeper experience at airports. What is clear though is that the thing people most hate about airports, perhaps even fear, is the boredom and waiting around for a connecting flight. Activities to relieve stress and anxiety due to layovers, delays and even the fear of flying are all surely welcome as airports are trying to lure more and more passengers to their airports in a world where air travel is poised to explode once again. Retail cannot be expected to completely fill this void in future airports (there is a limit to how much people can buy) so therefore new ideas and revenue streams need to be discovered and implemented.

In terms of materials being used in this new age of airports, steel and glass were to be the materials of choice. Starting with Jahn’s terminal at O’Hare in 1987 ranging to Fosters Beijing design in 2008, steel and glass have allowed airports to be transparent and unified in their appearance opposed to the disjointed and blocky terminals of the past. Fosters Stansted and Chek Lap Kok airports have really led the way in creating terminals “all under one roof” where all the functions are all encapsulated in a singular design.

Conclusion

In terms of airport design, airports have never really been able to keep up with the technological advancements in aviation. With every new era a new type of aircraft has emerged which has stretched airport infrastructure to its limit. Along with explosions in passenger numbers the response from airports has always been too late and in most cases wrong. There has been no future proof airport to this date. In most cases by the time an airport has been built it is already too small. The greatest problem is with trying to predict the future. What we know is that passenger numbers are on the rise and with the emergence of “Super Jumbos” the amount of passenger being able to travel at any one time has increased hugely. At this moment in time the aviation industry is leaning towards efficiency. What this means is that supersonic travel is not on the horizon and isn’t even really being contemplated. Also with the recent introduction of the A380 and its predicted lifespan (747 since 1970), if compared to the 747, of over forty years is anything to go by an introduction of an even larger plane is highly unlikely. Therefore we can, with this information, roughly estimate what an airport needs to be able to handle, capacity wise, at any future date. This of course means that an infinite timeframe could be estimated with an infinite amount of passenger but this isn’t realistic. At some point the airport, with a continuing rise in passenger numbers will always be too small. The trick is predicting this at a point in the future where the airport is past its useful life and the changes in aviation technology force the airport to build new or adapt.

“[The airport] sums up the promises of the age of modernity”

Alain de Bottom

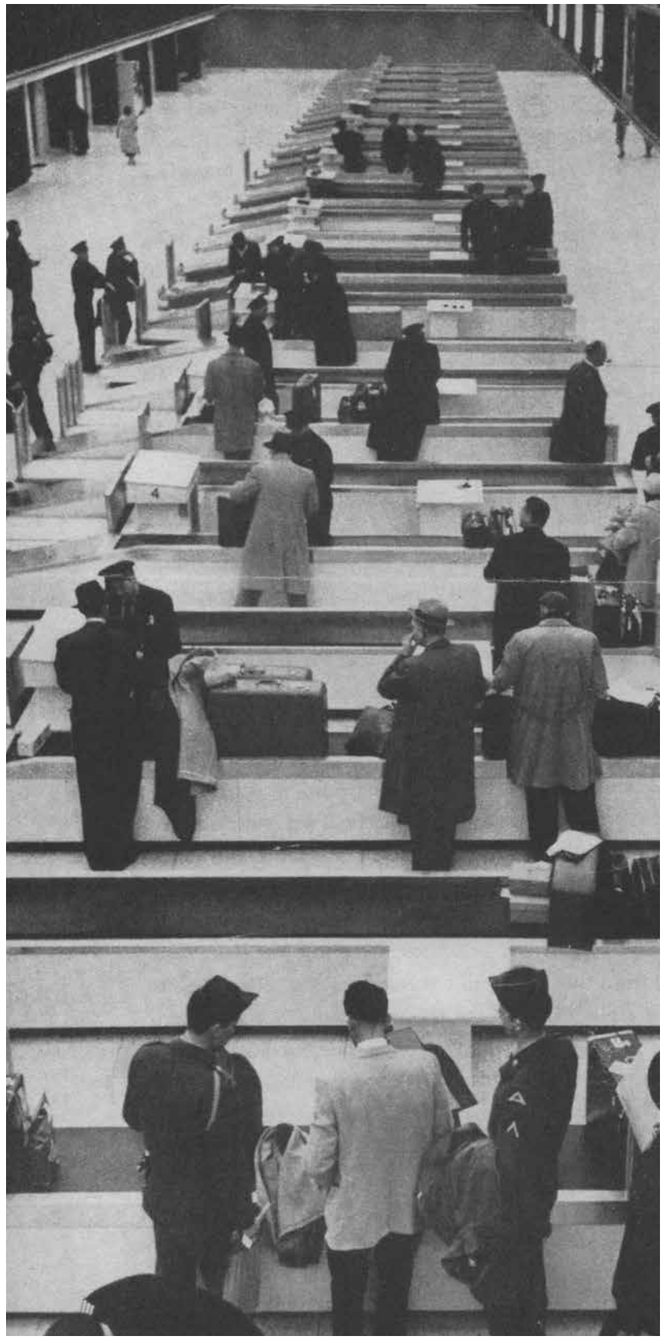
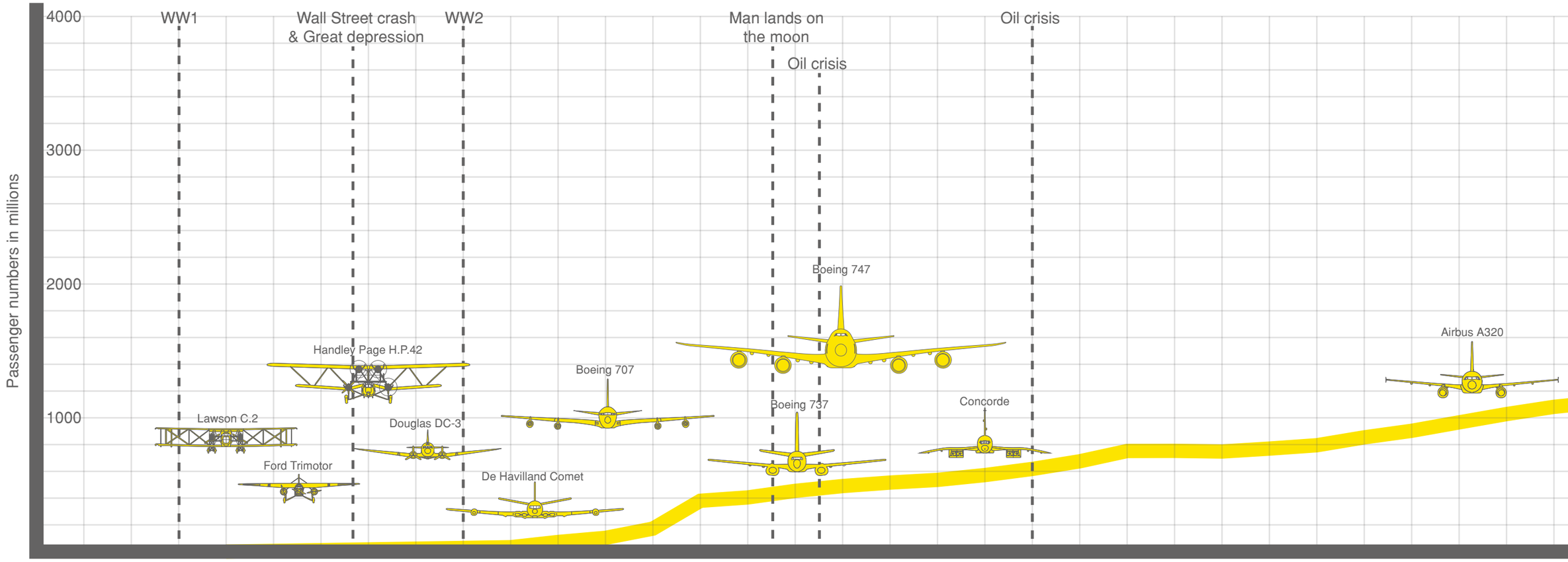


Fig.24. Customs at Idlewild Airport, 1960



1903 1920 1930 1950 1966 1974 1978 1982 1986

1903
Orville and Wilbur Wright of the United States made the first engine-powered, heavier-than-air flights, near Kitty Hawk, N.C. Their first flight went 120 feet (37 meters) and lasted only about 12 seconds.

1936
Pan American World Airways inaugurated the first transpacific passenger service.

1952
De Havillands Comet, the world's first large commercial jetliners, begins service.

1962
The TWA Terminal at New York's JFK International Airport, designed by Eero Saarinen, is opened. Embodied the glamour of flying in architecture.

1970
The first giant Boeing 747 went into operation for Pan American World Airways. It carried 362 passengers.

1976
Air France and British Airways put the first supersonic airliners into passenger service.

1978
The U.S. Congress passed the Airline Deregulation Act.

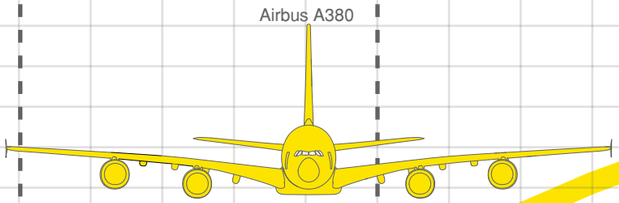
First Gulf war

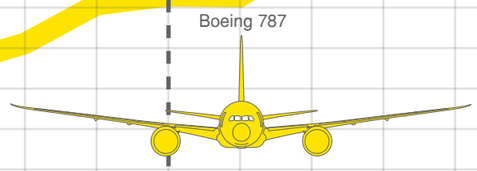
Asian crisis

9/11

Second Gulf war

Financial crisis





1990 1994 1998 2002 2006 2010 2014 2018 2020

1991
Stansted Airport, designed by Norman Foster opens. Perhaps the most important evolution in airport design in the 20th centrury.

1995
Introduction of the B777, the largest twin-engined commerical jet-liner, on a route from London to Washington D.C.

1998
Hong Kong International Airport opens and becomes the largest passenger terminal building in the world. Designed by Norman Foster it was the natural evolution of Stansted Airport.

2007
First commercial flight of the A380 from Singaporte to Sydney.

2008
Norman Fosters Beijing Capital International Airport opens in time for the Olympics. Fastly becoming the largest terminal/airport in the world.

2011
First commercial flight of the B787 from Tokyo to Hong Kong.

2018-2020
Widly expected that A380 will be able to fly non-stop from Europe to Australia

British Airways B747-400 at London Heathrow

AIRPORTS TODAY

Fig.25. Control tower at Suvarnabhumi Airport, Bangkok, Jahn

The airport today

The airport has an extremely easy functional description. It is place where aircraft land and take-off and passengers embark and disembark those aircraft. They can be tiny where only a handful of passengers come and go or they can be places where hundreds of millions go through each year. They all have similar facilities such as terminals but also functional requirements such as runways, servicing areas, air-traffic control and depending on the environment de-icing areas.

In the most important part of the airport; the terminal, there are many functions which are required for the airport to work correctly. There are always facilities like check-in (manual or automated), baggage systems to move baggage to and from the aircraft, security, passport control, customs and commercial facilities for passengers to consume. Past the security point begins the “sterile” area of the airport where all the passengers and employees have been screened. Past this point passengers are in the departure areas waiting for their flights. Here different facilities such as restaurants and public conveniences can be found to serve the waiting passengers. In this area there is also the potential for completely new and ground-breaking services which increase the appeal for waiting passengers who spend large amount of time waiting for flights. Another security concern are connecting passengers. These are passengers who are simply using the airport as a connection toward their final destination. The airport has a choice to screen them again or rely on the previous airport having done a reliable job. In most cases today however, the passengers are screened again.

Outside of the terminal most of the facilities revolve around the servicing and maintenance of the aircraft and the handling of baggage. There are facilities such as hangars where aircraft can be serviced. These are usually used by the airlines based at that particular airport but in some cases where unscheduled maintenance needs to be done other airlines can use them as well. When the aircraft are at the gates the turnaround time has to be kept to a minimum. Aircraft need to be refuelled, restocked and cleaned for the new batch of passengers about to board the aircraft. Fuel storage facilities are now found at every airport, and due to underground pipelines, every aircraft has access to fuel without the need for a fuel truck.

Whilst aircraft are being serviced the movement of baggage in an airport has become an extremely complicated automated system. The passenger only ever sees the beginning and end of a piece of luggage’s journey. After either checking the baggage in at a check-in desk or at a self-service desk, the baggage is then moved into a very complex baggage handling system. The baggage is either, depending on time to the flight moved into different “loops” in the handling system. If the flight is soon there is usually an express loop where the baggage is screened and taken via baggage system directly to the gate where it is then placed manually onboard the plane. The normal way baggage is transported is via the normal loop where it goes through numerous screening procedures and then is pooled with other baggage for that aircraft and loaded onto containers in a central location. From there it is taken via baggage carts to the plane. The last method is the type of baggage which stays in the system for an extended period of time. Here the baggage is screened normally but is then moved to a specialised holding space where the baggage is stored until the baggage can be pooled with the other baggage via the normal loop.

Another important aspect of larger airports is the facilities to handle large amount of cargo. These are facilities that passengers do not use and are only used for cargo handling. These cargo terminals process the cargo in the same way baggage is processed. In other words all cargo is screened for security threats and is then loaded onto aircraft.
The final thing which all airports have in common is their control towers. These towers are always clearly noticeable at airports because of their height. They are high for one simple reason: to allow the air-traffic controllers to view the entire airport and airfield in order to manoeuvre aircraft to and from their gates after landing and before takeoff. These are known as ground controllers whereas the air traffic controllers take control of the coordination before and after takeoff and landing. If the tower is not able to see all aspects of the airports operations ramp towers are used to split-up the ground controllers into more manageable areas.

Design Elements

The basic elements of airport design depend on a few key things which are common to all airports across the globe. For a city the choice where to situate an airport is a key decision not only for the present but also for the future of a city and its surrounding areas.

When choosing a location for a new airport numerous factors weigh into that decision. Some of those factors are: future passenger numbers, amount of available space for the airport, the availability of space which is conducive to prevailing wind conditions, the public connections to the airports (rail and road) and the surrounding areas around the future airport. All these factors have to be considered and addressed properly. For example a new airport might adhere to all these conditions except that the proposed location is in the middle of an urban area. This proposal of course would cause massive problems and would likely never see the light of day.

Once all aspects of infrastructure, space and location have been sorted out the finer details of the airports layout can be addressed. At the location the prevailing winds would be analysed and those results would be used to determine the direction of all the runways at the airport. Those results in conjunction with the projected passenger numbers would then also give us the amount of runways needed. However, some of the runways proposed may need to be altered slightly or disregarded due to factors such as obstacles or areas where no low-flying aircraft may fly over.
In terms of the airports themselves (terminals and adjacent facilities) there are many important factors to consider:

- Number of taxiways
- Size and form of the aprons
- Technical aspects: fuel storage, air traffic control facilities and navigational aids
- Obstacles in the secure area of the airport
- Number of and distribution of terminals, hotels and parking lots
- Development stages of the airport (all at once or in phases)
- Road and rail connections
- Strategy for public transportation
- Design of the terminal itself considering many aspects such as: check-in area, baggage systems, security, signage, airline offices, lounges, shops, gates and arrival halls.
- Aircraft servicing facilities (maintenance, turn around and de-icing positions.)
- Aircraft landing systems (ILS)

When all the above aspects have been considered a detailed plan of how the airport will be designed can be made.

Fig.26. Shopping at Dubai International Airport

Important to consider is always the way the passenger arrives, spends time and leaves the airport. Every part of the journey should be efficiently laid out in order to prevent the passenger becoming disoriented and feeling general discomfort within the airport.

Types of airports

Airports come in all types of sizes. They all provide the same basic services and only differ in size and the amount of people they can handle. Simple airfields are not airports. They are unable to provide all the services that modern aircraft require and are particularly different in the safety operations that need to be in place for such aircraft. Airports are however still subdivided into four different categories (Airports Council International):

- Category 1: Are all airports that handle over 25 million passengers per year. Also include so-called “hubs”. Examples include London-Heathrow, Chicago O’Hare, Paris Charles de Gaulle, Atlanta etc.

- Category 2: Are all airports that handle between 10 and 25 million passengers per year. Examples include Vienna, Munich and Oslo etc.

- Category 3: Are all airports that handle between 5 and 10 million passengers per year. Examples include Geneva, Hamburg and Stuttgart etc.

- Category 4: Are airports that do not handle over 5 million passengers per year. Examples include Salzburg, Frankfurt-Hahn and Newcastle etc.

Another major distinction between airports, in general terms, is that of the hubs and the regional airports. Hubs are major airports (category 1 or 2) which serve as major changeover points on routes to other destinations. Usually all regional airports feed into a hub of some kind. Hubs are also usually home to airlines and a substantial part of their fleets. For example British Airways uses Heathrow (category 1) as its “home airport”, United Airlines uses Chicago O’Hare (category 1) and Austrian Airlines uses Vienna (category 2). Hubs also generally need far more infrastructure and services for passengers. Most hubs have around 40-60% transit passengers who never leave the airport and their requirements are very different to those passengers who don’t fly on to different destinations. Facilities such as hotels have become extremely important for such airports due to the revenue they generate.

Regional airports don’t need the same facilities as the hubs. As there will hardly be any transit passengers due to the fact that these airports tend to be the final destinations or first departure locations the facilities can be more limited. If there is no airline based at that airport even maintenance facilities can be trimmed down to a minimum as aircraft, in most cases, return to their home airports for scheduled maintenance.

Another phenomenon that has occurred in the past decades is the rise of the budget airlines. The way the no-frills airlines save money is by reducing their overall costs. This means generating more revenue by selling expensive things onboard the aircraft instead of giving things away for free but more importantly by saving money by not spending huge sums on large landing fees at important hubs. Instead airlines like Easyjet and Ryanair who have dominated the market for years and belong in the top five largest airlines in Europe only fly from and to smaller airports such as Luton, Stansted, Bratislava etc. where there are very small landing costs. This has led to the rise of the cheap no-frills airports which cater to these airlines but differ massively to the regional or hub airports in terms of infrastructure and facilities.

45%

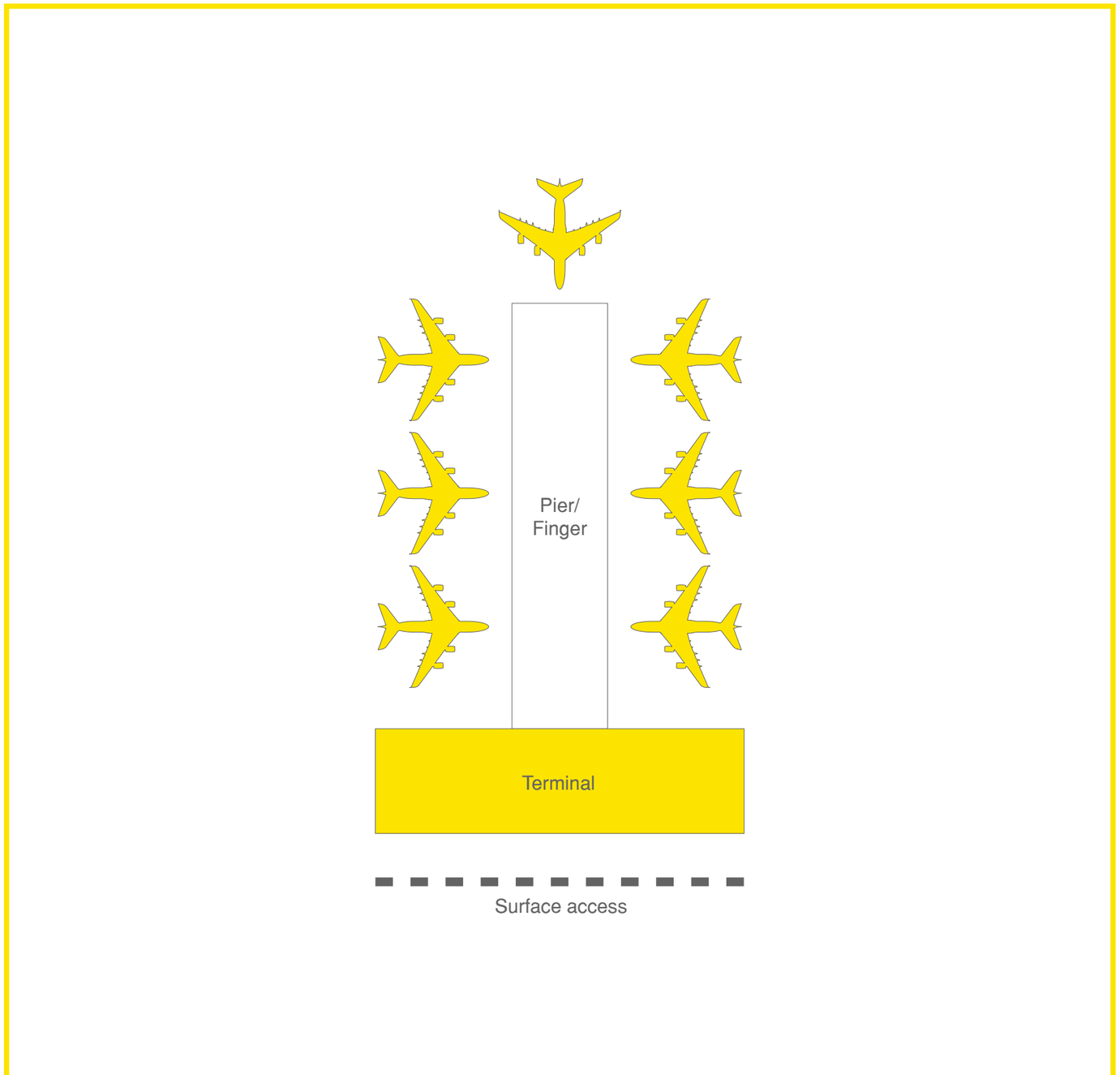
of all airport revenue is non-aviation related.

Non-aviation revenue

In the beginning airports all served the airlines. Facilities catered for only the passenger by supplying meals and bars for waiting passengers. The airports all wanted to entice airlines to come to them. At some point airports realised they were running a business and by letting the airlines do what they want they were losing a lot of money. As soon as airports started charging landing fees and gate fees the airlines were under pressure. For airlines the most important thing was getting to and leaving an airport on time and staying there for as little time as possible. This meant that the airlines aim was to keep the passenger at the airport for as little time as possible. Turnaround times had to be kept to a minimum and in general the saying went that any aircraft on the ground was simply losing money. The airports on the other hand wanted the complete opposite. Their aim was to keep the passenger in the airport for as long as possible. Simple facilities as bars and restaurants weren’t enough anymore. In order to raise revenue airports started turning themselves into shopping centres. By attracting high-street fashion labels and other stores passengers were at once confronted by their addiction to shopping. With the added enticement of Duty-Free, passengers have come to expect the ability to shop their favourite labels at airports. In some ways the airport has led to the demise of the shopping centre by becoming one itself with the added revenue stream of handling aircraft. In numbers the non-aviation revenue percentage at major hubs has nearly reached 45% and is continually growing. Soon shopping won’t be enough and things such as cinemas, spas and luxurious hotels will be popping up at airports. However passengers aren’t the only people that contribute to the revenues of airports. Locals, staff at the airport and people who pick and drop-off people contribute nearly 30% of all revenue. What this shows is that the retail segments can’t only be placed in areas for passengers but have to be strategically placed all around the airport and have to be incredibly diverse. Coupled with nearly 24 hour operation at airports the potential for retail at airports is humongous.

Fig.27. Aerial view of Heathrow Airport, London

TYPOLOGIES



Pier/finger typology

In terms of airport typologies, two different systems can be identified: firstly the centralised system and secondly the de-centralised system. The centralised system is usually an airport made up of only one terminal where everything is “under one roof”. The de-centralised system is made up of more than one terminal. Factors to consider when deciding which system is best include things such as airline presence at the airport, what type of passengers will use the airport (domestic/international), how flexible does the terminal need to be to accommodate the future needs of airline and which size and type of terminal is the most economic.

Centralised System

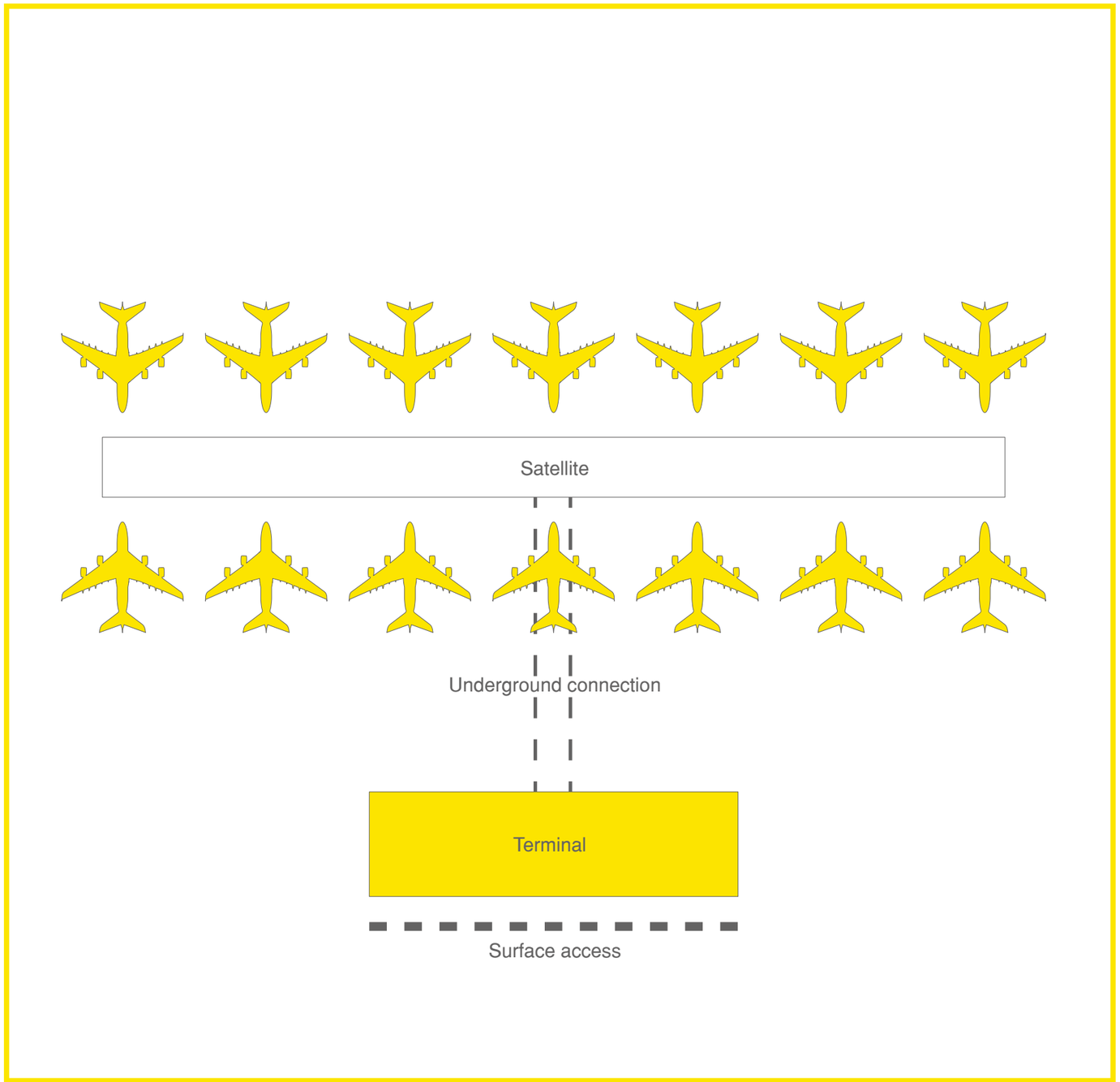
In this system all facilities for passenger check-in and baggage transfer to and from the aircraft are in one location. This leads to a cost-optimised solution in terms of equipment, technologies and personnel. The drawback is the size of the terminals required to handle the high number of aircraft which are expected at larger airports. The increased size and a high number of passengers can lead to huge distances for passenger to cover.

De-centralised system

This system allows the exact opposite of the centralised system. The distances to the aircraft are usually kept to a minimum however, due to baggage systems and other technologies being kept closer to the gate the cost of those system and personnel rise dramatically. These types of airports are usually kept relatively small or have more than one de-centralised terminals. The transfer between these terminals however, can also be quite time intensive for passengers. Hence, the tendency nowadays is to create centralised terminals with the associated typologies.

Pier/finger system

The pier system is a centralised system where passenger and baggage facilities are all in one central location. The pier, where the gates are situated on either side, is a long finger attached to the main terminal building. Every aircraft tends to have their own waiting areas, although in special cases some waiting areas can be combined into larger ones. The length of terminal and the pier all depend on the amount of passenger and aircraft that are expected at the airport. Airports can also have more than one pier connected to the terminal building.



Satellite typology

Advantages:
- Centralised, all facilities are in one place which tends to be more efficient.
- Extension of the piers is easily achieved.
- Very economic, used space is kept to a minimum.

Disadvantages:
- Long distances to the aircraft.
- Some aircraft have to travel long distances to the runways.
- Early check-in times.

Examples:
- Schipol, O'Hare (terminal 2 and 3), London Heathrow (terminal 1 and 3) and Zurich Kloten.

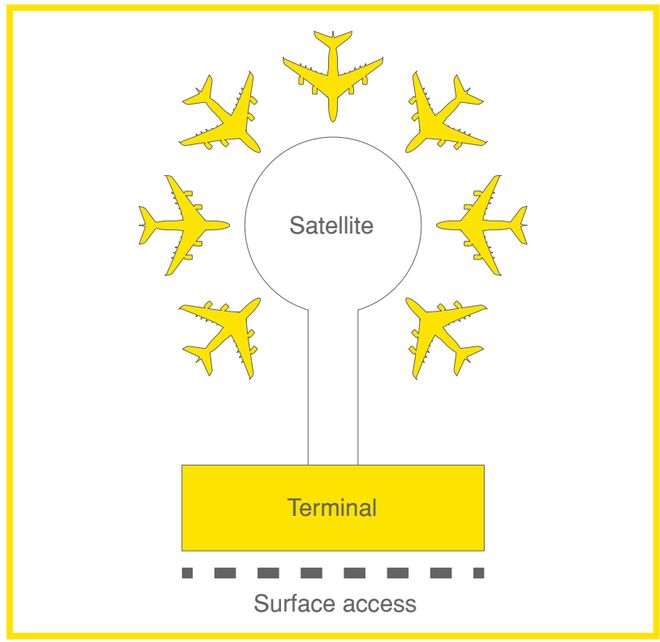
Satellite system

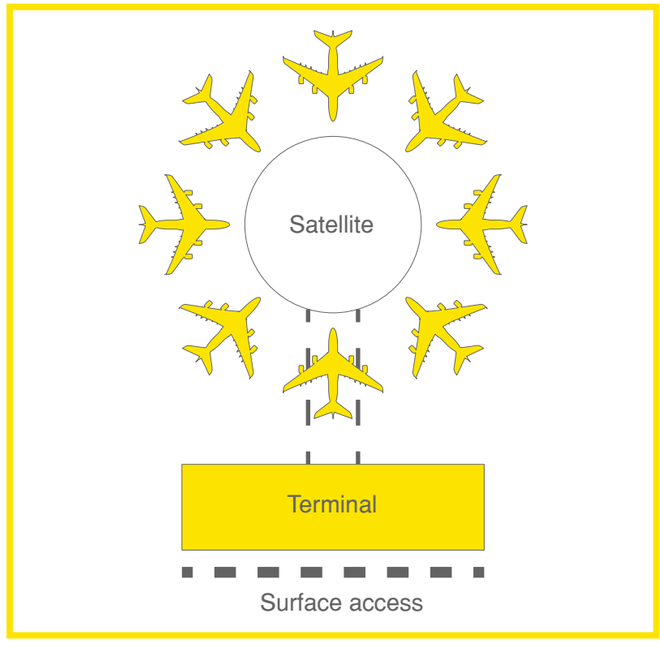
The satellite system is a centralised system where all passenger and baggage facilities are centrally located in the main terminal building. This is a very economic solution as it saves on the total costs of equipment and personnel. The satellites are positioned away from the terminals and are connected remotely via under- or above ground walkways or other systems. What satellites allow is the freedom of movement for aircraft in all directions thereby cutting the distance to the runways.

Advantages:
- Centralised, all facilities are in one place which tends to be more efficient.
- Small transfer times to other aircraft if in same satellite.
- Maximum flexibility for aircraft. Allows shorter distances to be achieved between runways.

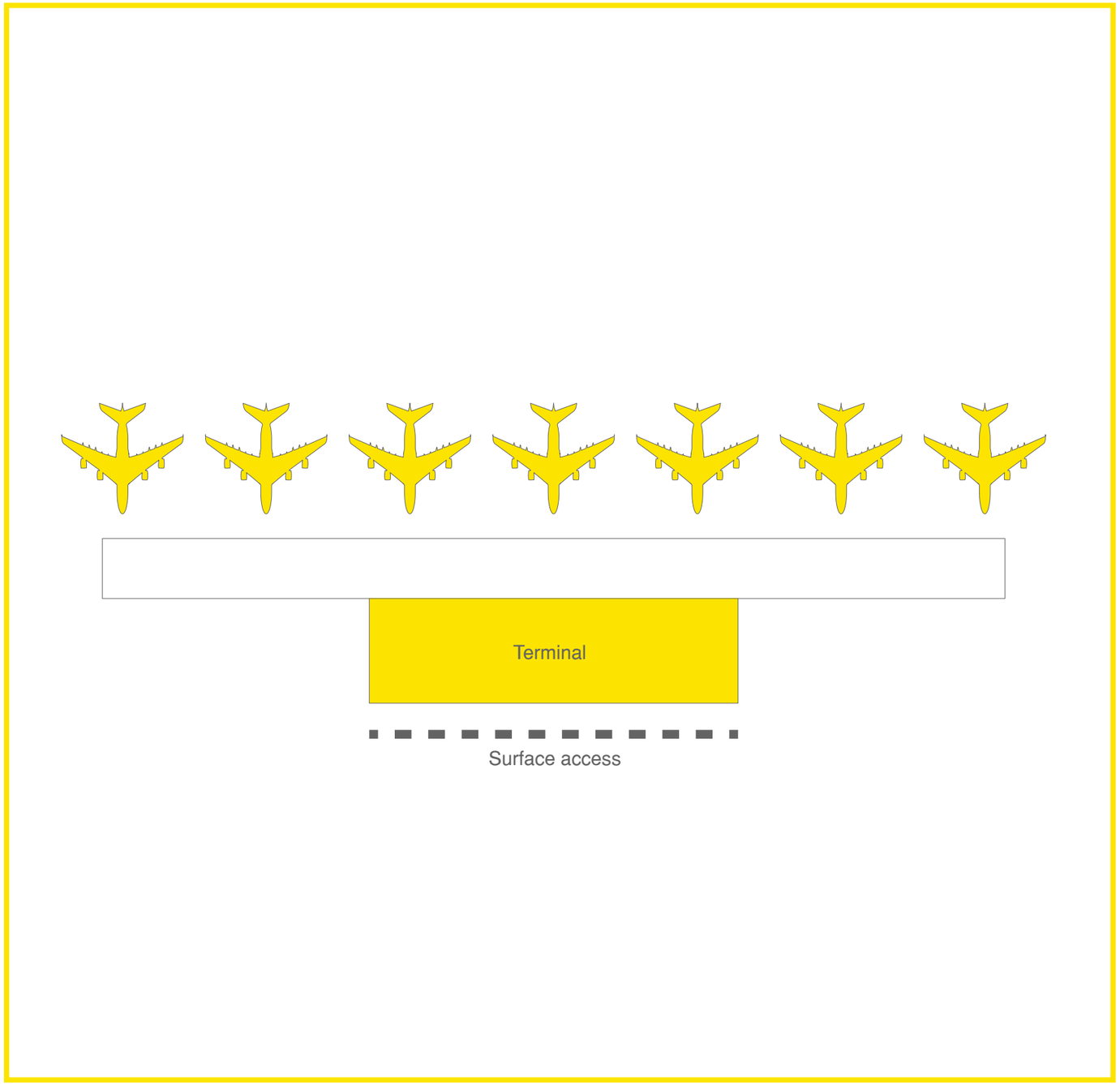
Disadvantages:
- Early check-in times.
- Long transfer times to other aircraft if in a different satellite.
- With round satellites there are smaller ground servicing areas.
- Round satellites may have issues with newer aircraft types.
- Extension of satellites leads to disruptions in normal service.

Examples:
- Atlanta, Denver, Orlando, Paris Charles de Gaulle (terminal 1) and Stansted.





Round satellite typologies



Linear typology

Linear system

The linear system is a decentralised system which spreads out all the passenger and baggage facilities. This leads to a system where there is much more infrastructure in the terminal than is actually needed in terms of machines and personnel. What it does allow is an extremely efficient and quick method of getting to the aircraft, via direct movements, from the time of arrival by car or other methods.

Advantages:
- Smaller distances for passengers to cover as there are no real bottlenecks.
- Expansion is easy as it has no impact on already built areas.
- Smaller footprint.
- Lower costs for baggage sorting and screening due to decentralised system.

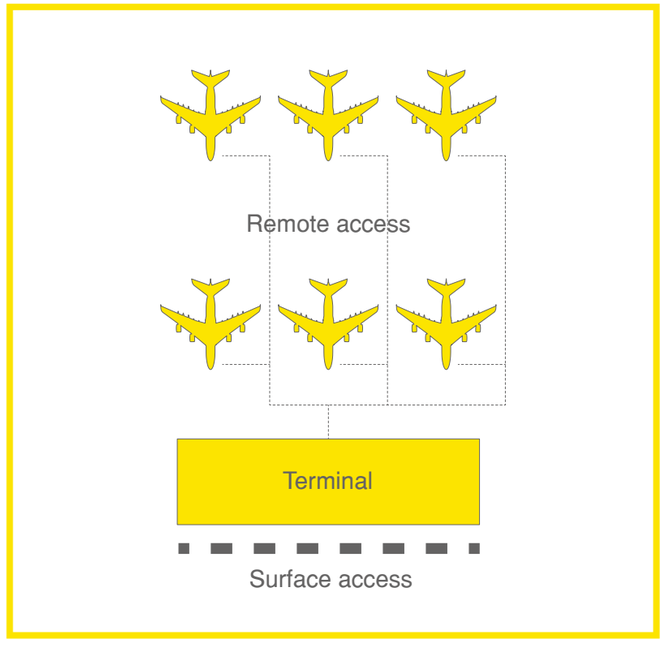
Disadvantages:
- Longer distances for transit passengers.
- Higher initial cost for many of the same passenger and baggage systems.
- Many types of the same concessions need to be multiplied throughout the terminal

Examples:
- Gatwick (terminal north), Madrid (terminal 2) and Munich (terminal 2).

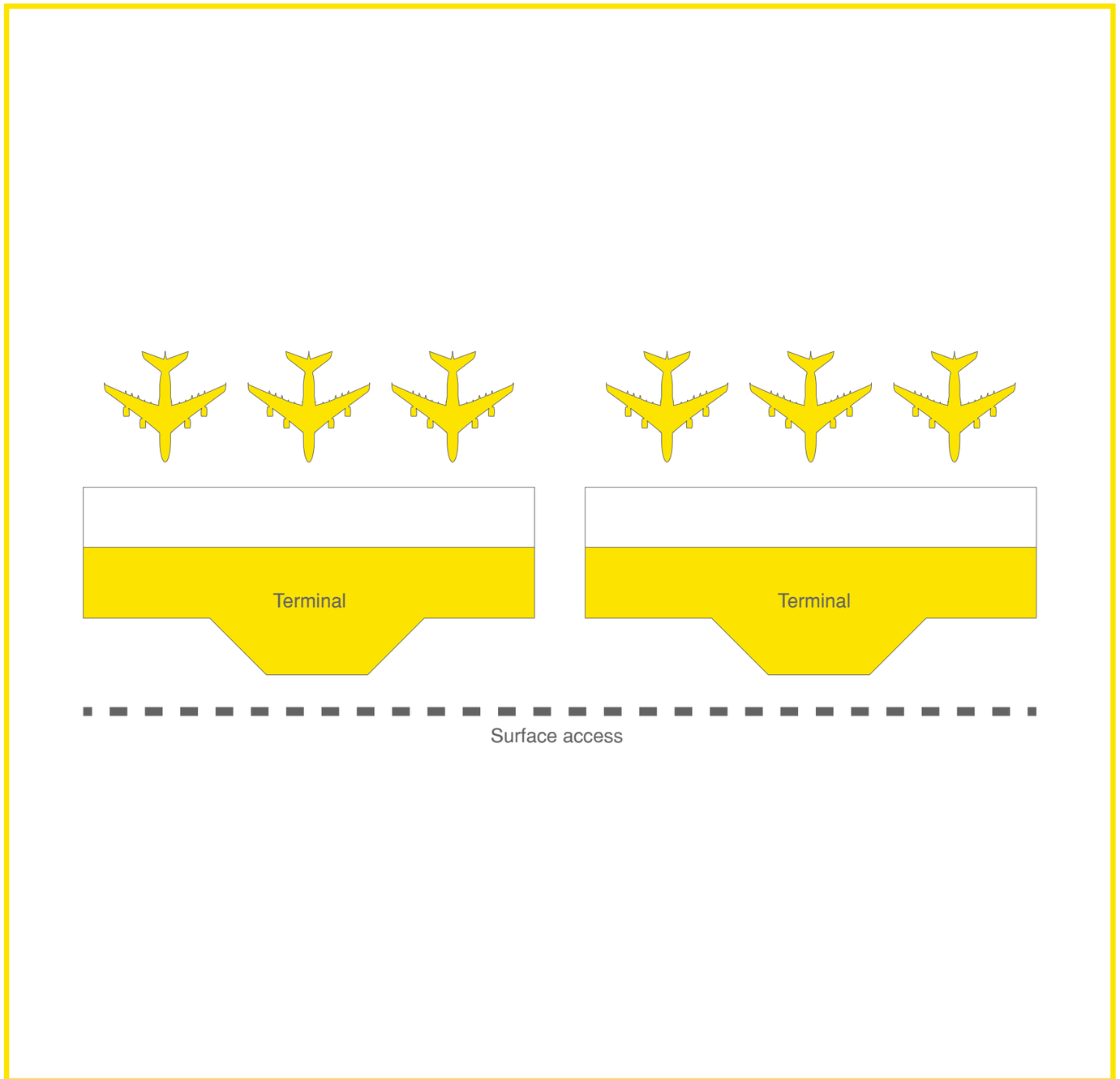
Transporter system

The transporter system is once again a centralised system where all passenger and baggage facilities are centrally located in the main terminal building. What sets this system apart from the others is the fact there are no gates where aircraft park. All aircraft park remotely on the apron and are also serviced there. Passengers wait in holding areas in the main terminal building and are moved to the aircraft over the apron via busses. This system would usually be used in only very remote locations for a few aircraft or in combination with other systems to boost overall capacity of the airport.

Advantages:
- Short distances to cover.
- Easy to orient inside terminal.
- No jet-bridges to aircraft.
- Aircraft can manoeuvre easily and by themselves.



Transporter typology



Modular/unit typology

Disadvantages:
- High transfer times for passengers.
- Extra cost for more ground personnel and vehicles.
- Large distances for baggage carts.

Examples:
- Washington Dulles International (past), Montreal Mirabel and Salzburg.

Modular/unit system

The modular/unit system was developed in response to the short-comings of the linear systems decentralised problems. What the unit system wants to achieve is a kind of centralised decentralisation. Passenger and baggage facilities are more condensed than in the linear system but still spreading them out more than in a truly centralised system. Usually unit systems will be found at airports where airlines have direct control over the terminals which tends to occur more in the United States. What the unit system also allows is the physical division between areas for passengers coming in and out from different places (Schengen etc.). Expansion is easily achieved by simply adding entire modules to the existing airport layout.

Advantages:
- Short distances between arrival of passenger and aircraft gate.
- Late check-in is not a problem.
- Expansion through additional modules.
- People mover systems not required.
- Simple baggage systems within each module.

Disadvantages:
- Less aircraft parking spaces.
- Large passenger volumes can cause congestion.
- Intra-module transfer systems are required to move transit passengers.
- Transit passengers require longer to move between modules.
- Complex public transport and road connections are required.
- Very personnel intensive.

- Examples:
  Dallas, JFK Int. and Paris Charles de Gaulle (terminal 2).

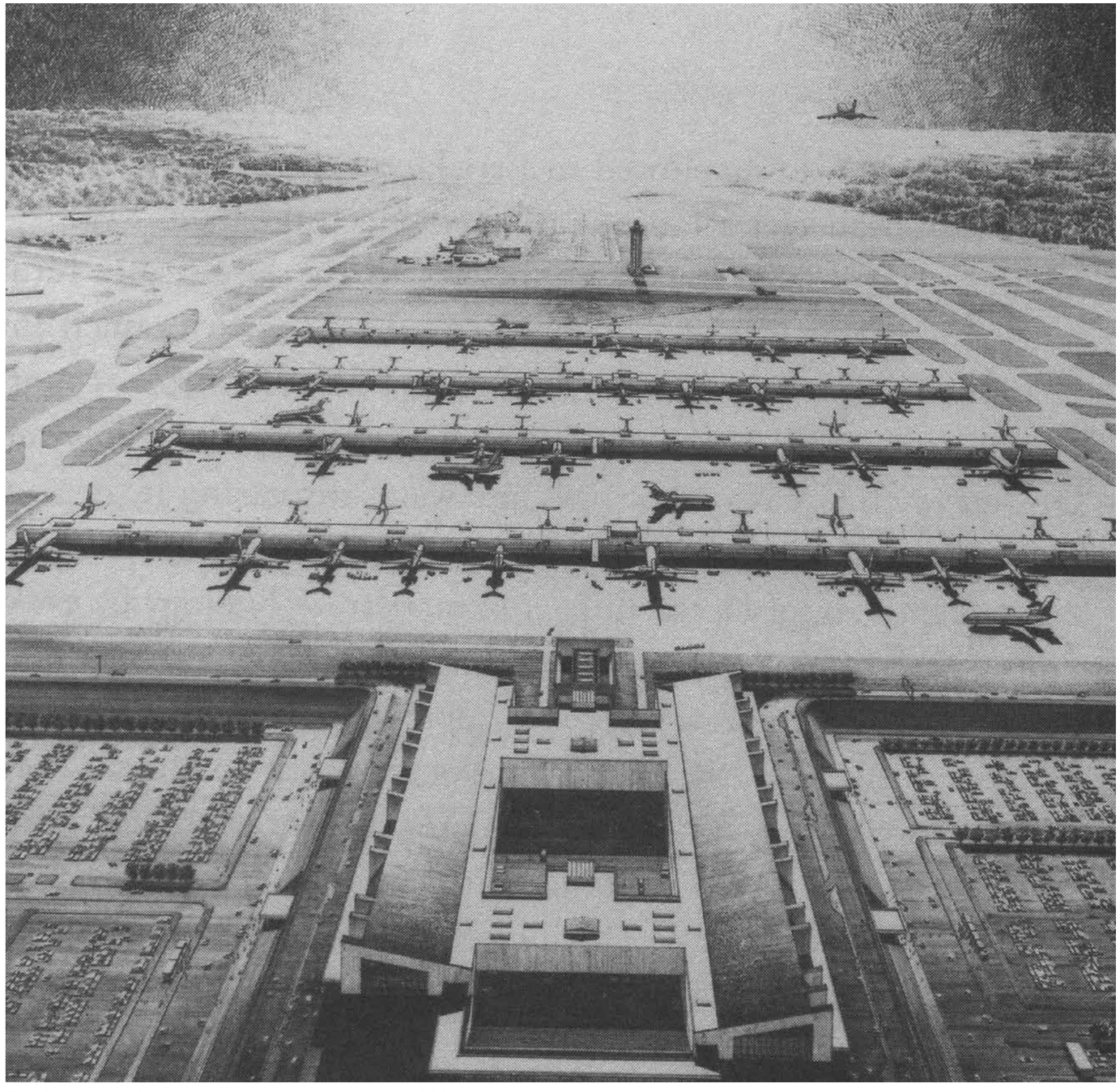


Fig.28. Atlanta Hartsfield International Airport, 1980

CASE STUDIES

CASE STUDY 01

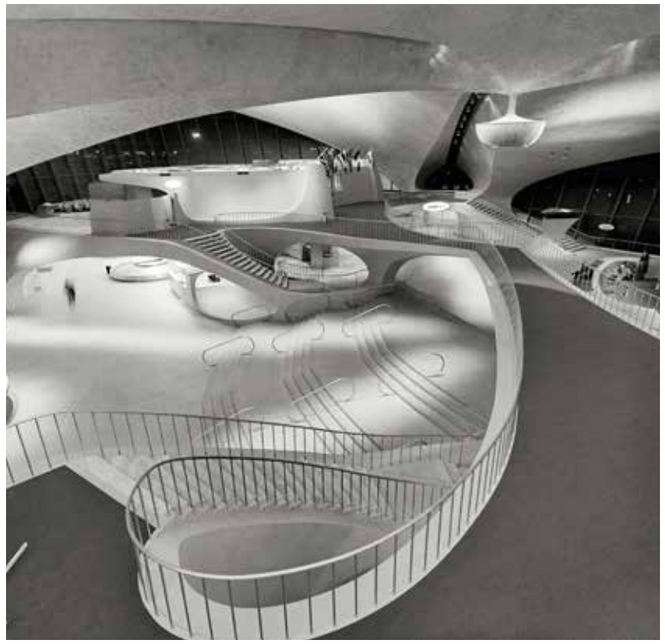
TWA Terminal, JFK Airport, Eero Saarinen, 1962

◀ *Fig.29. Interior view, TWA terminal, Eero Saarinen, 1962*
▼ *Fig.30. Frontal view, TWA terminal, Eero Saarinen, 1962*

As one of the unit terminals at New York's JFK International Airport, Trans World Airlines terminal would become an airport icon as well as an architectural icon. Its architect, Eero Saarinen, would however never see it finished as he died a year before its completion in 1961 due to a brain tumour.

The terminal is perhaps the greatest symbol of the jet-age. It sweeping forms reminiscent of a bird and its beautifully coordinated interiors which mirrored TWA's corporate identity were all aspects which led it to become one of the greatest single terminal buildings ever built. Saarinen however, wasn't purely focused on how the building looked from the outside. As all airlines were competing for passengers at JFK, each airline commissioned their own architects to build them terminals. Pan American for example commissioned Walther Prokosch to design the Pan Am Worldport, famous for its "Flying Saucer" terminal building. TWA wanted a terminal they could market from the very beginning and started doing so in 1957 by unveiling the building five years before it opened. The design would be made from a thin-shell concrete structure which could be moulded into many different expansive forms and allowed Saarinen to create the perfect shape for TWA. Inside everything was beautifully designed and matched TWA's corporate identity. Everything tried to evoke the spirit of flying and aerodynamic forms and stainless steel could be seen everywhere. The large expansive windows allowed passengers to view the incoming and outgoing aircraft with ease and Saarinen even developed his own curved edged ceramic tiles to conform to the beautiful shapes inside the building. The terminal however, wasn't just beautiful but it was extremely practical and efficient. It housed enclosed jet-ways for passengers, closed circuit television, a central public address system, baggage carousels, electronic schedule boards and baggage scales. Along with these systems and two satellites away from the terminal it was what Robert M. Stern called "hyper-efficient" and a "monument to human throughput". In 1969 the terminal received a new concourse and lounge called Flight Wing One, designed by Roche-Dinkleloo, which would accommodate wide-bodied aircraft such as the Boeing 747.

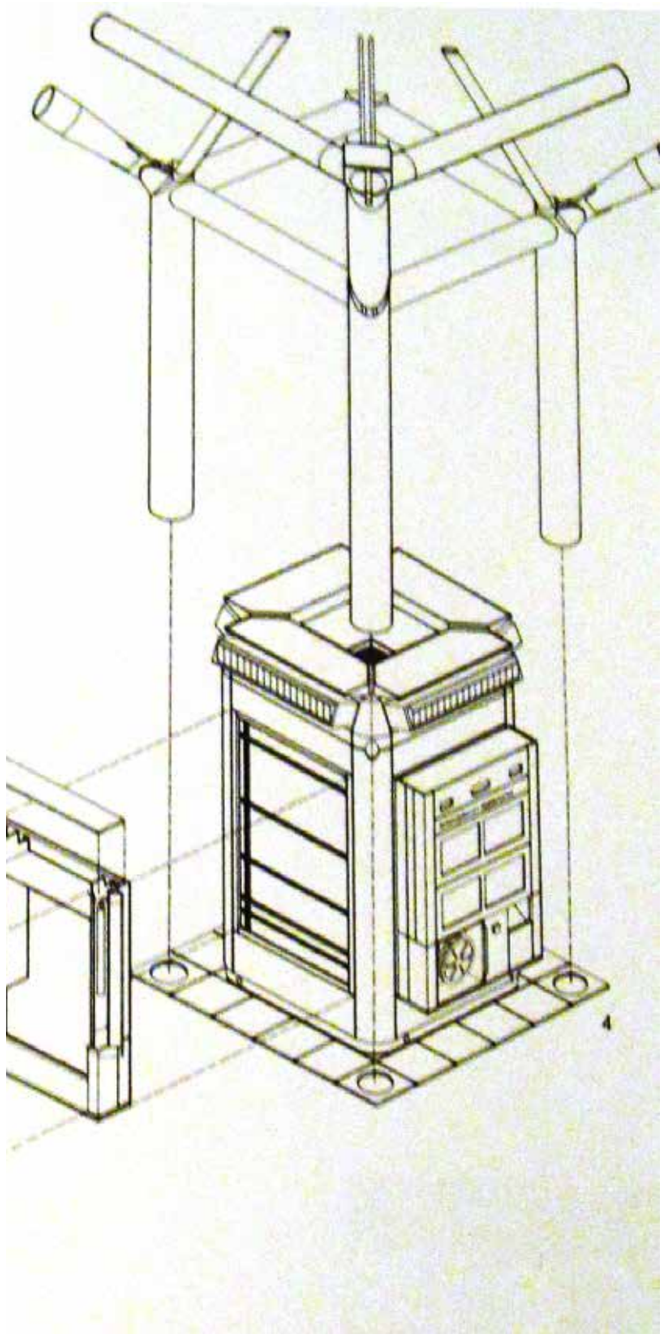
The terminal's success however was short-lived. With the increase of passengers and larger aircraft the terminal soon could no longer handle the pressure. As the terminal was a linear system where everything was decentralised, the increased passenger numbers due to larger aircraft and growing security concerns meant that the terminal had to do things it was never envisioned to do.



► *Fig.31. Interior view, TWA terminal, Eero Saarinen, 1962*
▼ *Fig.32. Advertisement, TWA terminal, Eero Saarinen, 1962*

CASE STUDY 02

Stansted Airport, Norman Foster, 1991



◀ *Fig.33. Construction concept, Stansted Airport, Foster, 1991*
▼ *Fig.34. Exterior view, Stansted Airport, Foster, 1991*

Stansted started out like many airports in the UK; as a wartime airfield. The airport was used by the RAF and USAF during the Second World War and remained in military hands up until 1949 where it was transferred to civilian authorities. At that point the British Airports Authority took control and Stansted immediately became a hit with charter airlines wishing to escape the high costs of Heathrow and Gatwick. Stansted would quickly become London's third airport and by 2014 would have nearly 20 million passengers passing through.

In 1984 a public enquiry, confirmed by the government of the day, stated that Stansted be limited to 25 million passengers per year and should be developed in two phases, including airfield and terminal improvements, which would, at the time, raise the capacity to 15 million passengers.

The new terminal would however become perhaps one of the most important designs in modern airport architecture. Designed by Norman Foster in the mid 80's and completed in 1991, the new terminal would become the blueprint for nearly every other airport built today. Foster wanted to return the airport to the early designs where passengers had an uncomplicated and relaxed journey to the aircraft, whilst always keeping the airfield and aircraft in view. Simply, it was to be an expansion of the linear system on which many early airports were based.

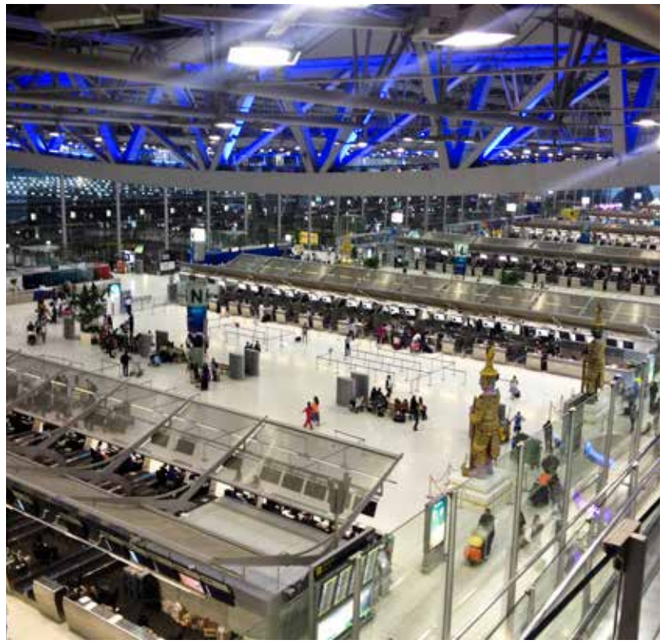
The new terminal would be light and airy thanks to the removal of all environmental systems from the roof into the basement where no passengers would see them. This allowed the roof to be incredibly transparent in places and light which led to an overall increase in quality for the passenger. The "floating" roof is supported by an inverted-pyramid roof truss which is meant to evoke a stylised swan in flight and also serves as a "utility pillar" housing many technical systems. The distances between these supporting structures allowed an easy flow of people across the entire floor plan all the way from the drop-off points through security and checking and on towards the gates. This way the passenger would always have the some sort of situational relationship to the outside world and know where they were situated at any point in time.

The terminal, as mentioned before, was a blueprint for all major new airports built thereafter. Foster himself continued progressing and refining his ideas in later airports such as Hong Kong, Beijing and only recently in Mexico. In between he has also designed a spaceport for Richard Branson and many other infrastructure projects.

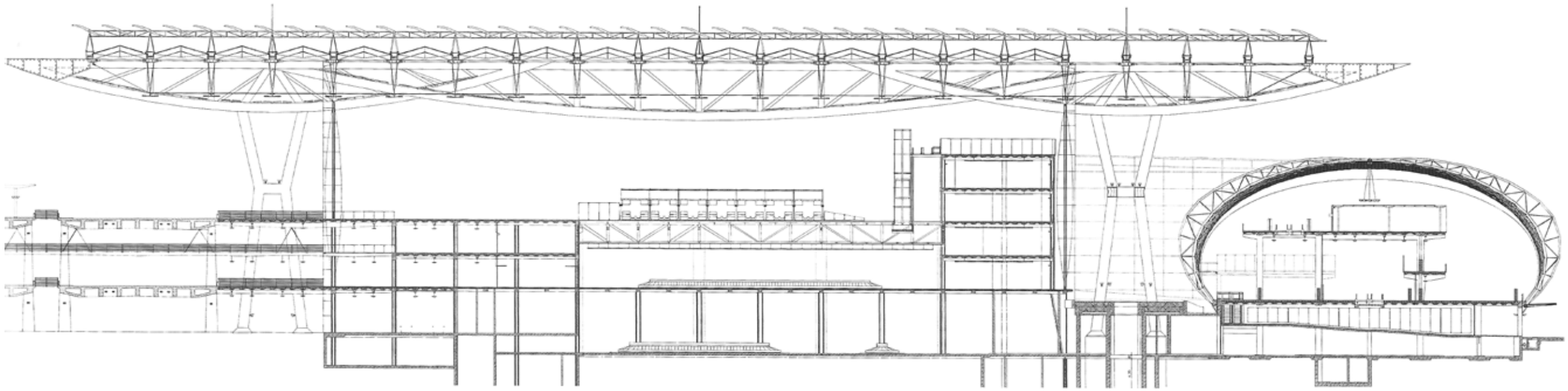
► *Fig.35. Drop-off areas, Stansted Airport, Foster, 1991*
▼ *Fig.36. Baggage reclaim, Stansted Airport, Foster, 1991*

CASE STUDY 03

Suvarnabhumi Airport, Helmut Jahn, 2006



◀ *Fig.37. Departure hall, Bangkok Airport, Helmut Jahn, 2006*
▼ *Fig.38. Section, Bangkok Airport, Helmut Jahn, 2006*



Bankgok Interantionl Airport or Suvarnabhumi Airport opened in 2006 and was designed by Helmut Jahn of Murphy / Jahn architects. The planning of the airport started in the early 60's when it was decided a new international airport was needed. The land which the airport now occupies was bought in 1973 but at the time student protests led to the collapse of the military government and the project was shelved for nearly two decades. In 1996 the "New Bangkok International Airport" company was formed but due to the Asian financial crisis in 1997 construction would not start till 2002. The airport is situated on a low-lying marsh which required extensive land reclamation and took five years (from 1997 to 2001) to clear.

The design itself is a hybrid pier/satellite system with a main terminal building where all the facilities for passengers and baggage can be found. The terminal is a multi-level building which divides functions such as check-in and baggage reclamation onto different levels. In the tropical climate of Thailand, designing such a huge airport was a monumental feat of design and engineering.

The challenge for the airport was keeping the hot climate out but also allowing a lot of natural light in. The response to this problem was a very innovative construction "where nothing must be added and nothing can be taken away" was developed. The roof of the main terminal is supported by only sixteen columns. It has a clear span of 126m and is cantilevered at each end by another 42m. The construction of the facades are constructed very lightly and consist of underslung vertical steel pipes acting as posts and prestressed cable trusses that are connected to the glass panes acting as the skin of the building.

In the concourses the construction is done primarily with exposed steel trusses which carry the structural fabric and glazed steel grid shells which span from truss to truss. The membrane (teflon covered glass fibres, a coated inner membrane and transparent PC sheets) which alternates between itself and the glass skin is a three-layered fabric which allows 1-2% of sunlight through as ambient light and reduces solar radiation of the roof to around 40%. It also counters outside noise with a 60% absorption rate towards the inside.

What Bangkok airport shows is a structural evolution in terms of designing airports in hostile conditions. The ideas of Foster have also been applied and together with the structural and design prowess of Murphy/Jahn architects, a truly innovative and modern airport has been established.

► *Fig.39. Pier, Bangkok Airport, Helmut Jahn, 2006*
▼ *Fig.40. Aprons, Bangkok Airport, Helmut Jahn, 2006*

View west, towards O'Hare, from Willis/Sears tower

CHICAGO

CHICAGO, ILLINOIS
UNITED STATES OF AMERICA
41°52’32.8”N 87°37’27.9”W

The choice of Chicago, as the location for a new airport, maybe a slightly peculiar one if one considers Chicago already has two airports. However, there are certain reasons for choosing the city that make it a perfect candidate for a new international airport.

Because there has been no completely new airport built in the United States since 1995 (Denver), American airports are starting to look jaded. In terms of passengers, they are starting to lose their grip at the top of the tables due to competition from emerging markets such as China, India and a few South American nations. Especially China has taken a huge leap forward due to increased international and domestic travel of its citizens. Dubai has also emerged as a leading hub airport for Europeans travelling east and to Australasia due to its popular airline; Emirates.

The one thing Americans like doing, in terms of air-travel, is flying domestically. Looking at the table for aircraft movements, eight of the top ten are in the United States. What this means is that many flights are being taken with few passengers on board, which gives a strong indication of domestic flight. At the top of that table is O'Hare which means Chicago tends to be seen as a domestic hub. Atlanta however, is near the top of both tables meaning it is seen as the top international hub in the United States. The reasons why Atlanta is more popular are unclear, but reasons could include a better airport, better airlines etc.

Because of this, I propose to replace both current Chicago airports and replace them with one super hub which will instantly handle around 95-100 million passengers a year. By creating a new airport with breathtaking architecture, excellent passenger service and stress free environments the hope is that Indiana Harbor International Airport will become the international hub of choice for the United States.

The airports location is also extremely positive, as it allows aircraft such as the A380 and long range B777's to fly non-stop all around the world. This will give future passengers an overwhelming choice of destinations and airlines as the new airport will have the increased capacity to serve nearly 150 million passengers a year travelling with many different airlines domestically and abroad. Due to the airports increase in size, nearly 4000 aircraft movements will be able to be undertaken every day. This would mean the new airport would quickly rise to the top of all the tables.

Top 10 international airports in terms of passenger traffic in 2014 according to Airports Council International

Rank	Airport	Location	Passengers (millions)
1	Hartsfield-Jackson Atlanta International Airport	Atlanta, USA	94.4
2	Beijing Capital International Airport	Beijing, China	83.7
3	Heathrow Airport	London, UK	73.4
4	Tokyo International Airport	Tokyo, Japan	72.8
5	Los Angeles International Airport	Los Angeles, USA	70.6
6	Dubai International Airport	Dubai, UAE	70.5
7	O'Hare International Airport	Chicago, USA	70.0
8	Charles de Gaulle Airport	Paris, France	63.8
9	Dallas/Fort Worth International Airport	Dallas-Fort Worth, USA	63.5
10	Hong Kong International Airport	Hong Kong, China	63.1
-	Midway International Airport	Chicago, USA	21.2

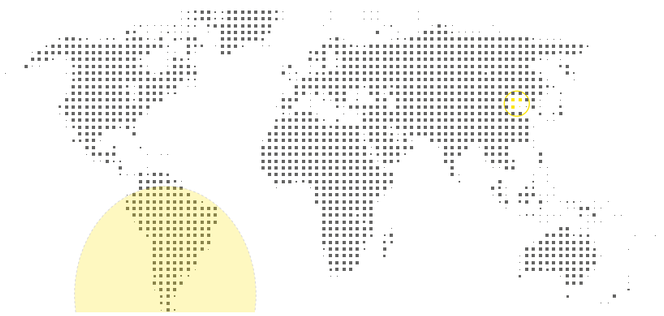
Top 10 international airports in terms of aircraft movements in 2014 according to Airports Council International

Rank	Airport	Location	Aircraft movements
1	O'Hare International Airport	Chicago, USA	881,993
2	Hartsfield-Jackson Atlanta International Airport	Atlanta, USA	868,359
3	Dallas/Fort Worth International Airport	Dallas-Fort Worth, USA	679,828
4	Los Angeles International Airport	Los Angeles, USA	636,706
5	Beijing Capital International Airport	Beijing, China	581,773
6	Denver International Airport	Denver, USA	565,525
7	Charlotte/Douglas International Airport	Charlotte, USA	545,178
8	McCarran International Airport	Las Vegas, USA	522,399
9	George Bush Intercontinental Airport	Houston, USA	508,935
10	Heathrow Airport	London, UK	472,817
-	Midway International Airport	Chicago, USA	249,252

Range of an Airbus A380 (15,700km) from certain cities around the globe. The yellow covered parts of the maps are places where there is no direct connection with that aircraft.

London, United Kingdom

Dubai, UAE



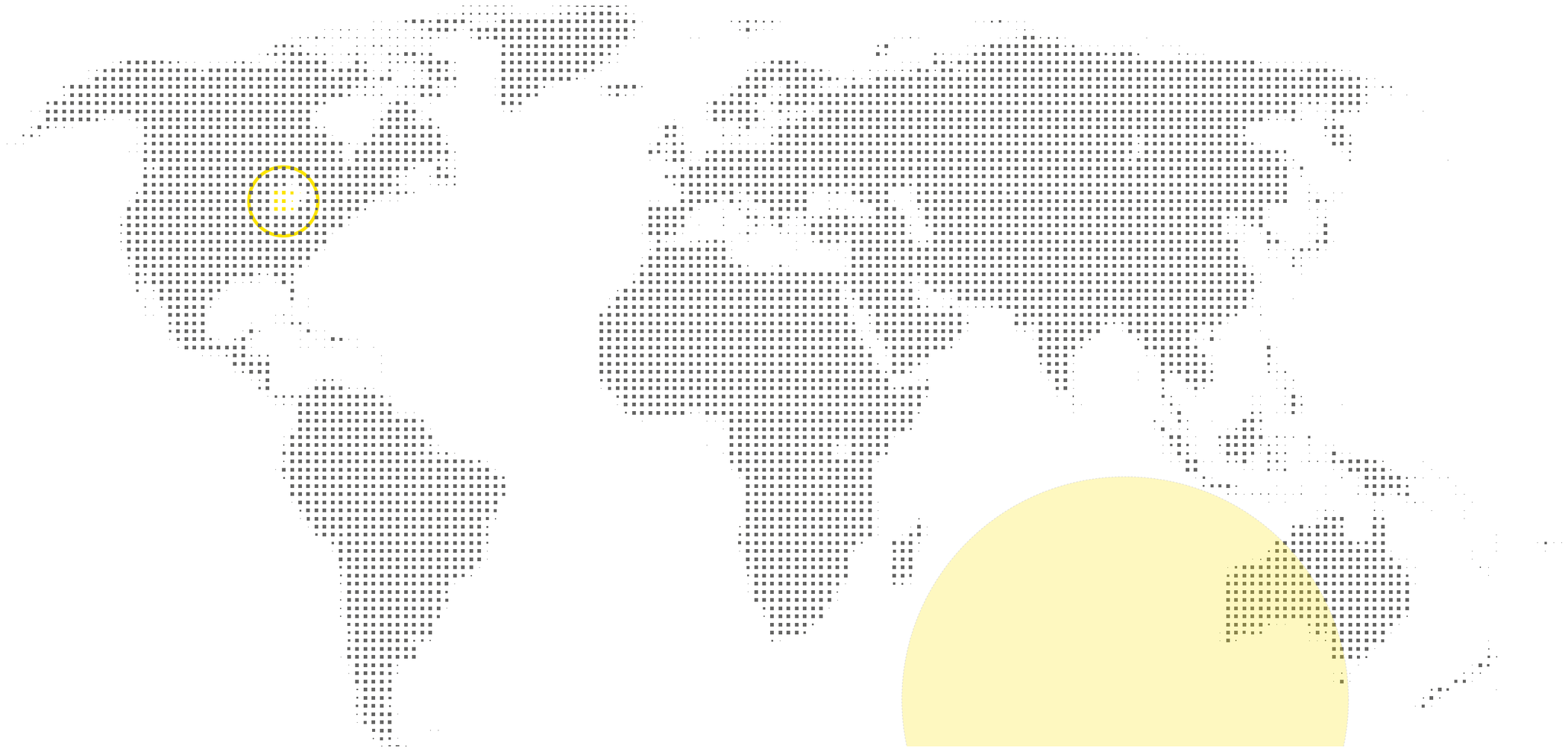
Beijing, China

Sao Paulo, Brasil

Lagos, Nigeria

Sydney, Australia

Chicago's location is, at the moment, a prime location for the A380 to fly from as it can cover the entire world non-stop except for the west coast of Australia.



Chicago, United States

PLAN OF CHICAGO

Scale 1:150000

Highways and major roads

Minor roads

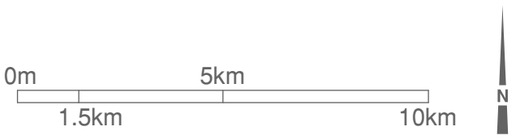
Rail connections

Express train route from Union Station

1 Chicago O'Hare International Airport

2 Chicago Midway International Airport

3 Proposed site for new airport



Downtown Chicago

5KM

15KM

25KM

LAKE MICHIGAN

1

2

3

60

PLAN OF INDIANA HARBOR

Scale 1:25000

Highways and major roads

Minor roads

Rail connections

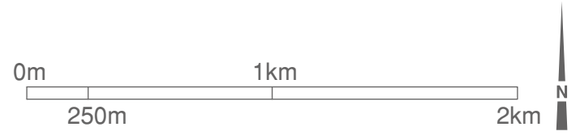
Express train route from Union Station

1 Proposed site for new airport
ArcelorMittal steel plants

2 Marktown
Clayton Mark's planned worker community

3 East Chicago, Indiana
Nearest urban area to new airport

4 Whiting Park
Whiting Lakefront Park, Whiting, Indiana



LAKE MICHIGAN

4
Whiting Park

1

2
Marktown

5
East Chicago

LOOP + SUBURBS

1

1 - “L” Train in Chicago
2 - Mies van der Rohe’s Postal office building
3 - Daniel Burnham’s / FLW’s Rookery building
4 - Mies van der Rohe’s Farnsworth house
5 - View over the north loop from the Willis/Sears tower
6 - Mies van der Rohe’s Crown Hall
7 - Frank Lloyd Wright’s Arthur Huertley house

2

3

4

5

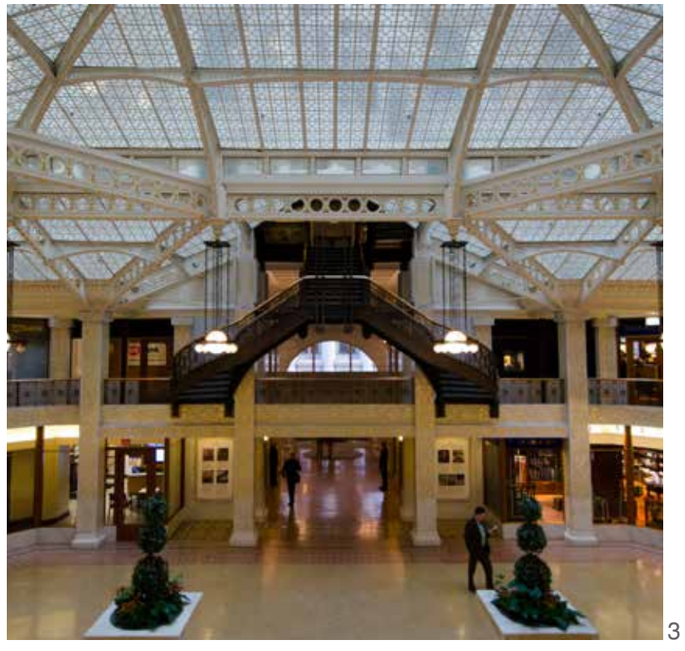
6

7

1

1 - View over the Chicago river
2 - Vitzthum and Burns' One Lasalle Street building
3 - Inside of FLW's renovated Rookery building
4 - Jeanne Gang's Aqua building

2



3

4

6

5

5 - Mies van der Rohe’s Lake Shore Drive buildings
6 - Anish Kapoor’s “Bean” sculpture
7 - SOM’s John Hancock building

7

MARKTOWN

1

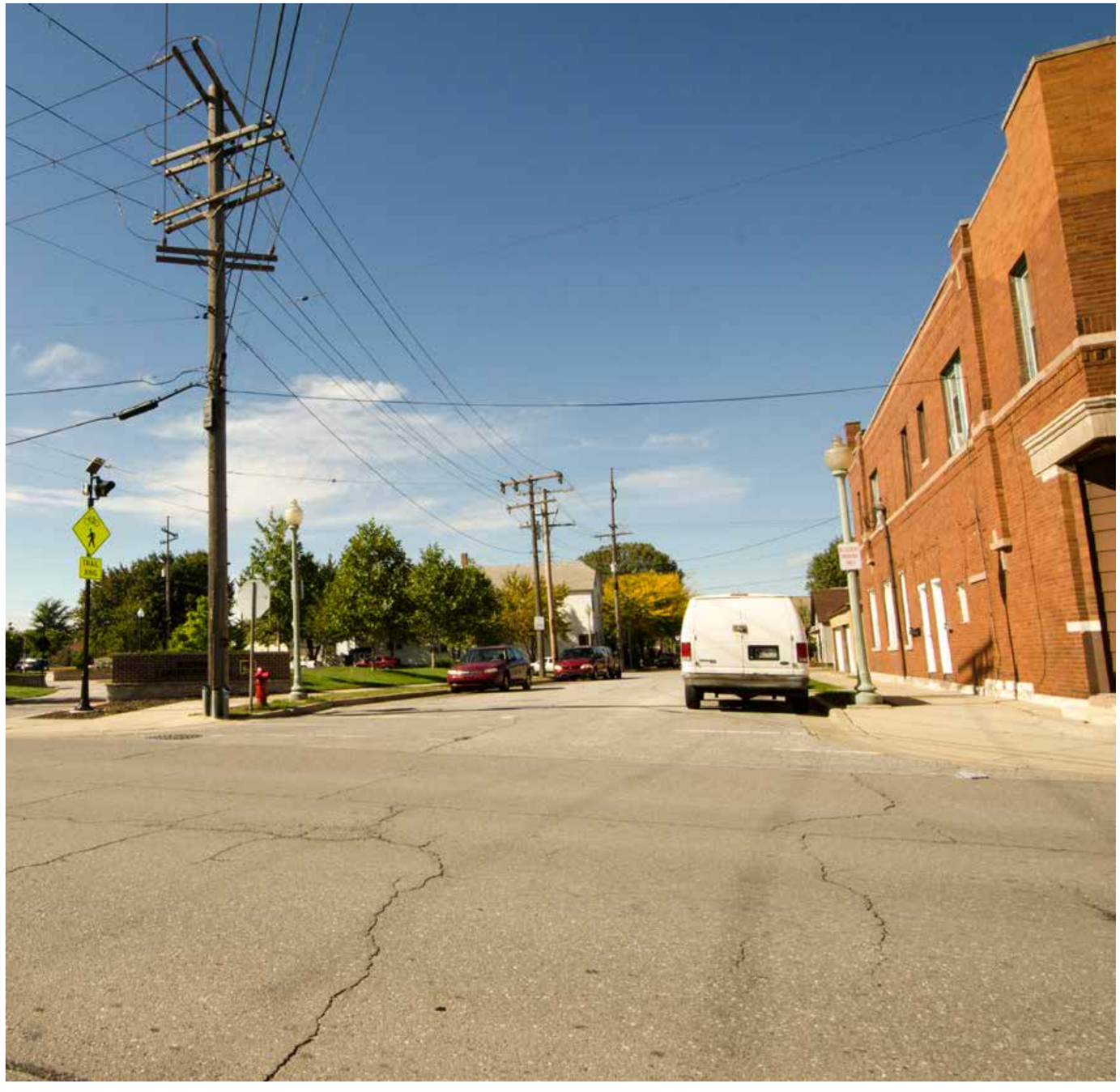
1,2,3 - Marktown homes
4 - Marktown park
5 - Shops and flats on the highstreet
6 - Marktown highstreet intersection

2

3

4

5



6

WHITING PARK

1

1 - Whiting park
2 - Whiting park looking towards Chicago skyline
3,4,5 - Whiting park looking towards Indiana Harbor

2

3

4

5

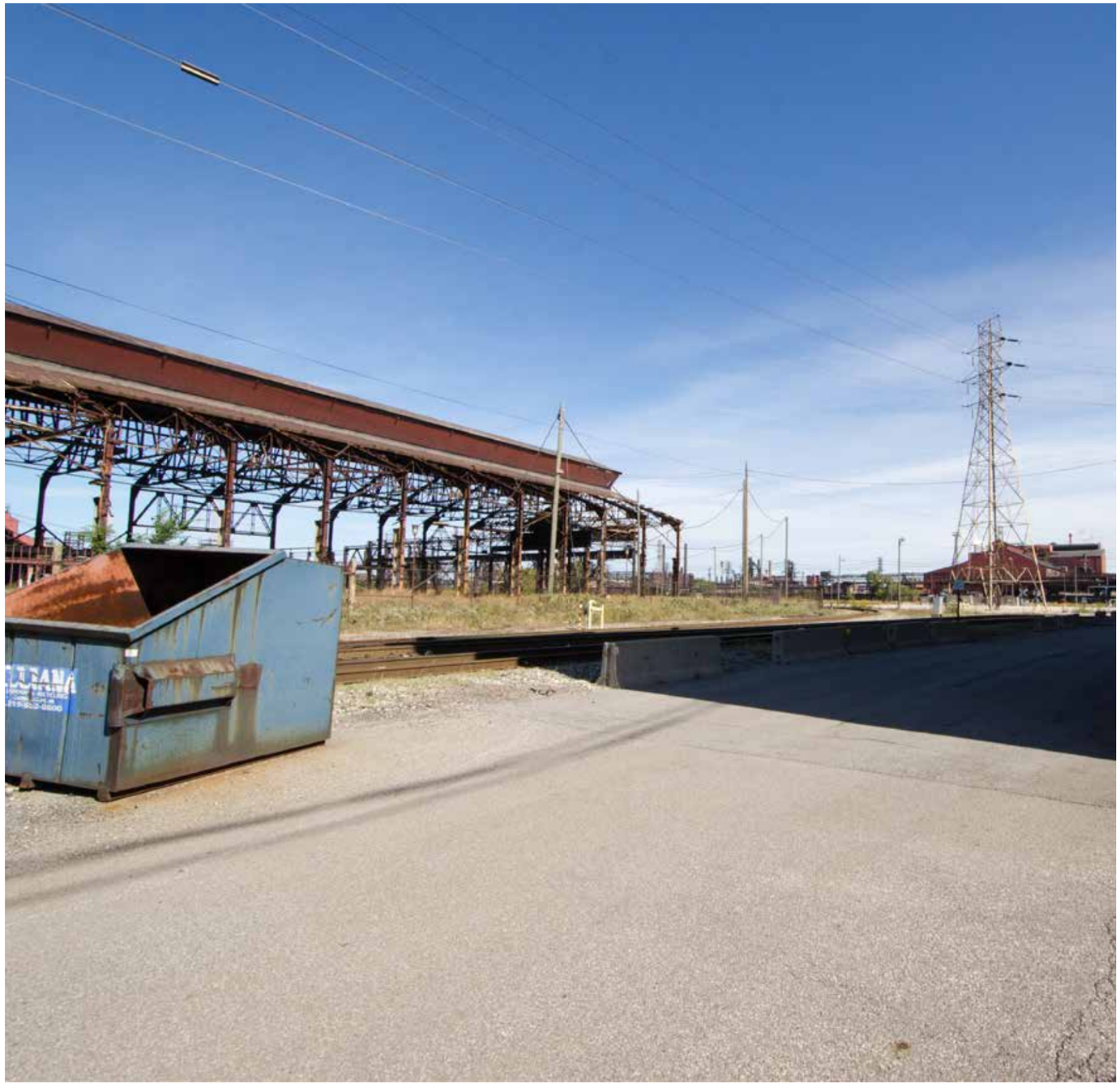
INDIANA HARBOR

1

1 - Part of BP oil storage facilites
2 - Main road leading to Marktown
3 - Fig.41. Aerial view of Indiana Harbor
4 - Abandoned buildings in Indiana Harbor
5 - ArcelorMittal adminstration building
6 - View towards the Ameristar Hotel and Casino

2

3



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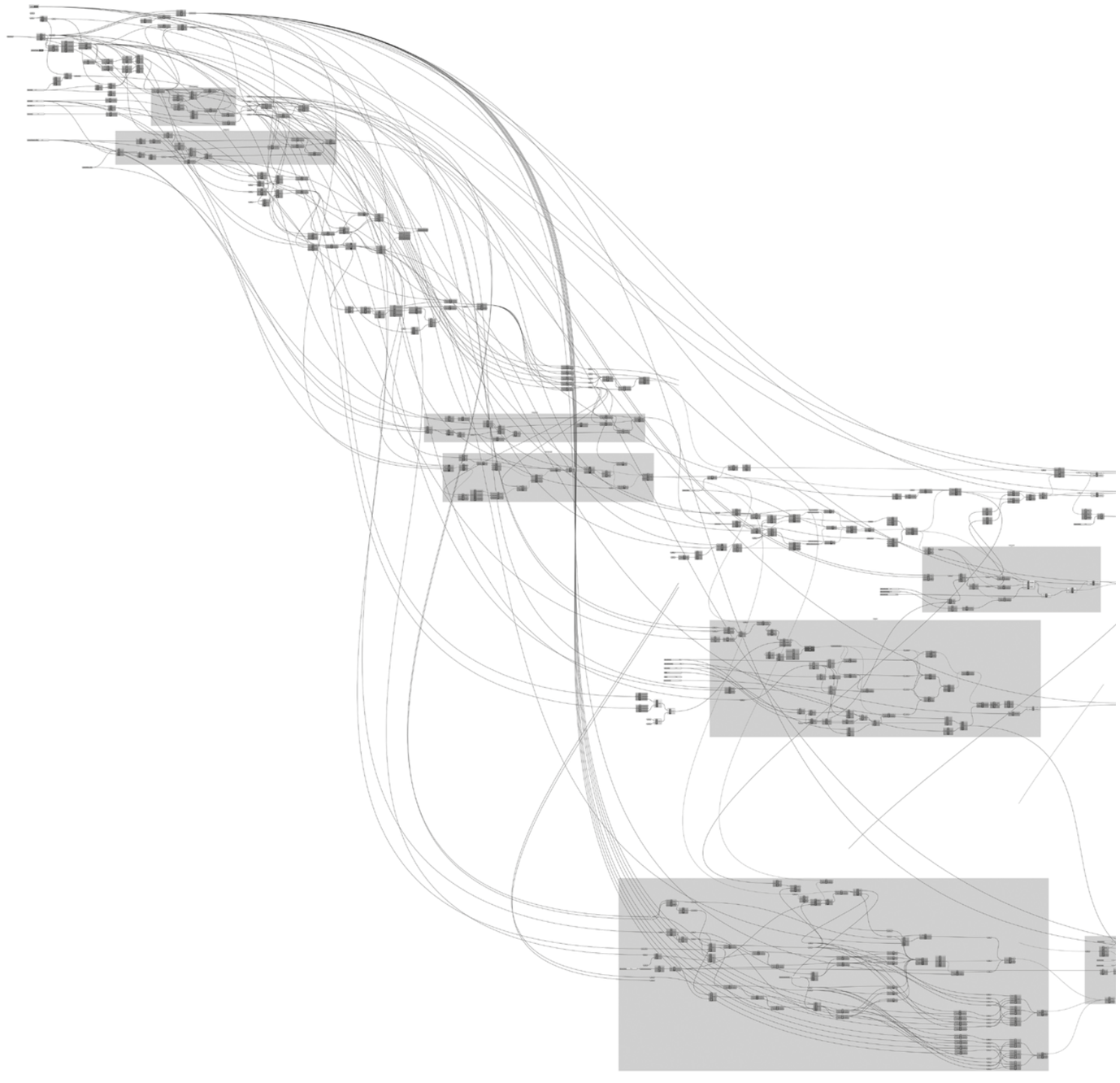
5

6

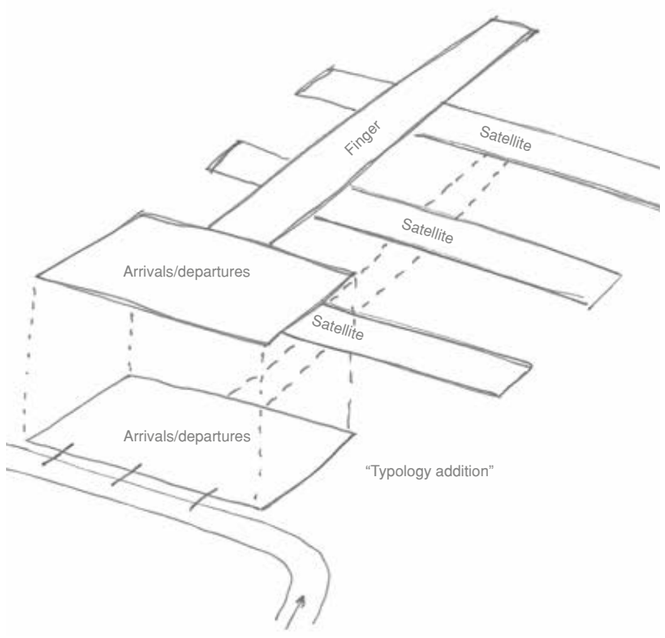


Part of a parametric design for escalators in grasshopper

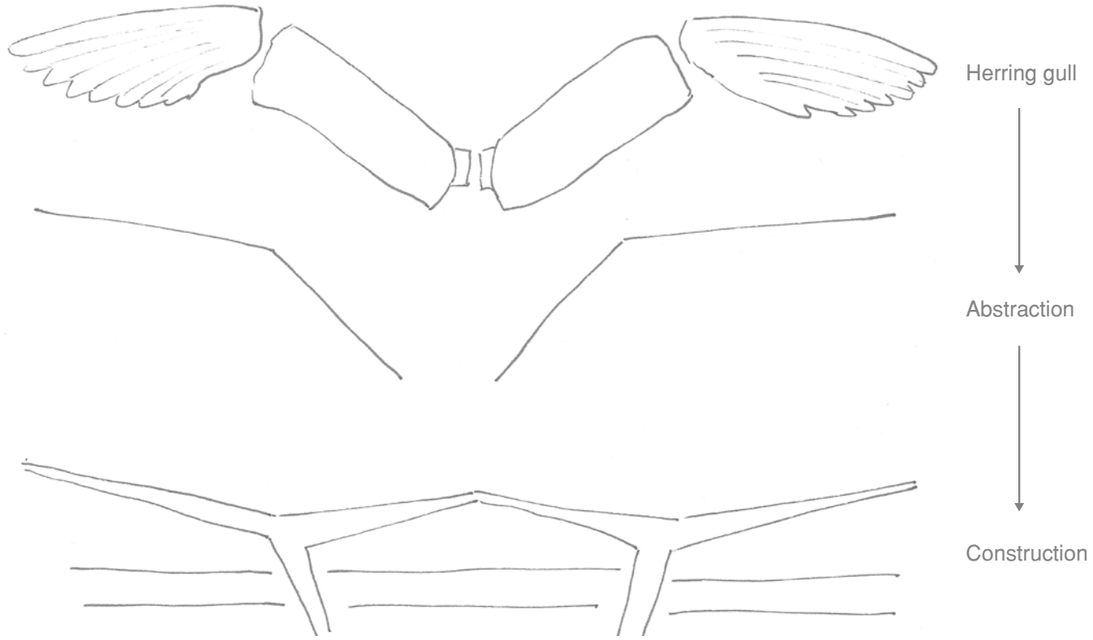
DESIGN

CONCEPT

▼ *Sketch of “typology addition”*
► *Bird wing inspiration*



“Typology addition”



Historical influences

Historical and situational context were extremely important factors in my design decisions. I wanted to create an airport which epitomises air-travel like the terminals of the 60's but also create an airport which mirrors Chicago character as a city. Le Corbusier's themes of the naked airport which played such a vital role for Norman Foster also play a vital role here. My aim was to create an airport where the passenger always sees the aircraft and the aprons. This means passengers will never get lost or lose orientation. Essentially I have thrown out concepts of underground passages and rooms which have no outside view. Everything should be as transparent as possible. Chicago's architecture is perhaps the most important in the United States. My two main influences here were Mies van der Rohe and Frank Lloyd Wright. Both inspired the way the construction enables my airport to allow the concepts of transparency whilst also mirroring the awe-inspiring nature of air-travel. In terms of materials, the main ingredient here is the use of steel and glass, something which Mies van der Rohe used extensively around Chicago.

Location

The design of an airport is an extremely complicated and thought provoking process. Many functions have to go in to the design of these mammoth buildings. In the case of the new airport for Chicago at Indiana Harbor the brief was relatively simple: create an airport which will replace the two current ones in Chicago (O'Hare and Midway) and cater for over 150 million passengers a year. What this means is an airport that will be larger than any other on the planet but still functioning in a manner that won't put passengers off from flying through Chicago.

150 million passengers a year means that there will be upwards of over 1500 flights landing and taking-off every day to and from every destination you can think off. The idea behind the airports location was to find somewhere that will never be in a suburban area of a city. Many airports have made that mistake and have found themselves in the middle of built-up urban areas (O'Hare, Midway, Heathrow etc.). The new airport will be built in an area known as Indiana Harbor. Indiana Harbor was once home to a bustling steel industry but as this industry is in decline, and even moving to different countries, large swathes of land have become available to build on, on a man-made peninsula 27km to the south-east of central Chicago. Compared to O'Hare the new airport will only be two kilometres further away from the downtown areas of Chicago but be without the need to travel through dense built up areas to get to and from the airport.

Infrastructure

In terms of infrastructure the new site processes many of the same and essential building blocks that all airports need. There is already an existing rail connection for cargo and passengers from Chicago and further afield. A new six-lane highway has just been build through the area and would only require ramps to be constructed to allow access for road vehicles. The highway feeds directly into Chicago without going through any dense neighbourhoods. This means that local traffic from rush hours would no longer hinder travel to and from the airport. Travel time to the airport by car from downtown Chicago would take approximately 30 mins whereas the time it takes to get to O'Hare can take up to 60 mins. This together with an express train leaving Chicago every 15 mins and only taking 15 mins to get to the airport also allows many people to arrive by public transport and thus reduces the reliance on cars for travel.

Size and Runways

Getting the size of an airport right is an essential design decision which will shape its future. The idea is to create an airport which will have enough capacity for the next 40 years but also an airport that is not wasting unused space. One of the first decisions is the number and orientation of the runways and this is essentially predetermined by the prevailing winds in the area. In the case of Chicago the analysis shows most of the prevailing winds come from between the west and the south and occasionally from the north-east. This means that runways need to be lined-up in those directions whilst being able to allow for 15 knots of crosswind on landing. The arrangement I have chosen covers nearly 90% of all prevailing winds. This is a much better result than O'Hare presently, where planes continually land into strong crosswinds and experience rough landings. The orientation of the runways along with the location of the new airport means that no approaches to the airport go over dense urban areas but instead go over water or industrial areas. This drastically reduces noise pollution and essentially allows for a 24 hour operation at the airport. Currently aircraft have to fly directly over the city to reach O'Hare and Midway.

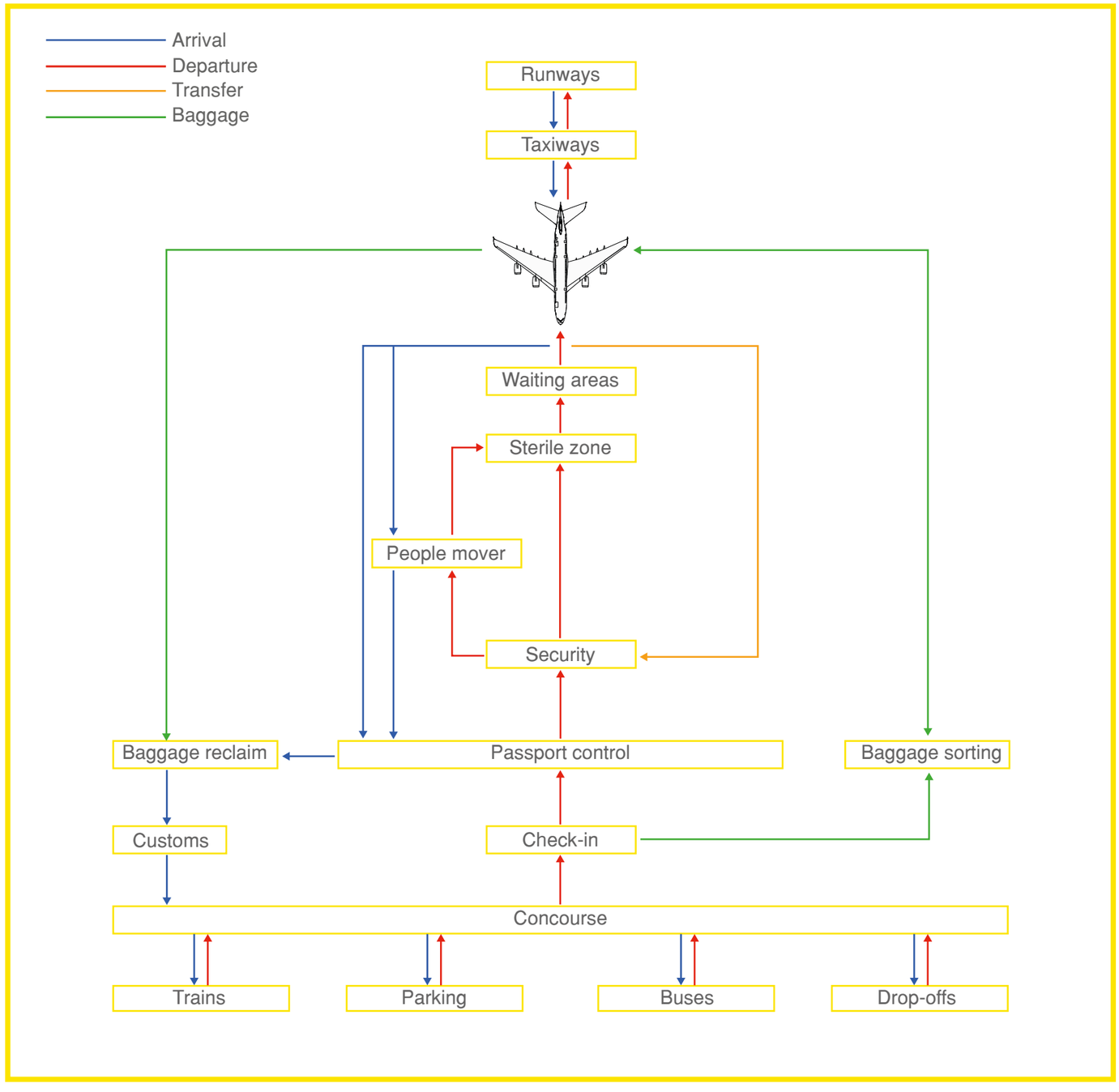
The number of runways is also a critical design decision. More passengers mean more aircraft and that in turn means more aircraft landing and taking-off. In this design I have created an eight runway layout whereby only four can ever be used in any one wind condition. Of the four that can be used there are always two pairs where in each pair one is used for takeoffs and one used for landings. This essentially splits the airport in two and allows for a far greater number of take-offs and landings per hour. The pair is then also separated by 400m in order to reduce wake turbulence effects on other aircraft. What this also means is that because two runways can each be used for takeoff and landing, the shortest distance from gate to runway can be used instead of forcing aircraft to taxi many kilometres before taking-off or reaching the gate because only one runway can be used at any one time. Once the runways have been defined the next and most important stage of the design can be decided.

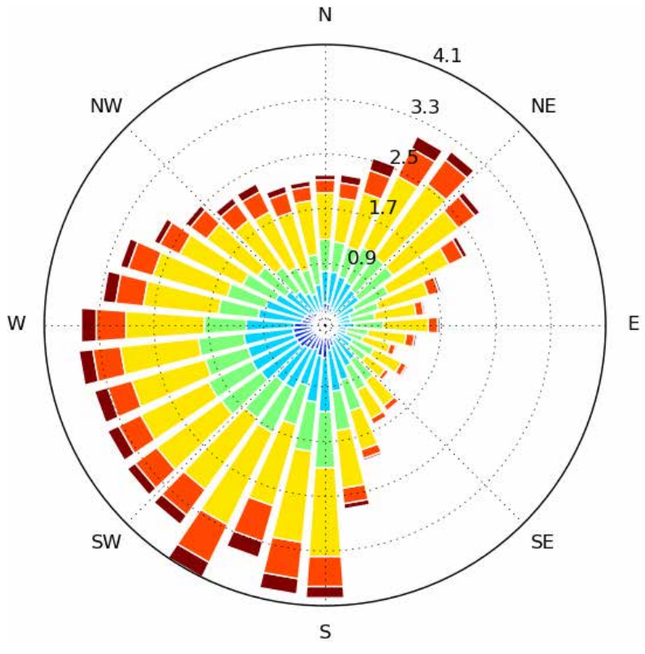
Terminal and Typology

The main terminal building is where people go through in order to get on and off aircraft. Many functions and amenities have to be placed in this building. Functions such as check-in, security, baggage reclaim, restaurants, offices, waiting areas and lounges all need to be situated in the correct and most efficient places. When deciding how an airport should function the typology plays a very important role in that decision process. In a previous chapter the typologies were examined and what crystallised out of that analysis was that the finger and satellite typologies are the most modern and efficient. However, both have negative aspects which limit their attractiveness for an airport of this size. The finger or a terminal with many fingers means huge distances between aircraft and centralised facilites and also doesn't allow for a huge number of aircraft to be placed at that airport. The satellite system is very attractive but it means in most cases that some sort of underground connection, between the satellites, needs to be in place to allow an efficient movement of people. As one of my main design ideas was the reintroduction of the "naked airport", any underground connection was unacceptable.

The result is a hybrid system of a finger with attached satellites. What this means is that I have a central spine which serves as my above ground connection whilst also allowing planes to dock along it. The five satellites spread along the spine are the main areas where aircraft park.

◀ *Conceptual flow-diagram of new airport*
▼ *Fig.42. Wind analysis for Chicago from 1970 to 2014*





The main arrival/departure hall is placed at the base of the spine and houses all the important functions of the airport. In this area trains from the city arrive and depart, there are parking garages, car rental facilities and a bus depot. What makes this part of the building special is the idea of the way the approach to the airport is solved. Usually terminals of this size have a frontal approach along the front of the building. This usually makes the terminal unnecessarily wide and then creates bottlenecks inside. My terminal has two side approaches which turn back on themselves. By doubling the length of the approach because of the two sides, I have eliminated the frontal approach allowing for a tall and slim terminal rather than a short and fat one. What this basically does is create two natural end-points where people are drawn to. At one end is an open-air plaza with hotel and conference centre and at the other is the security check-point where people go through to get to the aircraft. By expanding the waistline it further emphasises the direction which people need to go whilst also cutting down space in the corners of the building which are furthest from the centre.

Services & Passenger experience

In terms of services and the experience of the passengers whilst waiting for their flights, the airport of tomorrow can no longer just be a place where aircraft land and take-off. People want an airport where it is enjoyable to stay and spend time. Retail is an extremely important aspect and will account for nearly 50% of the airports revenue. But shopping isn't something that everyone always wants to do. Perhaps the simplest and most important design decision was the implementation of parks in the terminal area. Along the spine of the building there are four areas which are accessible to all passengers and allow people to get fresh air or lay in the sun whilst waiting for their flight. This in addition with cafes and restaurants brings and urban flair to the airport which will draw more passengers to want to fly from Chicago. Other facilities such as cinemas, spa's, short-term hotel options, child-care along with all the retail and cuisine options really pushes the passenger experience much farther than any airport has before it and should lead to an increase in passengers using the airport as a hub. For passengers that will only use the airport as a domestic departure point the same applies, but all these facilities are never forced upon the passenger and it therefore allows domestic passengers to get through the airport quickly and efficiently.

Because the airport is nearly 3km long in length the internal transportation concept also has to be extremely efficient. Throughout the entire airport there is not a single step which a passenger has to overcome. Lifts and moving-walkway form the mainstay of passenger movement throughout the terminal. The gate areas feature one-way ramps and everything is also accessible via stairs. To overcome the massive distance from one end to the other an internal people mover is also provided. As the airport is essentially split in two, there are also two people movers servicing each side of the airport moving at 4-5 min intervals between stations. Each has one stop along each of the five faux-satellites and one above the security check-point. Essentially what this means is that walking distances are kept to a maximum of around 800m (at the most) and time wise a person can reach the farthest aircraft in fewer than 20 mins. The aircraft themselves are also situated in a special manner. International flights find themselves leaving from the end of the satellites whereas the domestic flights are along the spine and the intersections. This leads to domestic passengers needing to travel smaller distances from the people mover stops to reach their aircraft.

Construction and form

As I mentioned before, the construction of the roof and façade should mirror the awe inspiring nature of air-travel. What led me to the form was, perhaps, a purely sculptural reason and not an economic one. The form mimics the flapping wings of a bird, similar to Eero Saarinen's TWA terminal, whilst also retaining a slightly aggressive, pointy look matching the character of Chicago as a city.

The construction which holds the roof and the façade is made up of a varying amount of steel truss frames clad in steel. They vary in size and height but all remain identical form-wise. By varying the sizes and spans it allows a greater efficiency in use of the materials and also leads to a more natural looking building. In between the frames are simple glass panels which line the roof and façade. The glass itself is toned to maximise the amount of solar energy which is repelled and to provide a temperate climate inside the building without having to waste copious amounts of energy on air-conditioning.

The levels which form the parts of the building where passengers walk on are entirely made from multi-directional span tee-beam concrete floors. This allows wide spans between columns and further reinforces the ideas of a transparent building. Inside the floors and underneath the final surface is the floor cooling/heating system for the airport. The terminal uses this to remove any heat which is a result of solar heating. If it is cold this system is used to heat the building. As the climate in Chicago swings quite dramatically from summer to winter, this system should be enough to temperate the building suitably. If not, then the addition of air-humidifiers and climate control can be implemented into the steel-truss frames spanning the building.

Parametric design

Perhaps one of the most important tools is used during the design process was the implementation of grasshopper as a parametric design tool. I used grasshopper in a way that is maybe not immediately recognisable. Instead of using it as a tool to give me a finished design, or variations thereof, I used it to simplify the design of singular objects. As the airport is so large, and is composed of so many parts, the simple task of creating the design for the construction can be a time consuming task. However, as each part of the construction was parametrically designed, I was able to control the look of each frame individually and collectively in order to reach the final design goal. Grasshopper enabled me to interpolate the dimensions of all the frames in accordance with the span they have to bridge very quickly. This led to a very natural change in sizes between the frames. Modelling each individually would not have been possible, especially if I had then wanted to change something again. Other elements such as escalators and moving-walkways were also parametrically designed in order to cater for different heights, angles and lengths. Grasshopper then calculated step numbers etc. automatically in accordance with the height the escalators had to traverse.

The main strength of parametric design is the ability to quickly change the final design of an object by changing certain parameters. While it saves time at the end of a design process the amount of time needed to develop the parametric designs is very time consuming but essential in a project of this size.

OVERVIEW AND PLANS

View of the airport looking towards downtown Chicago

PLAN OF NEW AIRPORT

Scale 1:25000

Highways and major roads

Minor roads

Rail connections

Express train route from Union Station

1 Proposed site for new airport
ArcelorMittal steel plants

2 Marktown
Clayton Mark's planned worker community

3 East Chicago, Indiana
Nearest urban area to new airport

4 Whiting Park
Whiting Lakefront Park, Whiting, Indiana

4
Whiting Park

2
Marktown

1

5
East Chicago

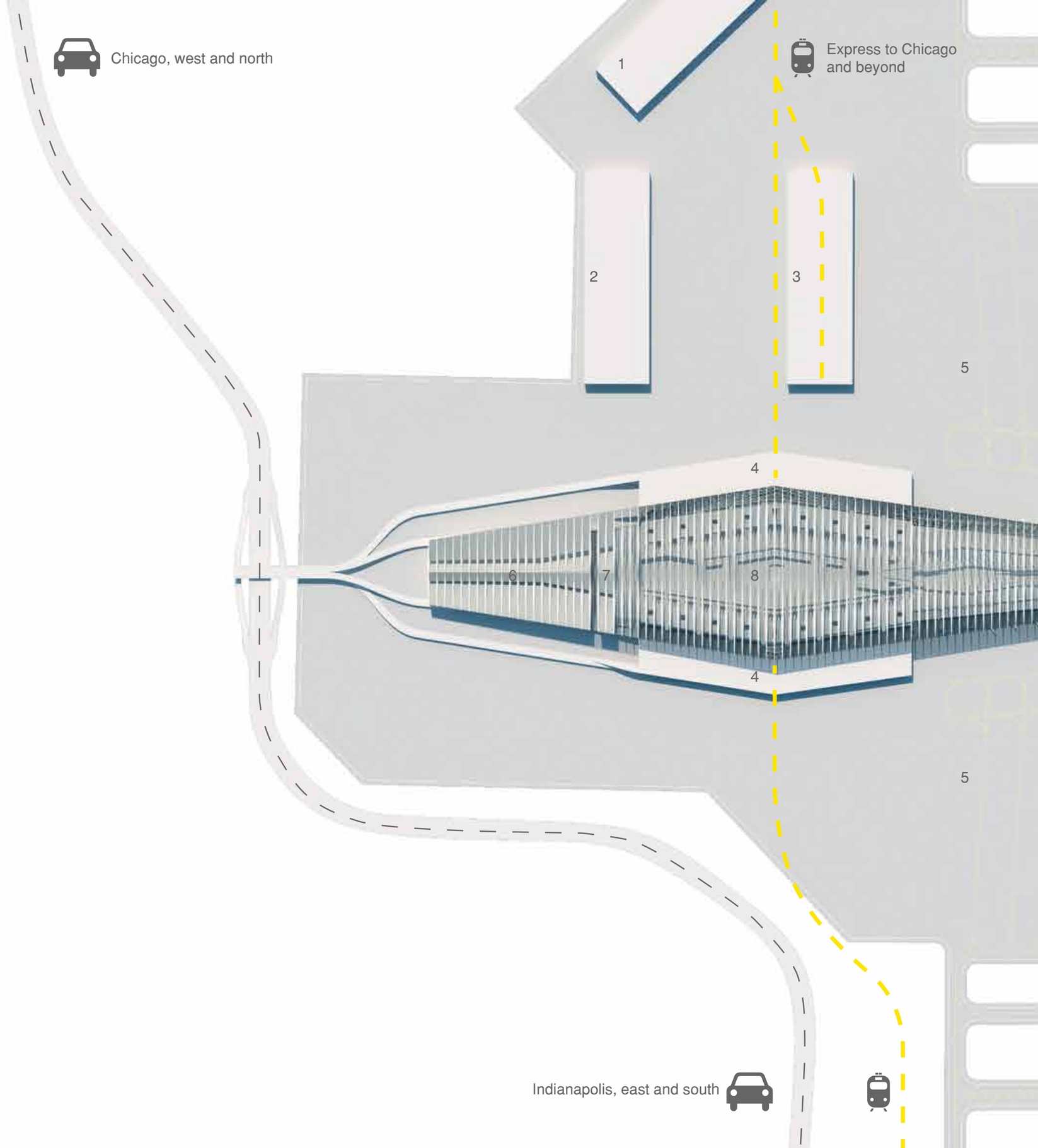
AIRPORT OVERVIEW

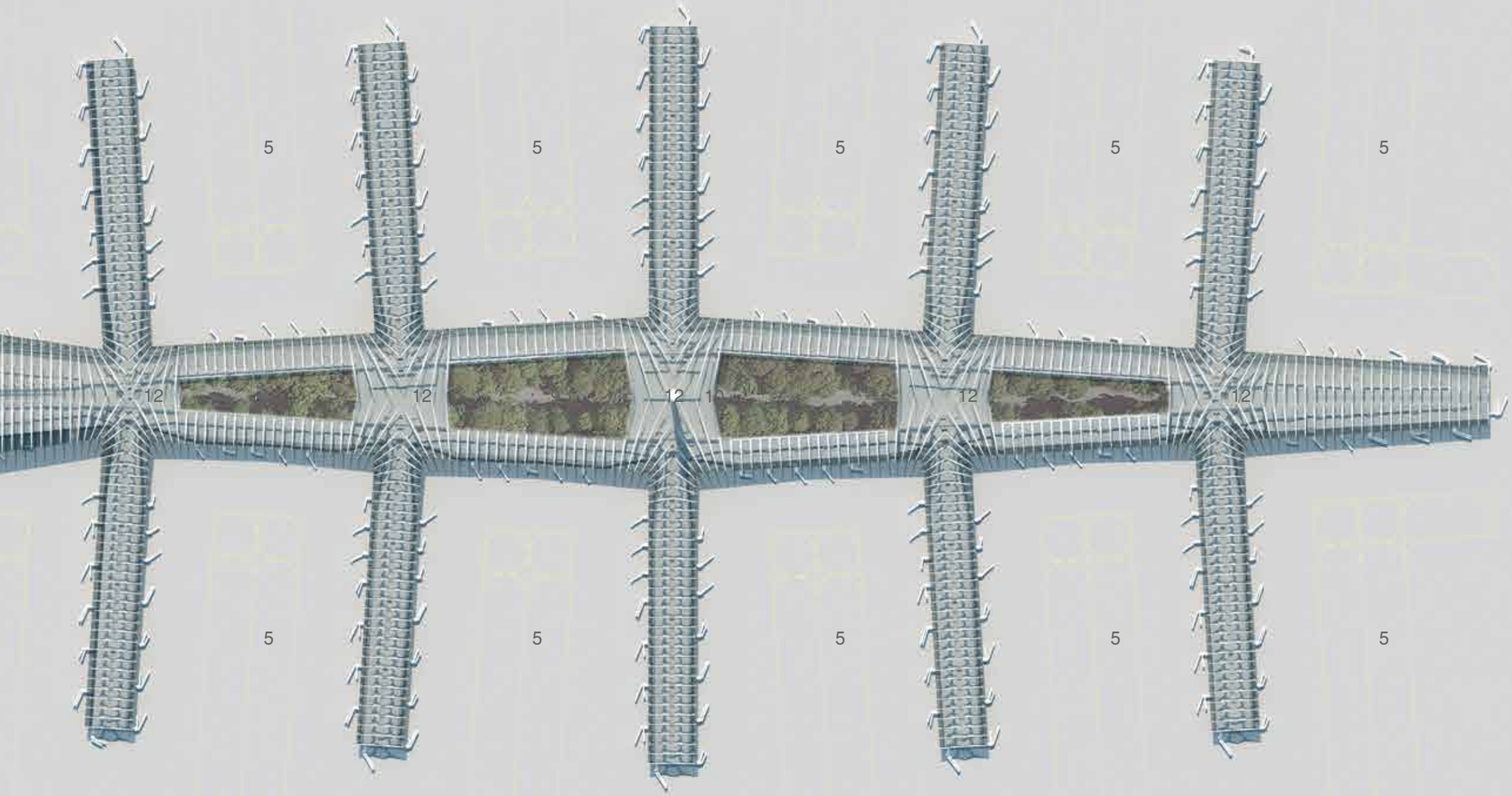
No scale

Rail links (underground)

Highway

1	Aircraft maintenance
2	Aircraft service centre and cargo
3	Cargo
4	Parking garages and bus depots
5	Airport apron
6	Business and conference centre
7	Main airport hotel
8	Departure and arrival building
9	In-terminal park
10	Air traffic control
11	Runways
12	Internal junction with people mover stations




5
5
5
5
5
12
12
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10
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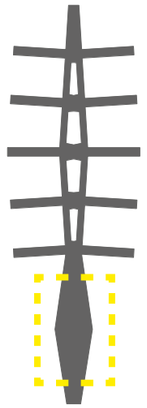
5
5

MAIN AREA

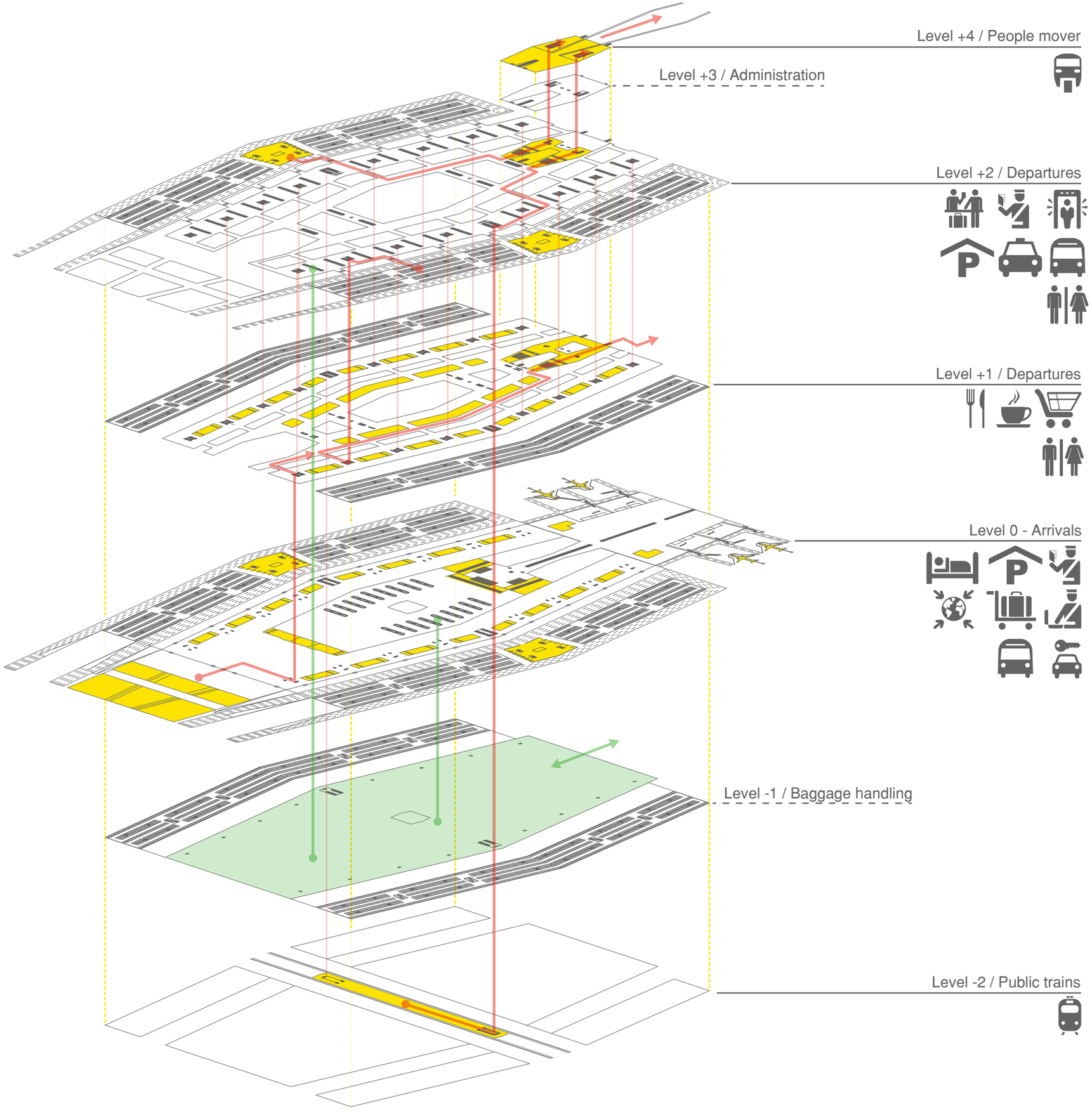
Axonometric view of departures

- Departures
- Arrivals
- Flight connections
- Baggage movement
- Physical barrier



ICONS:

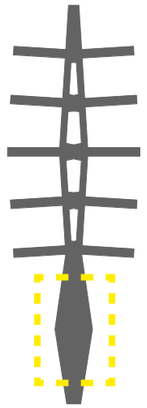
- Public trains
- Taxis
- Public buses
- Car rental
- Check-in
- Parking
- Customs
- People mover
- Passport control
- Security
- WC
- Baggage reclaim
- Cafe
- Business centre
- Restaurant
- Park
- Hotel
- Retail


Level +4 / People mover
Level +3 / Administration
Level +2 / Departures
Level +1 / Departures
Level 0 - Arrivals
Level -1 / Baggage handling
Level -2 / Public trains

MAIN AREA

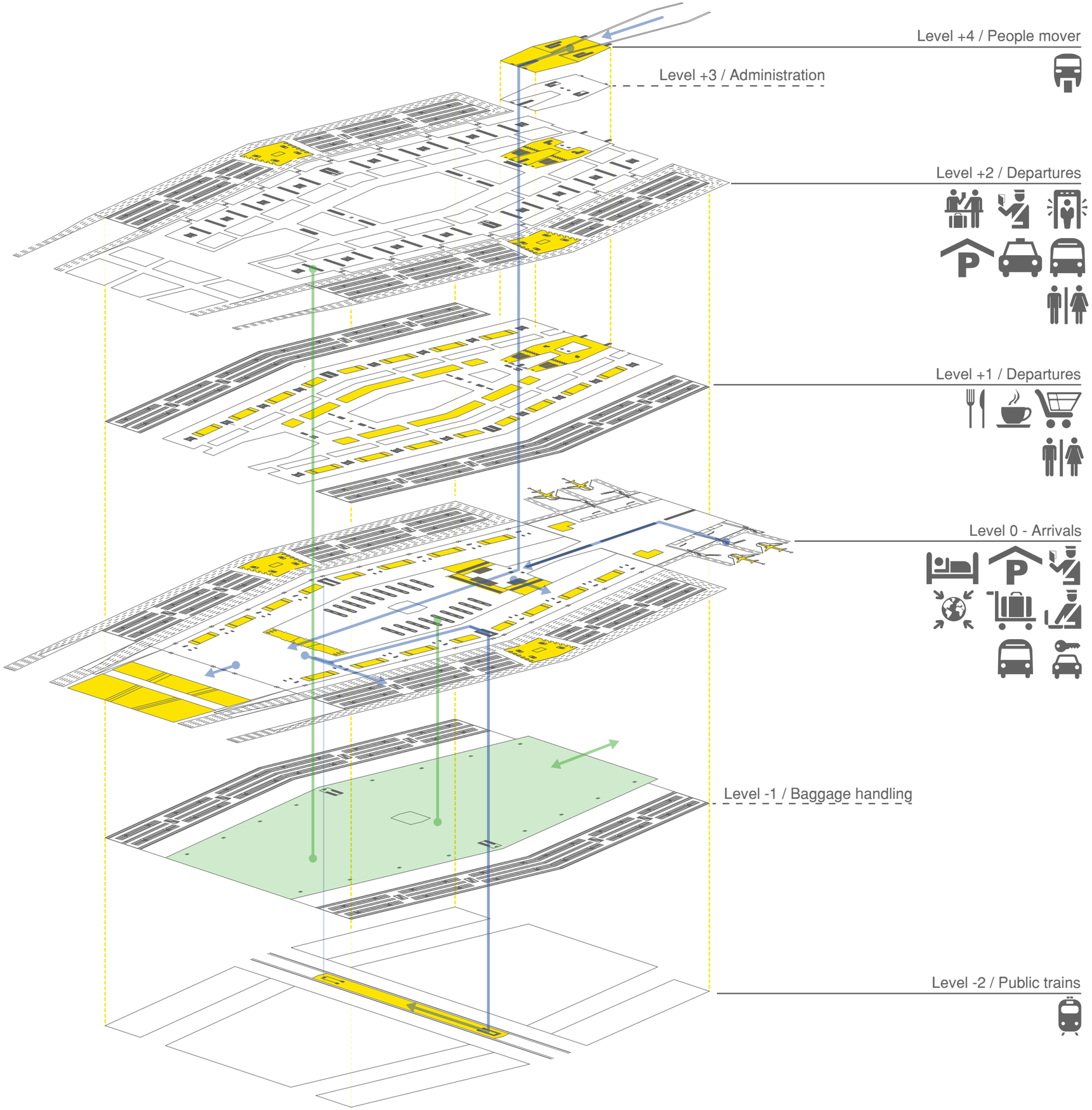
Axonometric view of arrivals

- Departures
- Arrivals
- Flight connections
- Baggage movement
- Physical barrier



ICONS:

- Public trains
- Public buses
- Check-in
- Customs
- Passport control
- WC
- Cafe
- Restaurant
- Hotel
- Taxis
- Car rental
- Parking
- People mover
- Security
- Baggage reclaim
- Business centre
- Park
- Retail


Level +4 / People mover
Level +3 / Administration
Level +2 / Departures
Level +1 / Departures
Level 0 - Arrivals
Level -1 / Baggage handling
Level -2 / Public trains

MAIN AREA

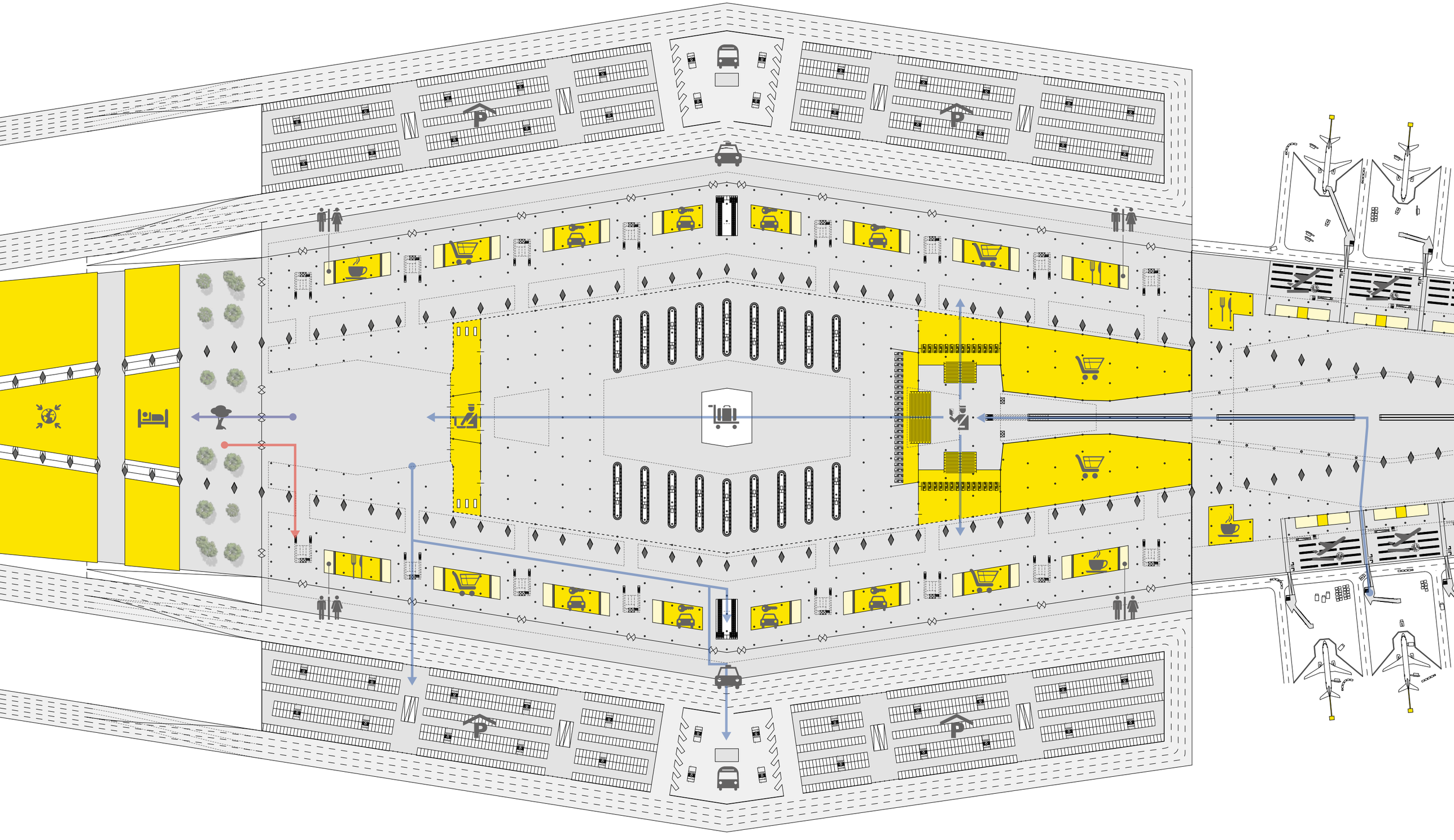
Arrivals +6m / Scale 1:2500

- Departures
- Arrivals
- Flight connections
- Baggage movement
- Physical barrier

+30m
+25m
+20m
+15m
+6m
+0m
-10m

ICONS:

- Public trains
- Public buses
- Check-in
- Customs
- Passport control
- WC
- Cafe
- Restaurant
- Hotel
- Taxis
- Car rental
- Parking
- People mover
- Security
- Baggage reclaim
- Business centre
- Park
- Retail



MAIN AREA

Retail & departures +15m / Scale 1:2500

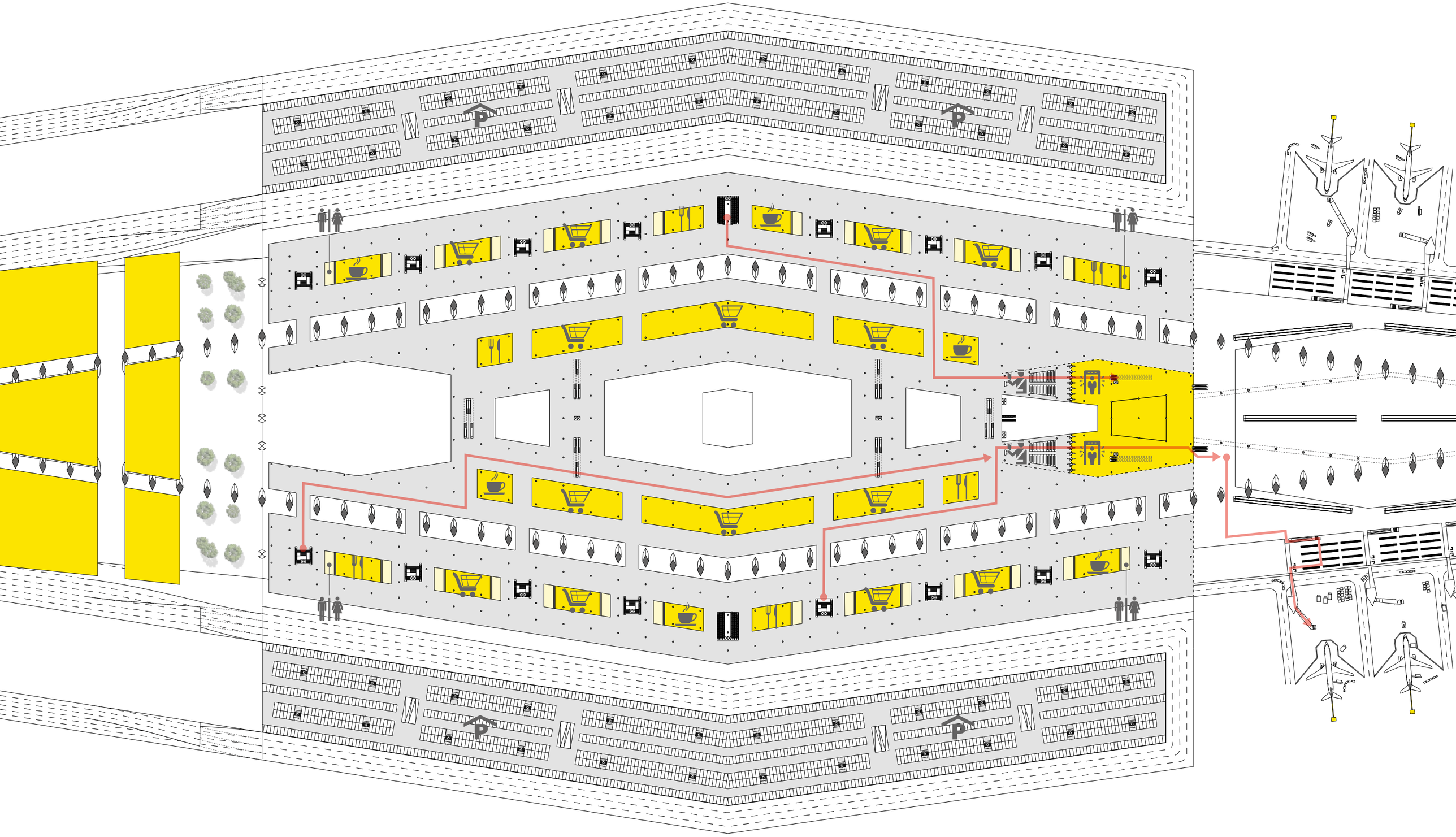
Departures
Arrivals
Flight connections
Baggage movement
Physical barrier

+30m
+25m
+20m
+15m
+6m
+0m
-10m

ICONS:

Public trains
Public buses
Check-in
Customs
Passport control
WC
Cafe
Restaurant
Hotel

Taxis
Car rental
Parking
People mover
Security
Baggage reclaim
Business centre
Park
Retail



MAIN AREA

Check-in & departures+20m / Scale 1:2500

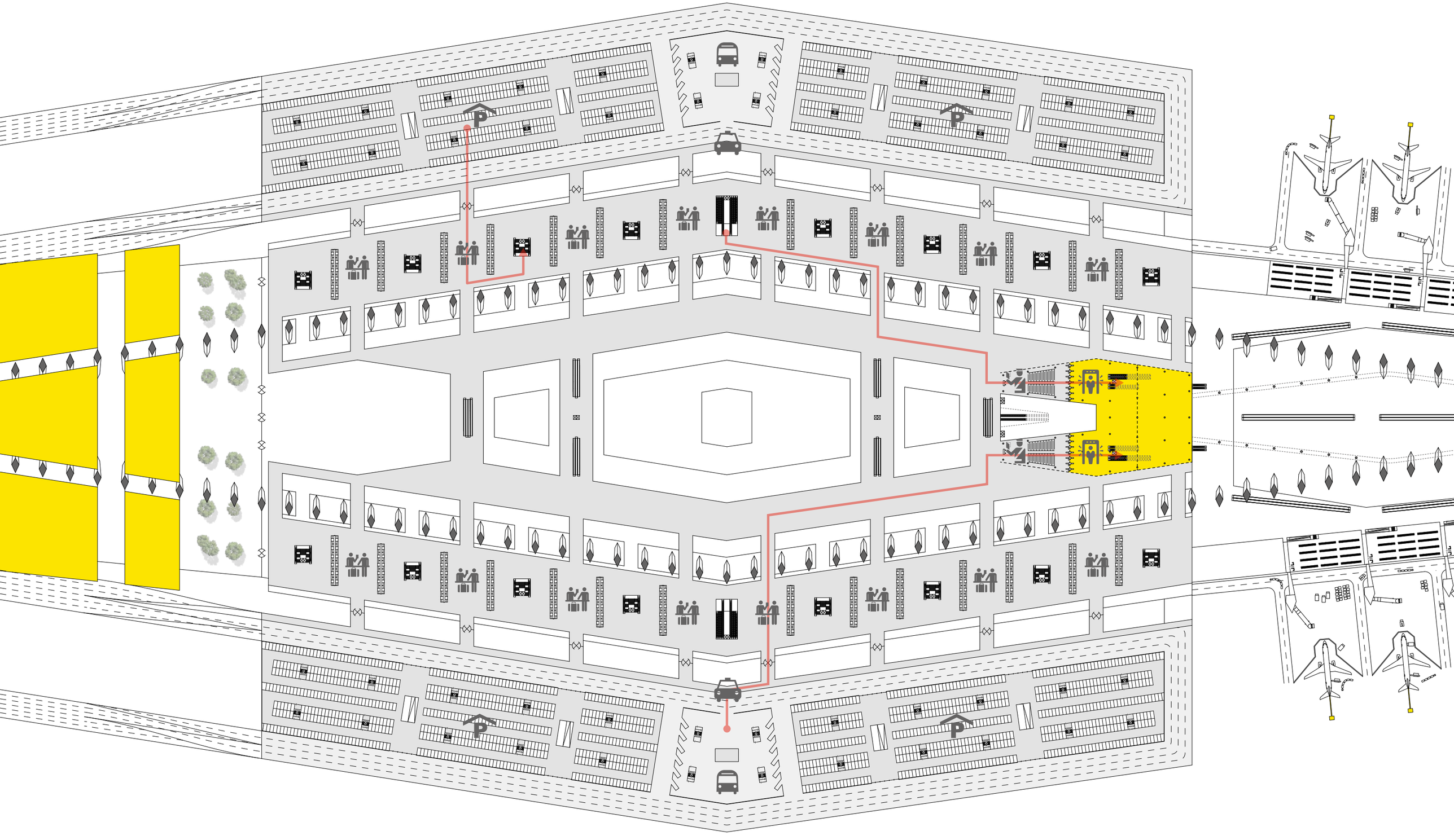
Departures
Arrivals
Flight connections
Baggage movement
Physical barrier

+30m
+25m
+20m
+15m
+6m
+0m
-10m

ICONS:

Public trains
Public buses
Check-in
Customs
Passport control
WC
Cafe
Restaurant
Hotel

Taxis
Car rental
Parking
People mover
Security
Baggage reclaim
Business centre
Park
Retail



MAIN AREA

People mover level +30m / Scale 1:2500

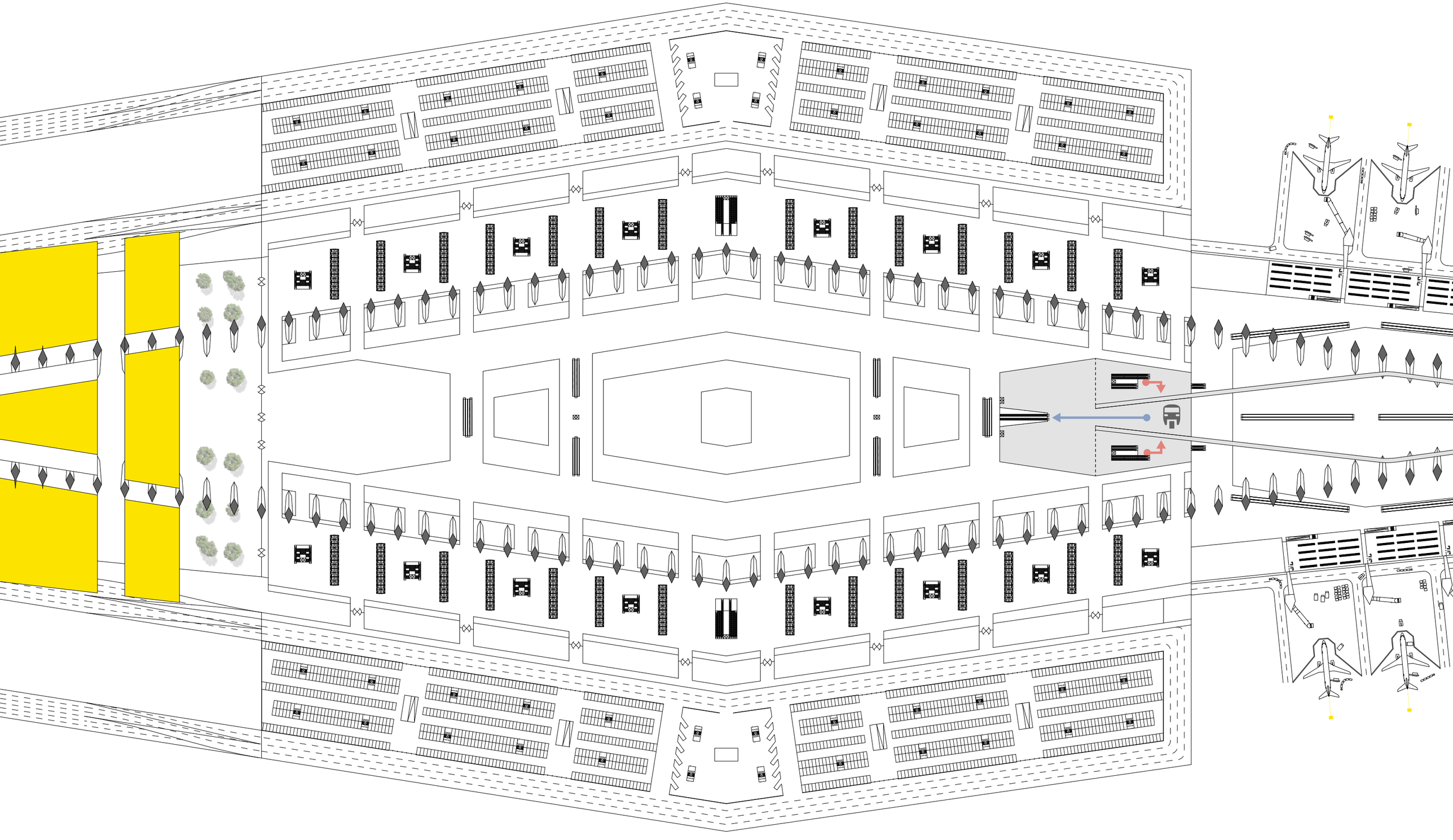
Departures
Arrivals
Flight connections
Baggage movement
Physical barrier

+30m
+25m
+20m
+15m
+6m
+0m
-10m

ICONS:

Public trains
Public buses
Check-in
Customs
Passport control
WC
Cafe
Restaurant
Hotel

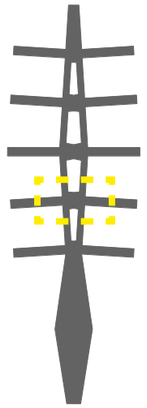
Taxis
Car rental
Parking
People mover
Security
Baggage reclaim
Business centre
Park
Retail



TERMINAL INTERSECTION

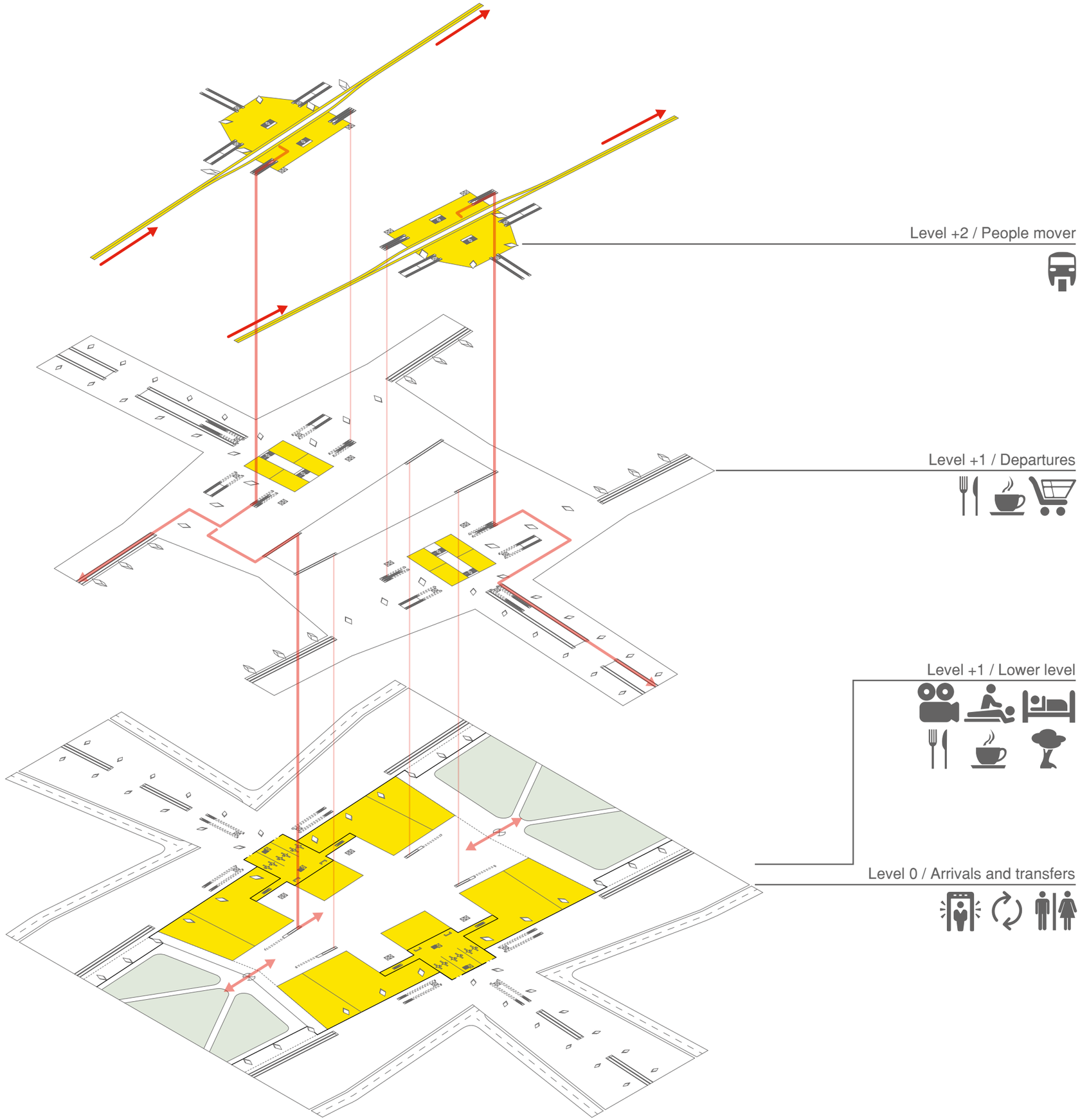
Axonometric view of departures

- Departures
- Arrivals
- Flight connections
- Baggage movement
- Physical barrier



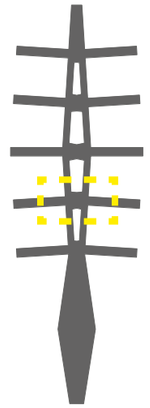
ICONS:

- Lounges
- Passport control
- WC
- Cafe
- Restaurant
- Spa
- Hotel
- Flight connections
- Security
- People-move
- Cinema
- Park
- Retail


Level +2 / People mover
Level +1 / Departures
Level +1 / Lower level
Level 0 / Arrivals and transfers

TERMINAL INTERSECTION

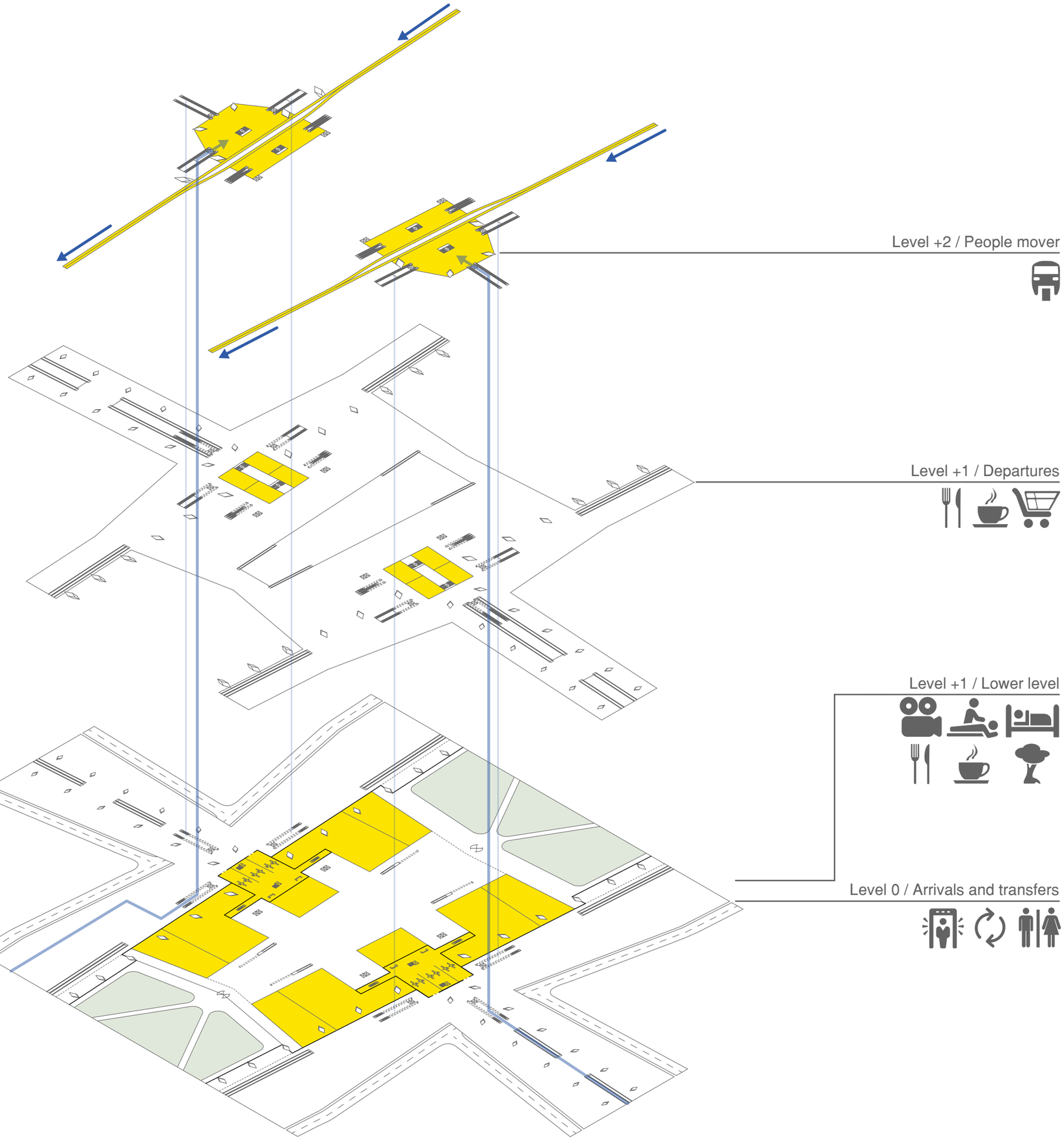
Axonometric view of arrivals



- Departures
- Arrivals
- Flight connections
- Baggage movement
- Physical barrier

ICONS:

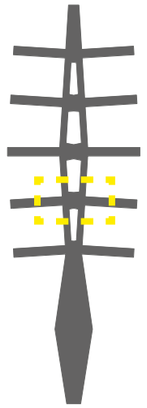
- Lounges
- Passport control
- Flight connections
- WC
- Security
- Cafe
- People-move
- Restaurant
- Cinema
- Spa
- Park
- Hotel
- Retail


Level +2 / People mover
Level +1 / Departures
Level +1 / Lower level
Level 0 / Arrivals and transfers

TERMINAL INTERSECTION

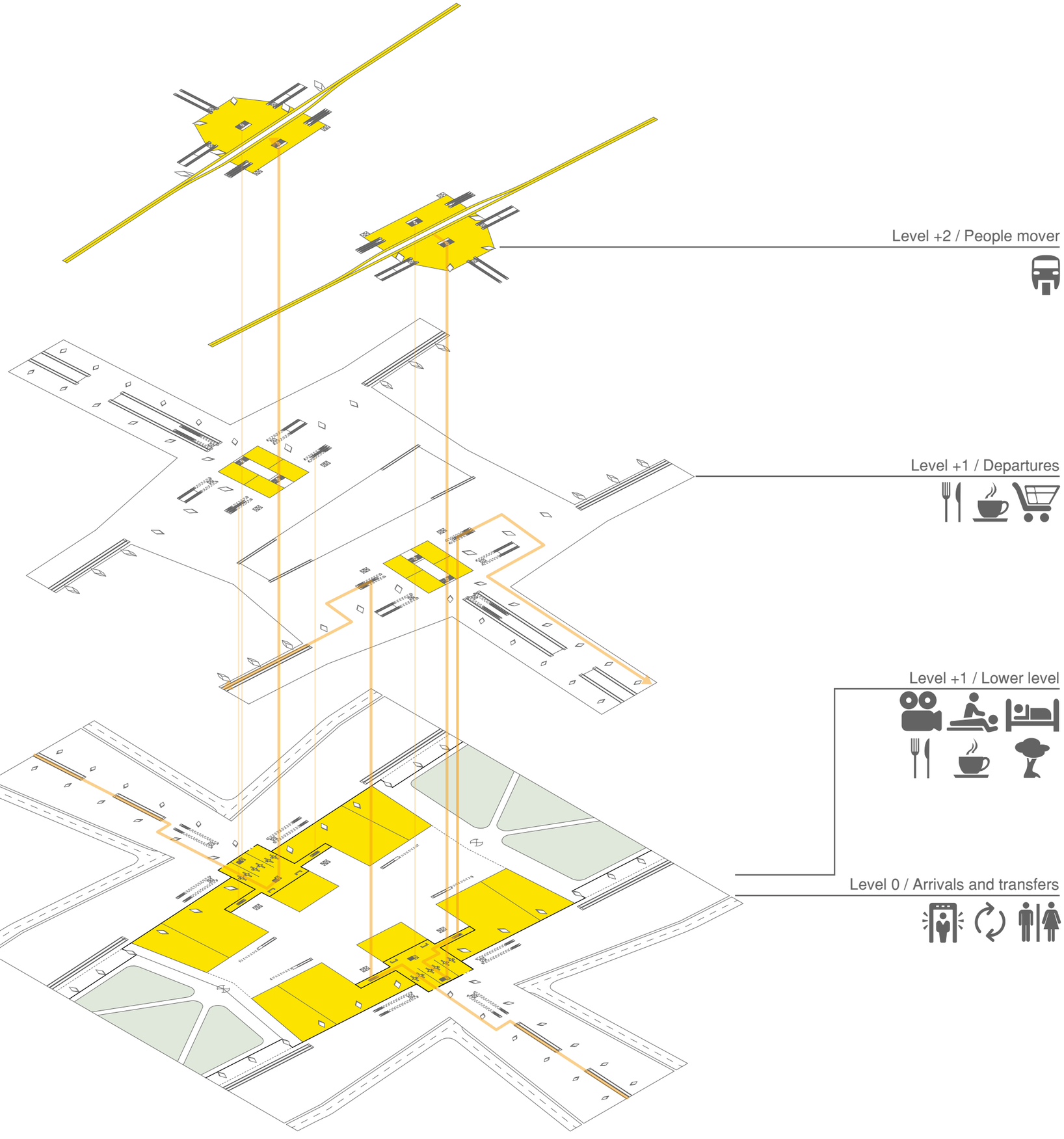
Axonometric view of flight connections

- Departures
- Arrivals
- Flight connections
- Baggage movement
- Physical barrier



ICONS:

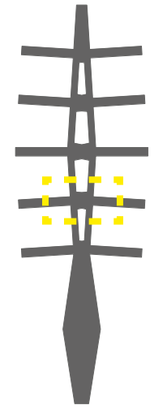
- Lounges
- Passport control
- WC
- Cafe
- Restaurant
- Spa
- Hotel
- Flight connections
- Security
- People-move
- Cinema
- Park
- Retail


Level +2 / People mover
Level +1 / Departures
Level +1 / Lower level
Level 0 / Arrivals and transfers

TERMINAL INTERSECTION

Arrivals and departures +6m / Scale 1:1000

Departures
Arrivals
Flight connections
Baggage movement
Physical barrier



+18m
+11m
+6m
+0m

ICONS:


Lounges


Passport control


Flight connections


WC


Security


Cafe


People-move


Restaurant

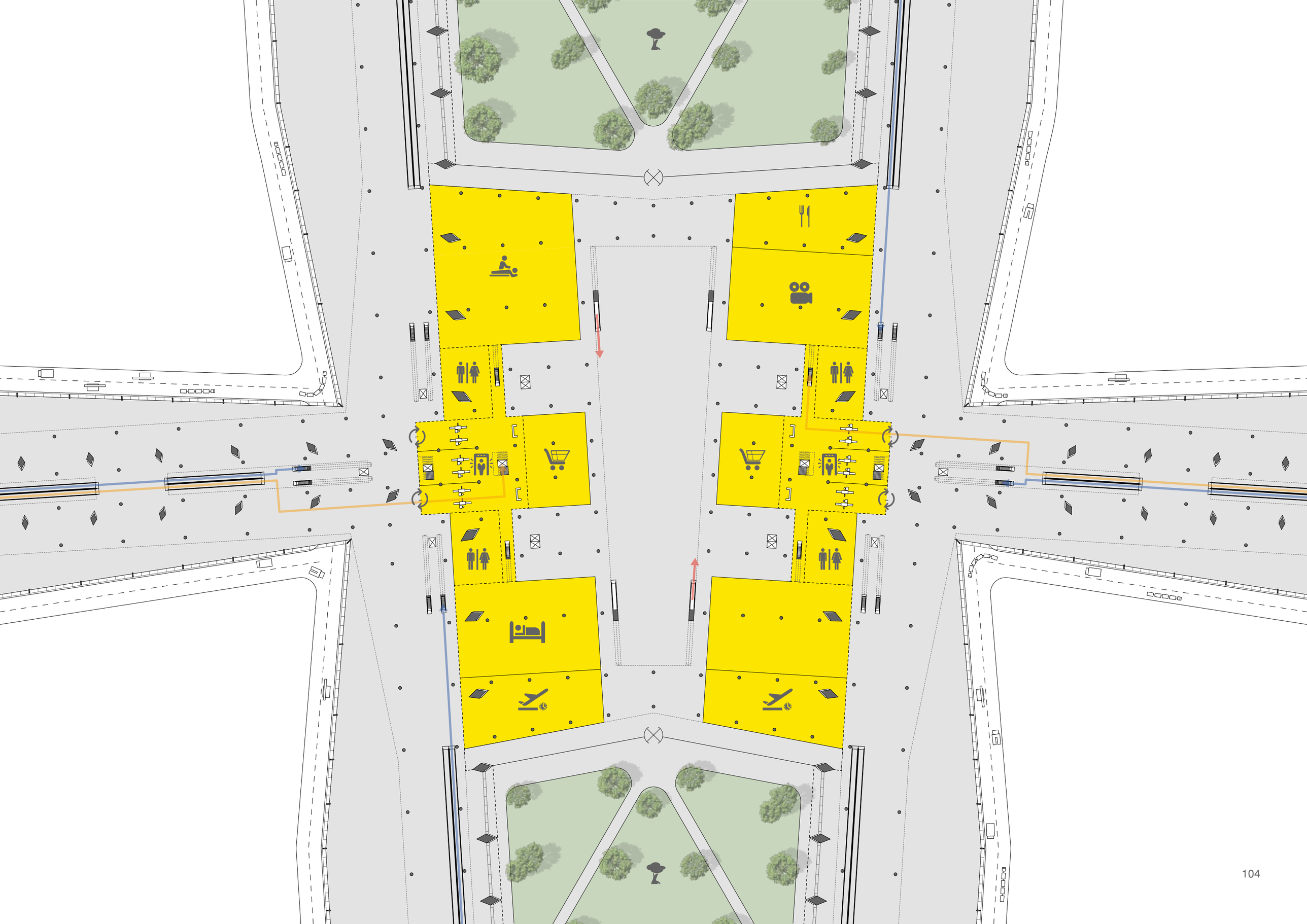

Cinema


Spa


Park

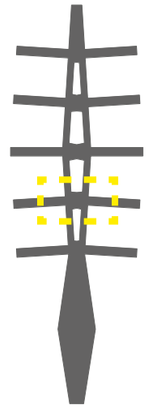

Hotel


Retail



TERMINAL INTERSECTION

Departures+11m / Scale 1:1000

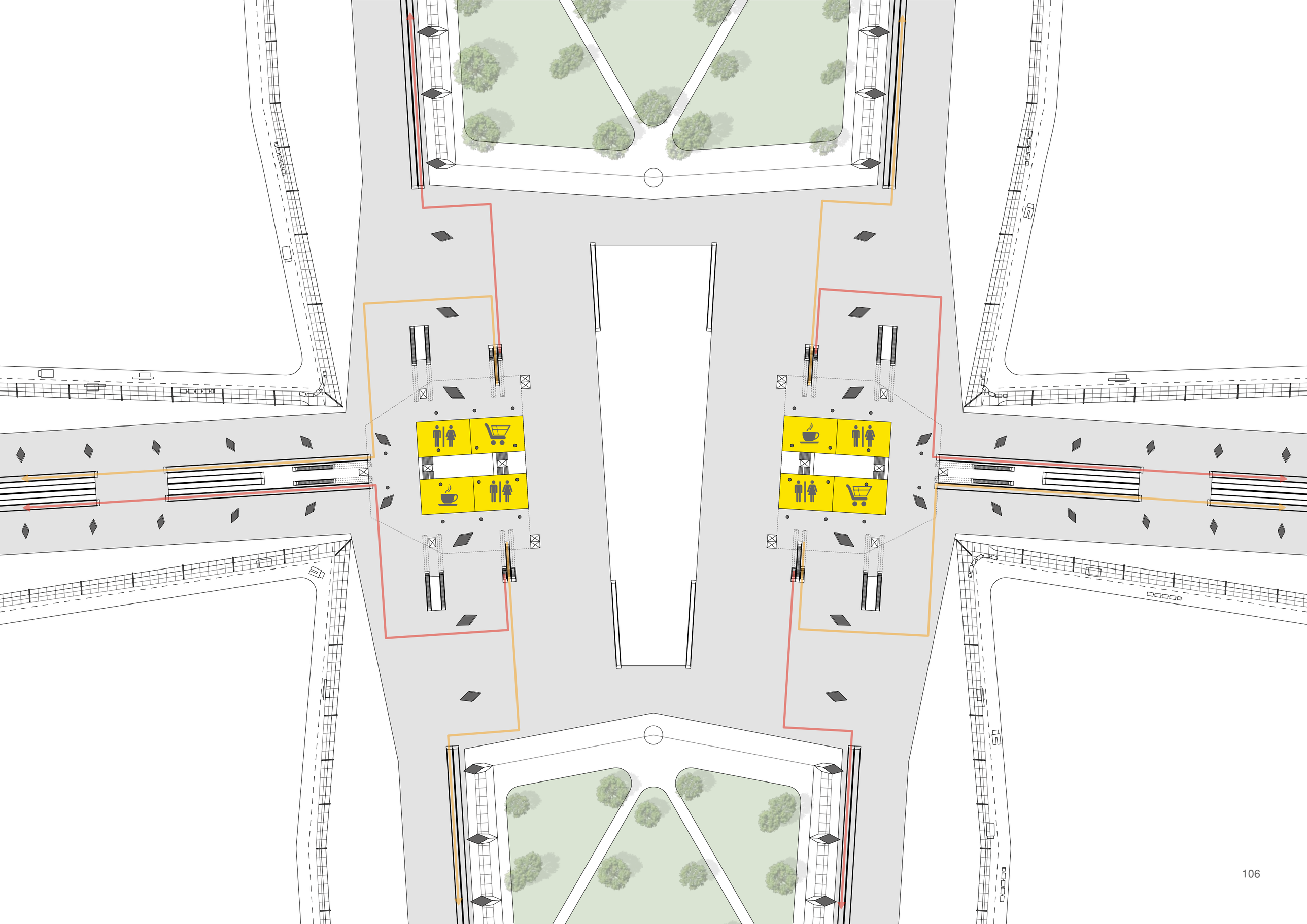


Departures
Arrivals
Flight connections
Baggage movement
Physical barrier

+18m
+11m
+6m
+0m

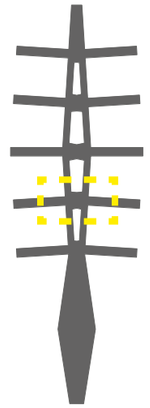
ICONS:

Lounges
Passport control
Flight connections
WC
Security
Cafe
People-move
Restaurant
Cinema
Spa
Park
Hotel
Retail



TERMINAL INTERSECTION

People mover +18m / Scale 1:1000



Departures
Arrivals
Flight connections
Baggage movement
Physical barrier

+18m
+11m
+6m
+0m

ICONS:


Lounges


Passport control


Flight connections


WC


Security


Cafe


People-move


Restaurant

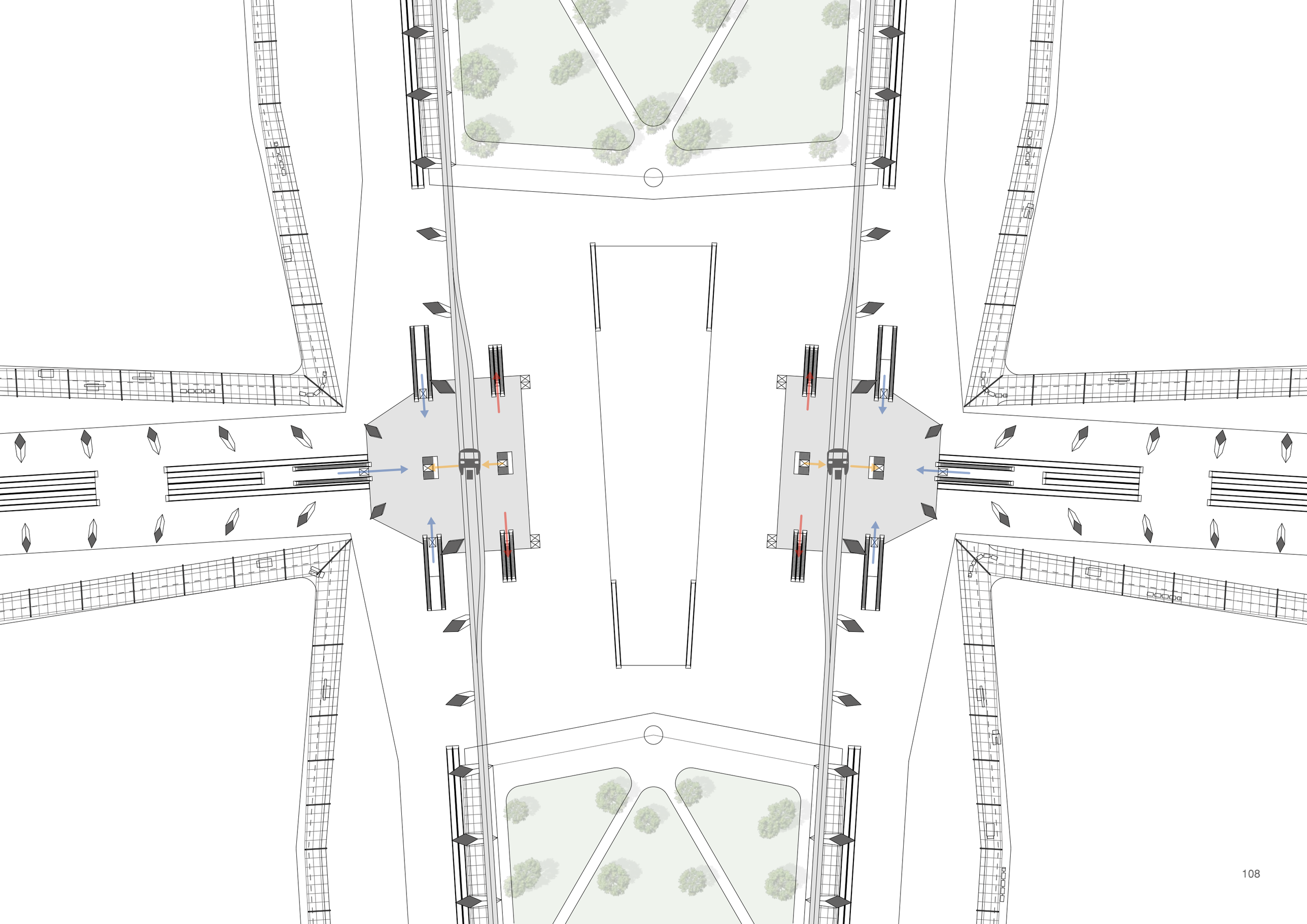

Cinema


Spa


Park


Hotel

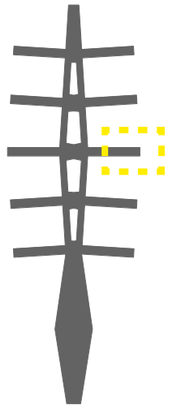

Retail



TERMINAL FINGER

Axonometric view of departures

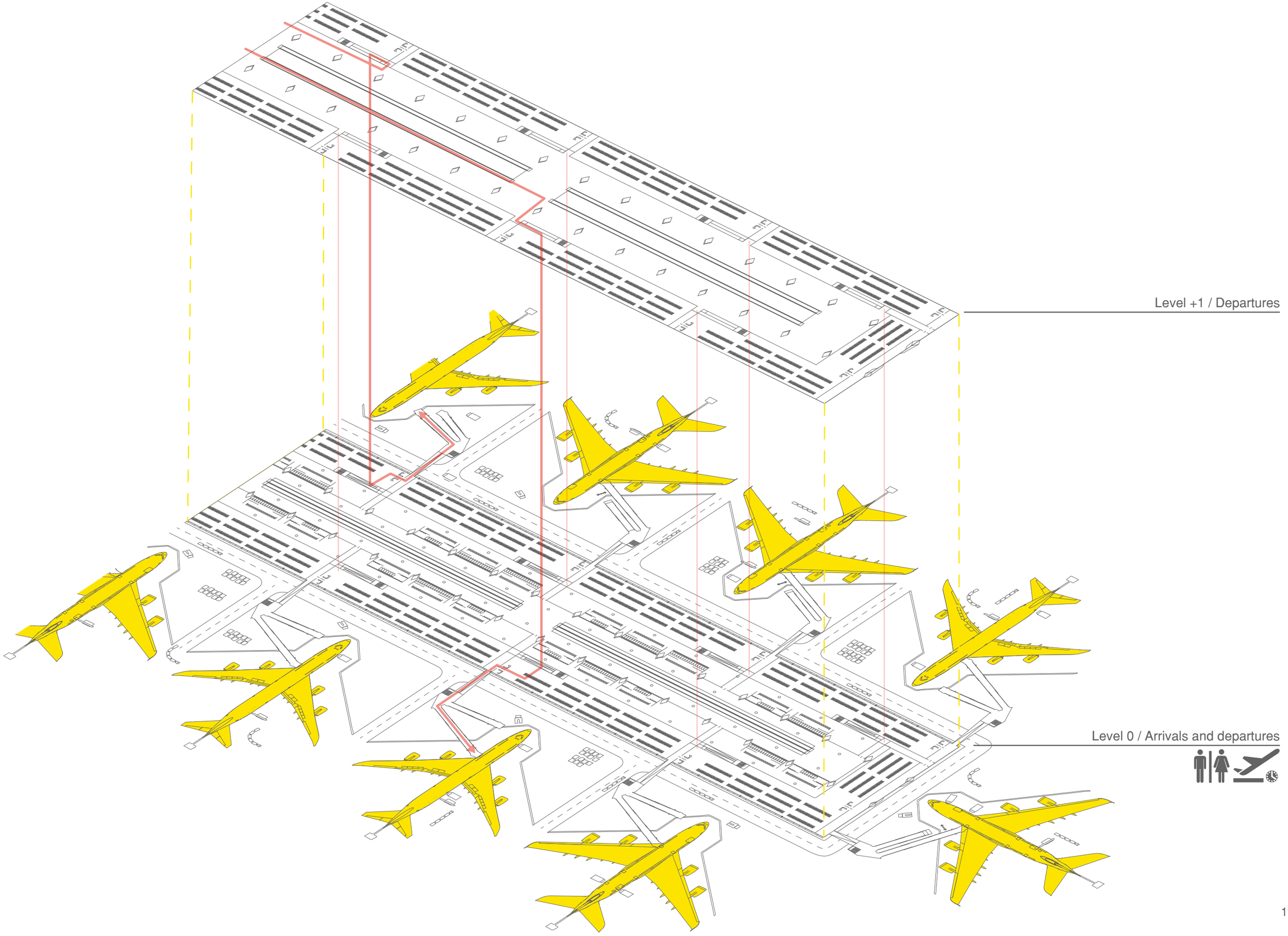
- Departures
- Arrivals
- Flight connections
- Baggage movement
- Physical barrier



ICONS:

WC

Waiting areas

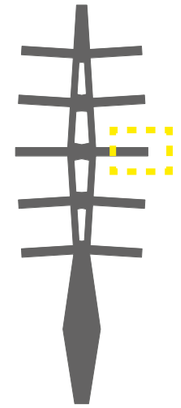


Level +1 / Departures

Level 0 / Arrivals and departures

TERMINAL FINGER

Axonometric view of arrivals



- Departures
- Arrivals
- Flight connections
- Baggage movement
- Physical barrier

ICONS:

WC

Waiting areas

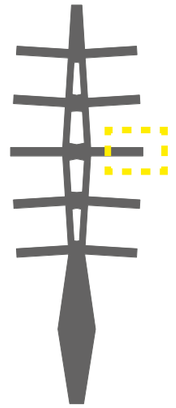
Level +1 / Departures

Level 0 / Arrivals and departures

TERMINAL FINGER

Axonometric view of flight connections

- Departures
- Arrivals
- Flight connections
- Baggage movement
- Physical barrier



ICONS:

WC

Waiting areas

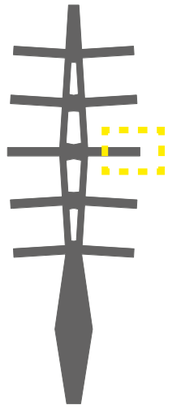
Level +1 / Departures

Level 0 / Arrivals and departures

TERMINAL FINGER

Departures +6m / Scale 1:1000

Departures
Arrivals
Flight connections
Baggage movement
Physical barrier

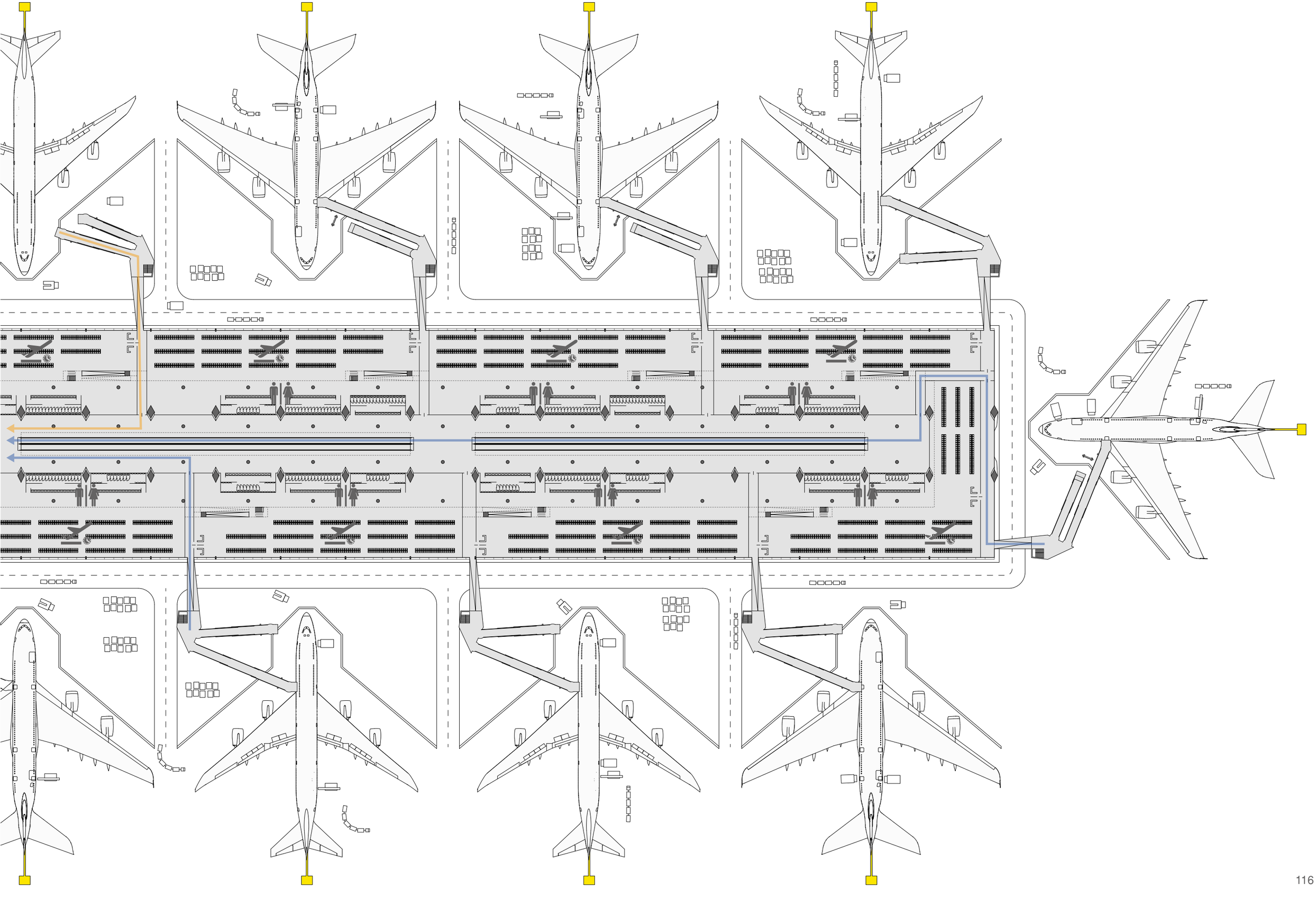


+11m
+6m
+0m

ICONS:

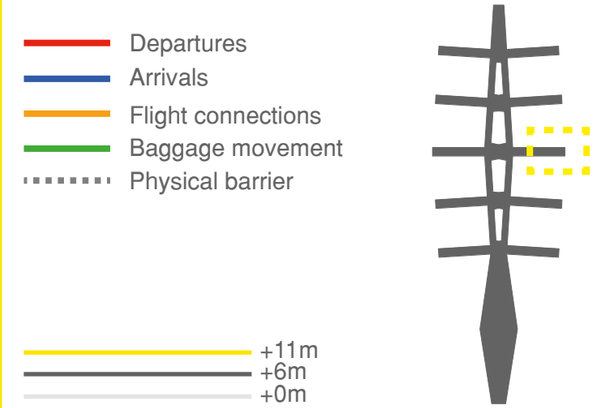
WC

Waiting areas



TERMINAL FINGER

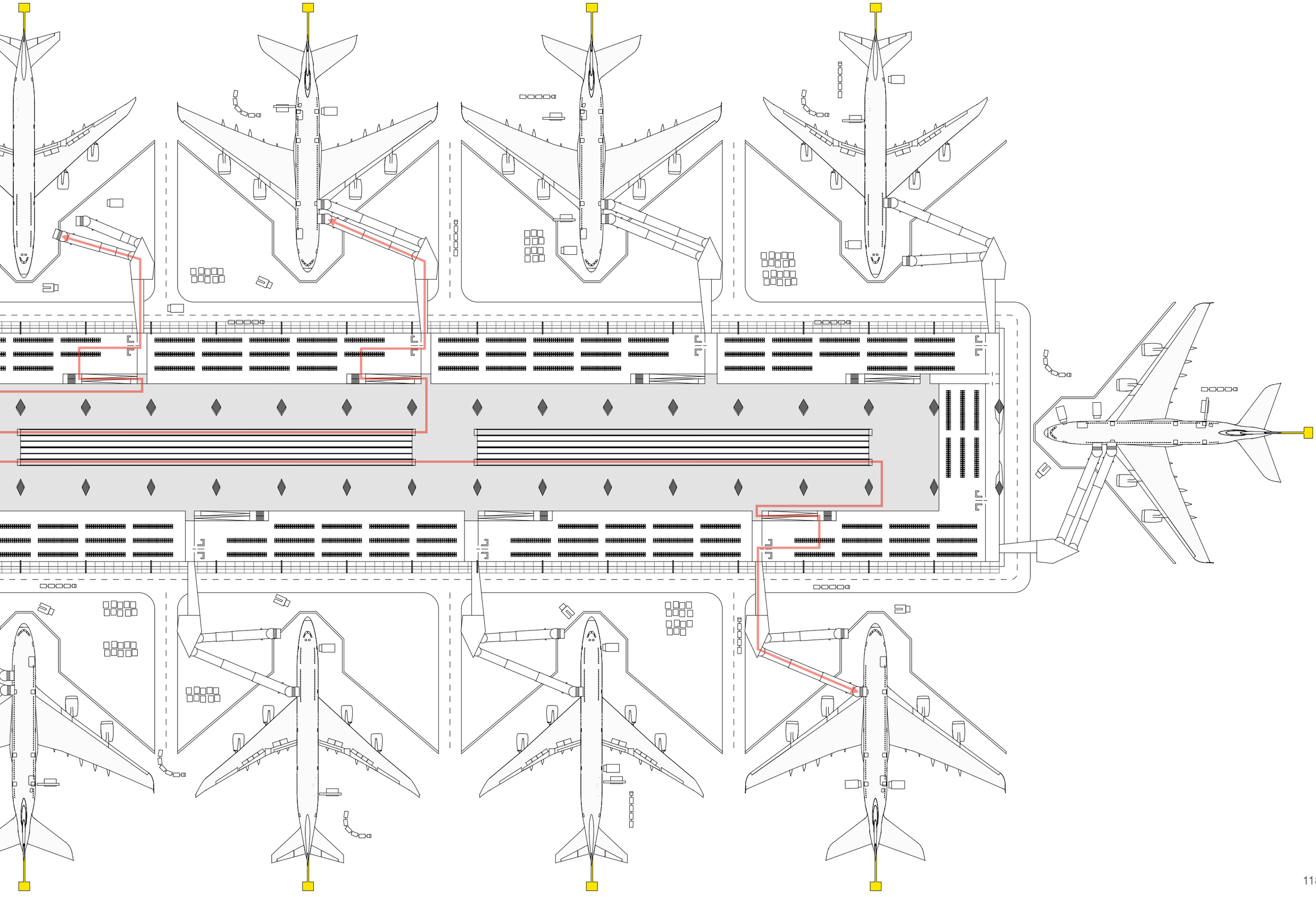
Departures & arrivals +11m / Scale 1:1000

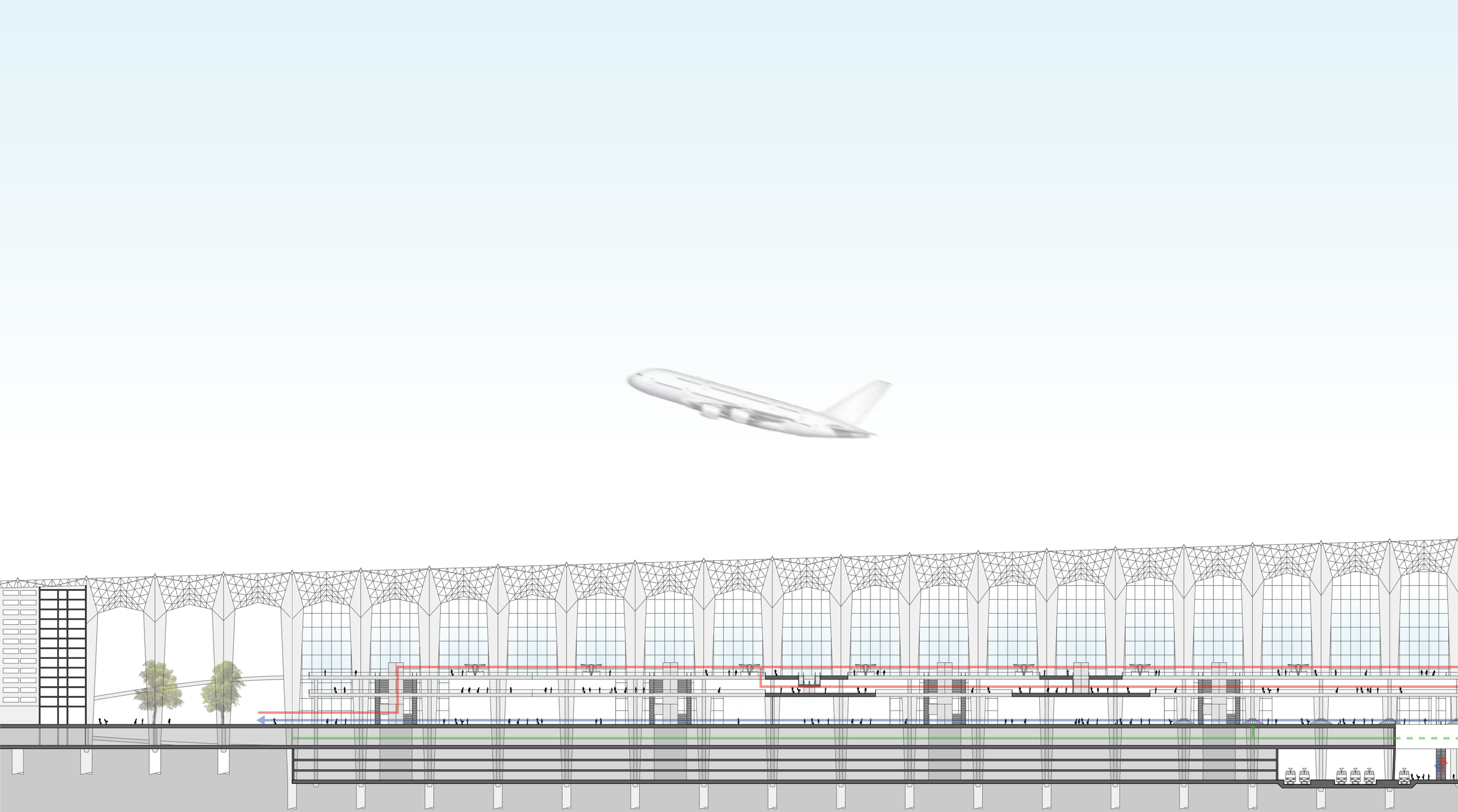


ICONS:

WC

Waiting areas

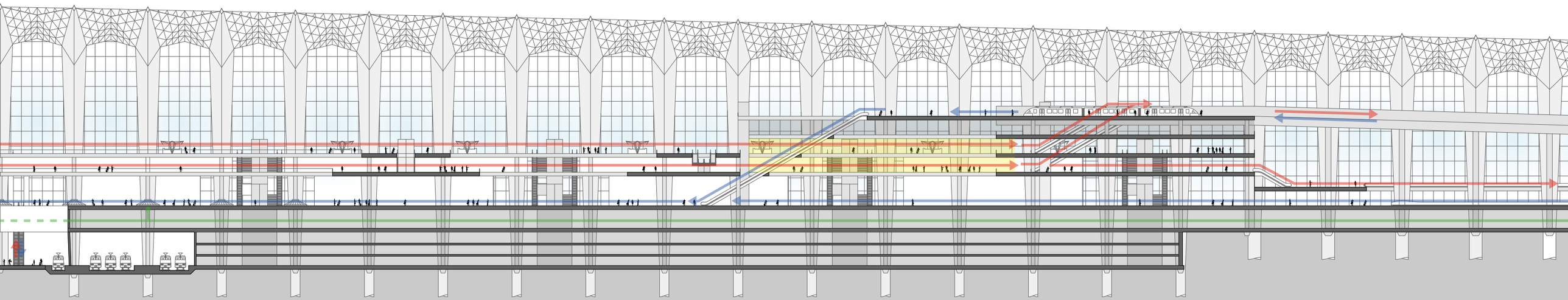


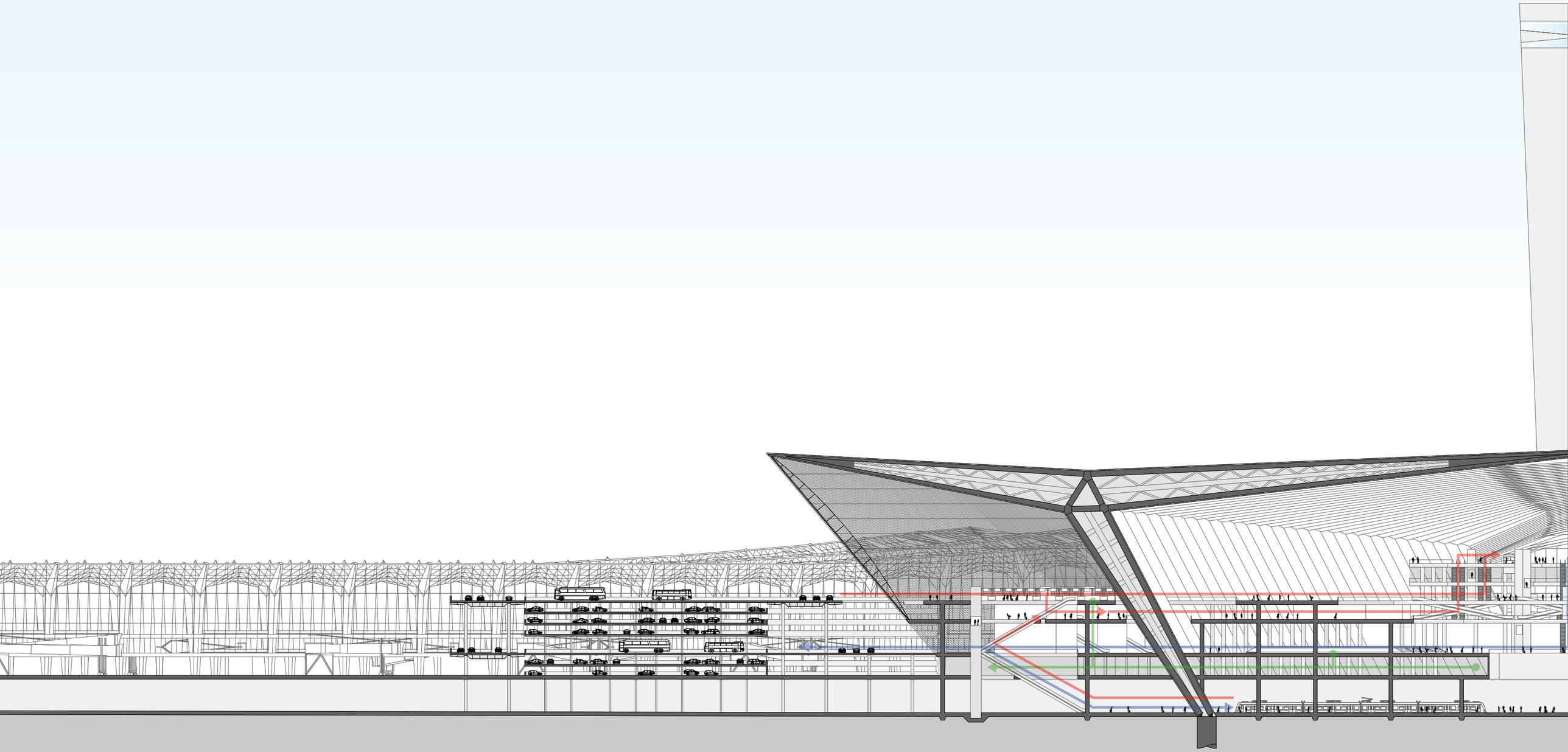


SECTION A-A

Departures & arrivals / Scale 1:1000

- Departures
- Arrivals
- Flight connections
- Baggage movement
- Physical barrier
- Security areas

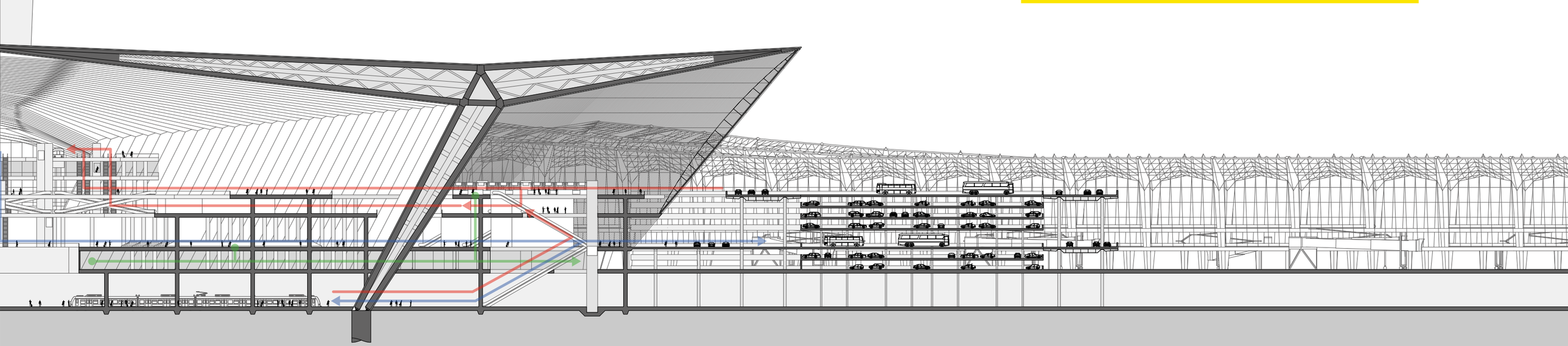


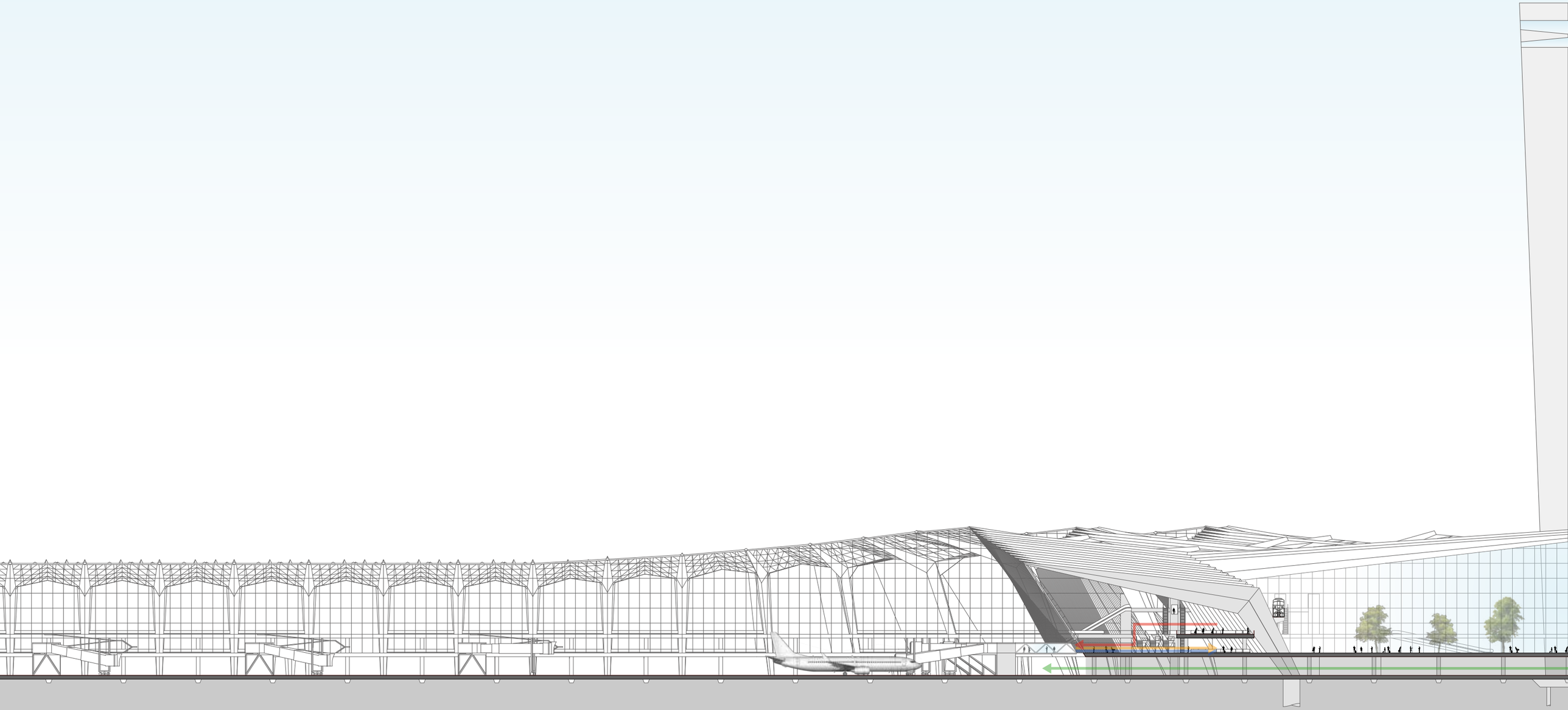


SECTION B-B

Departures & arrivals / Scale 1:1000

- Departures
- Arrivals
- Flight connections
- Baggage movement
- Physical barrier
- Security areas

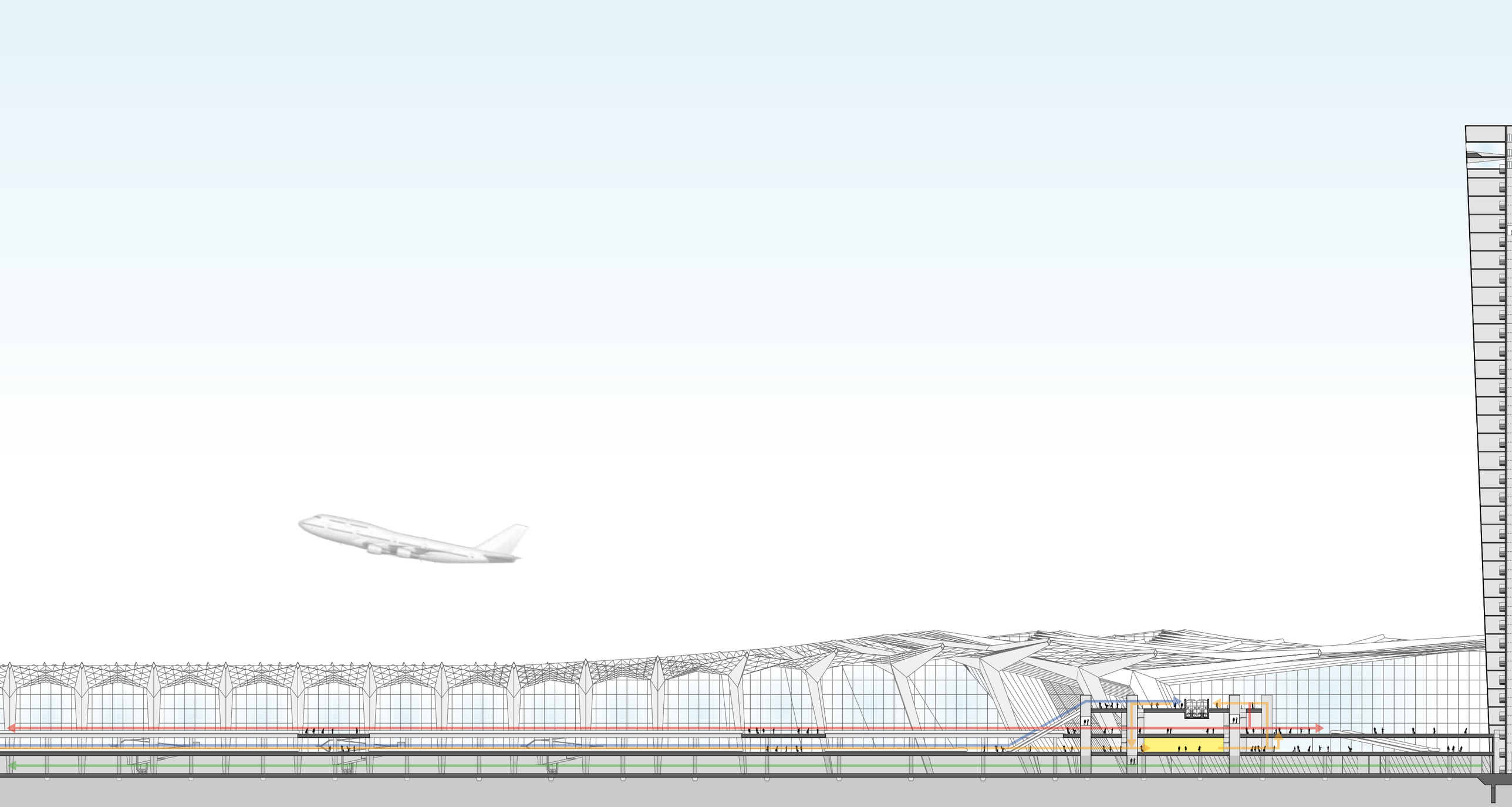




SECTION C-C

Terminal park / Scale 1:1000

- Departures
- Arrivals
- Flight connections
- Baggage movement
- Physical barrier
- Security areas



SECTION D-D

Terminal intersection / Scale 1:1000

Departures

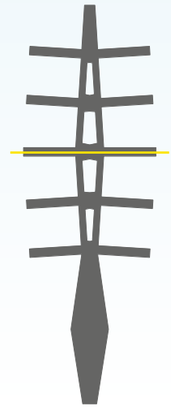
Arrivals

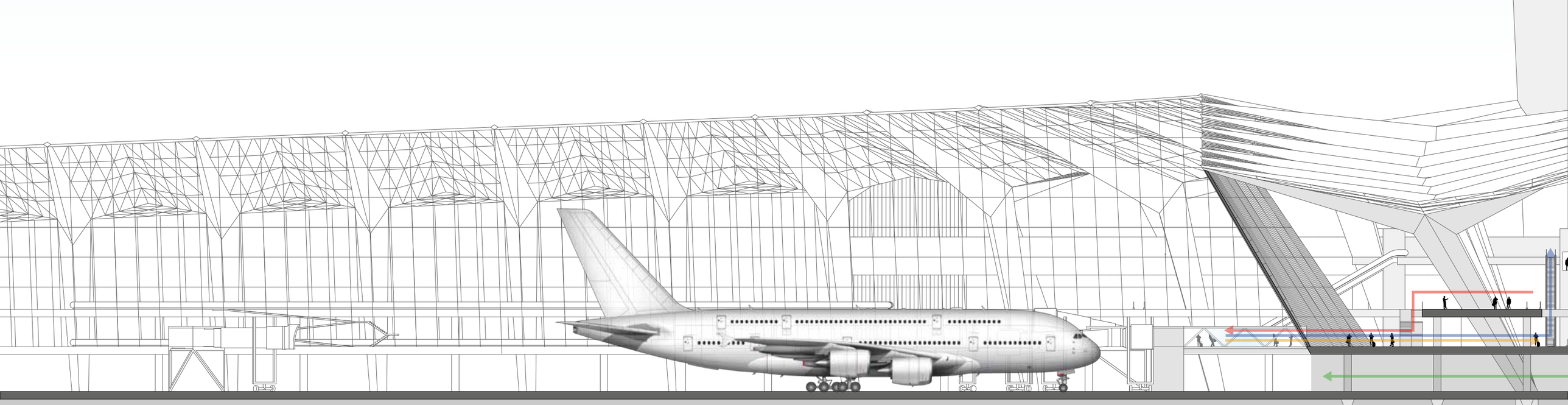
Flight connections

Baggage movement

Physical barrier

Security areas

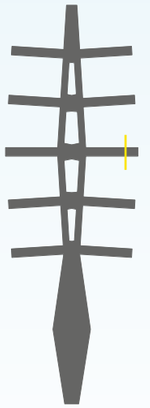


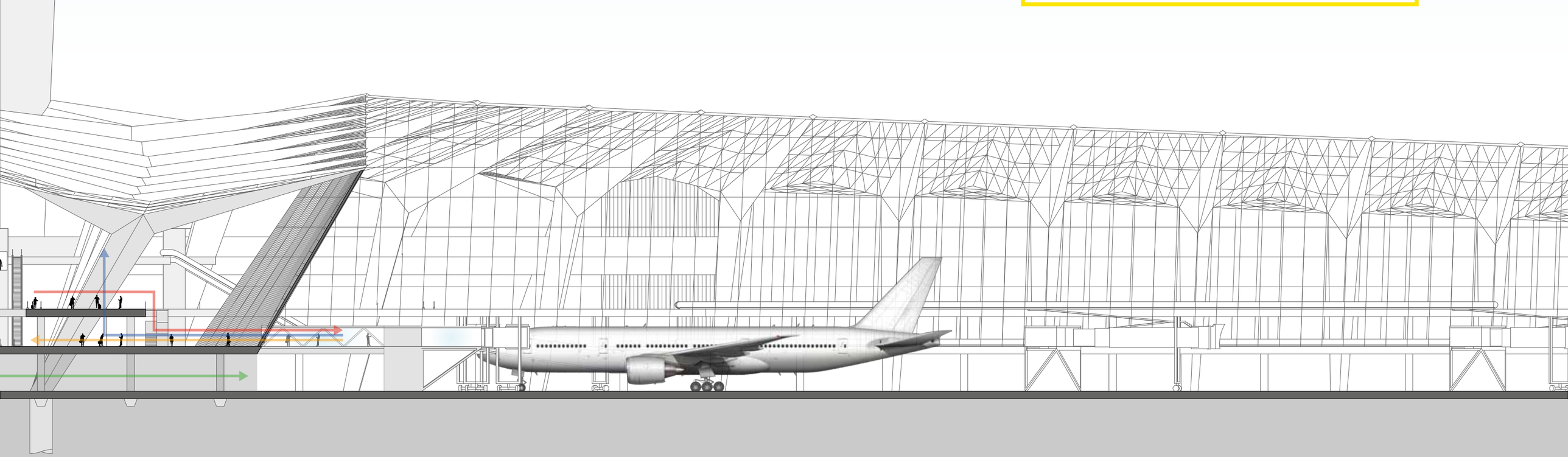


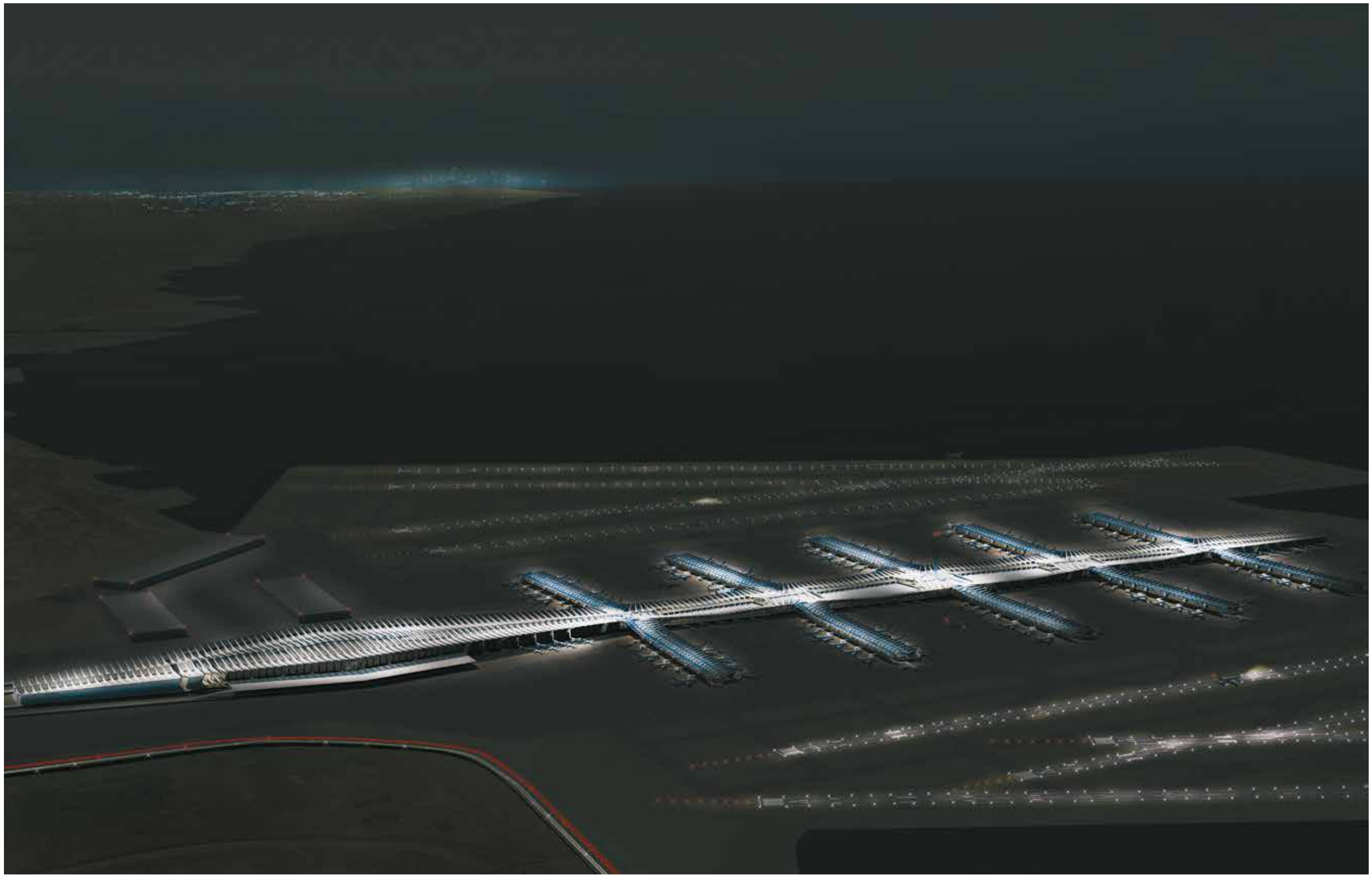
SECTION E-E

Terminal finger / Scale 1:500

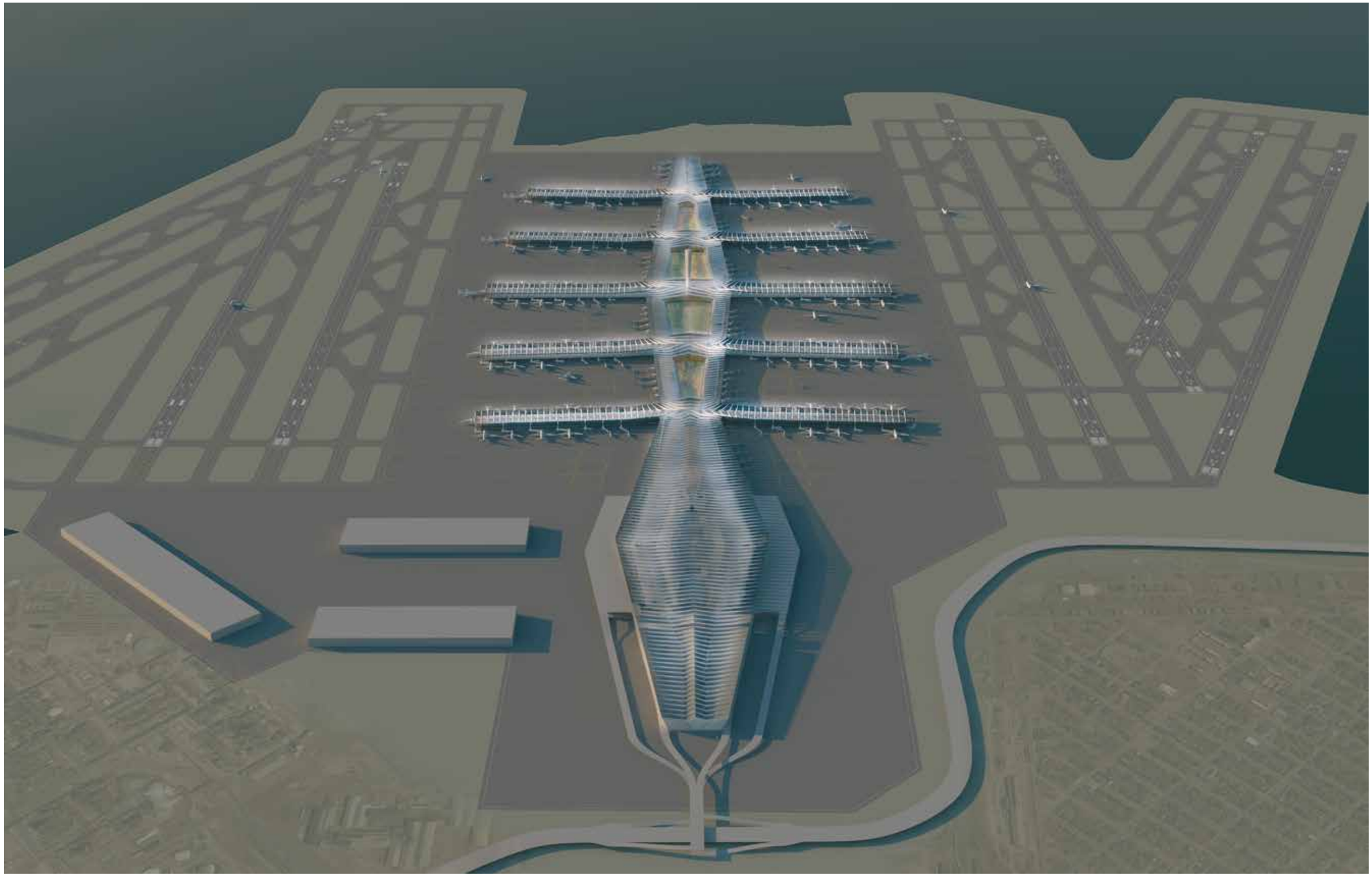
- Departures
- Arrivals
- Flight connections
- Baggage movement
- Physical barrier
- Security areas



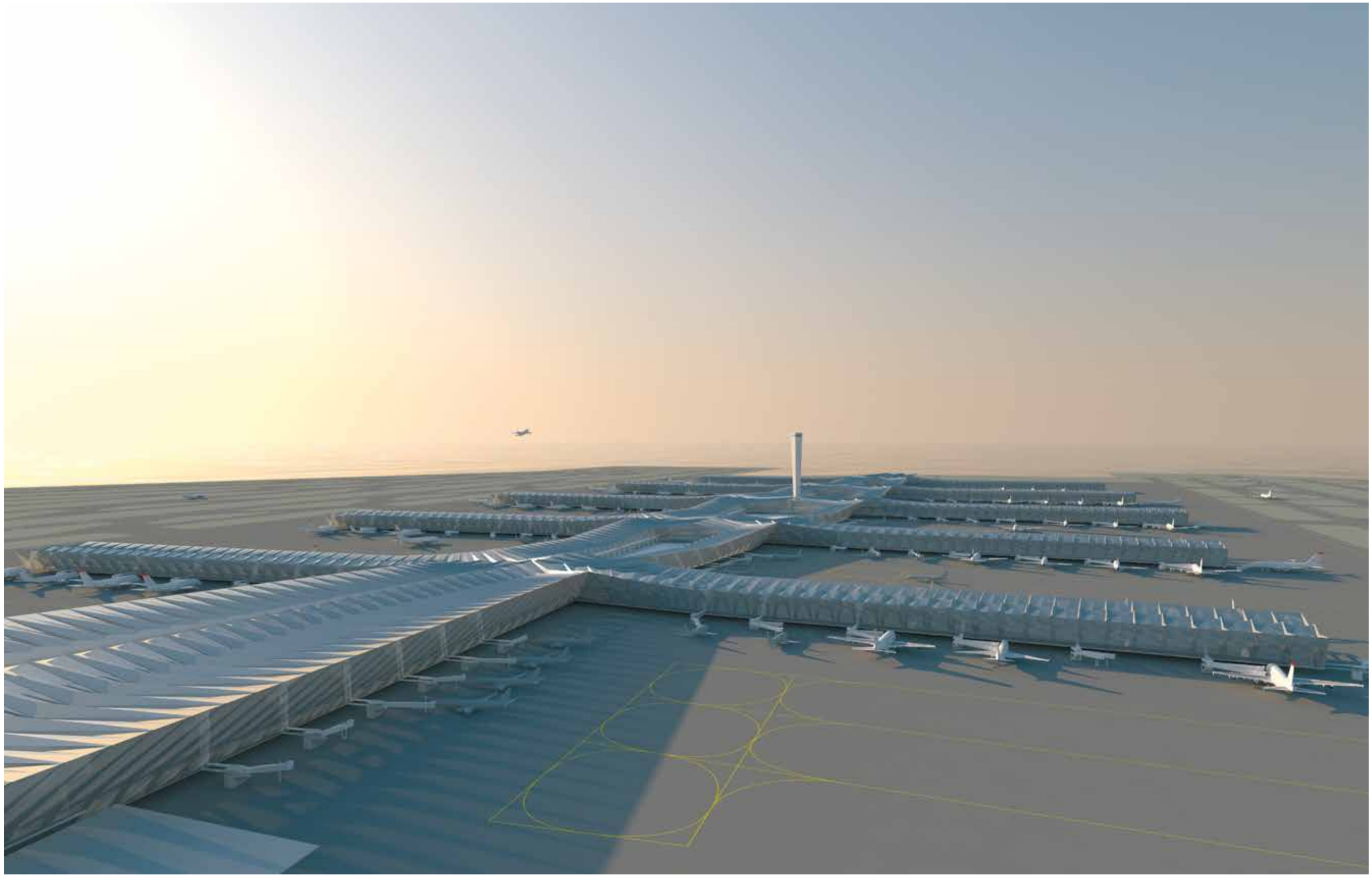




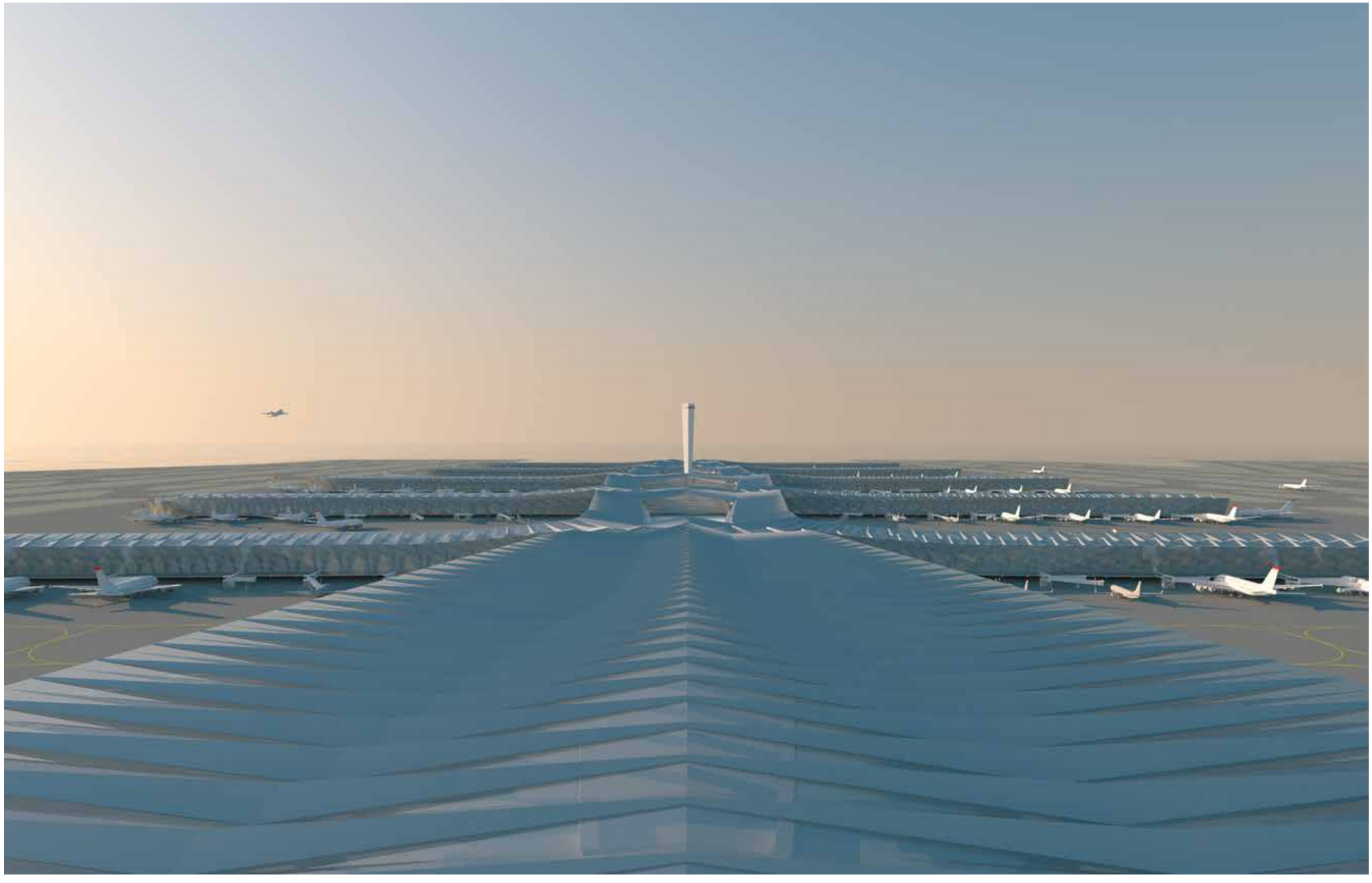
View of the airport, by night, looking towards downtown Chicago



View of the airport from the south-west at dusk

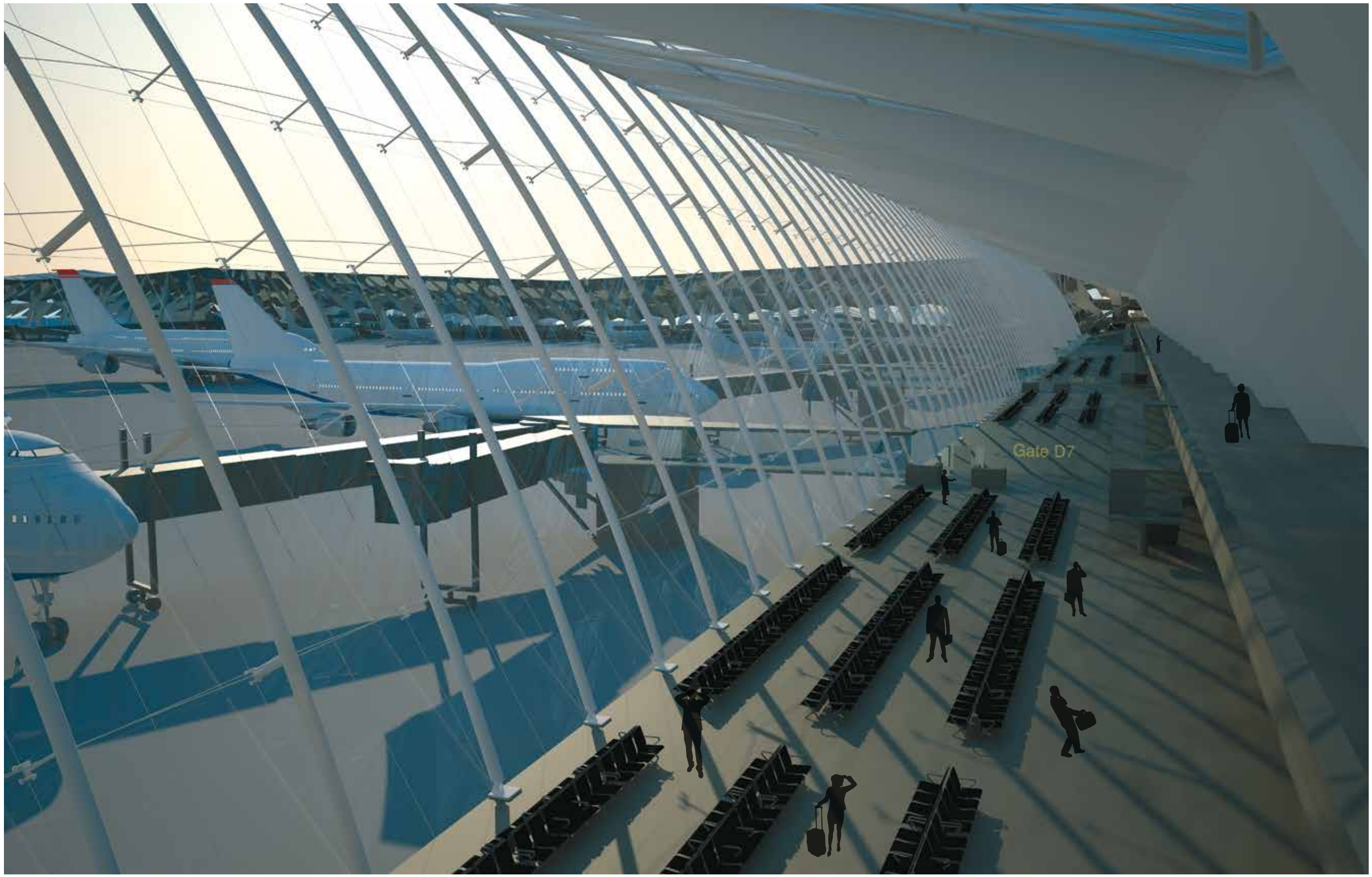


View looking towards the air-traffic control tower



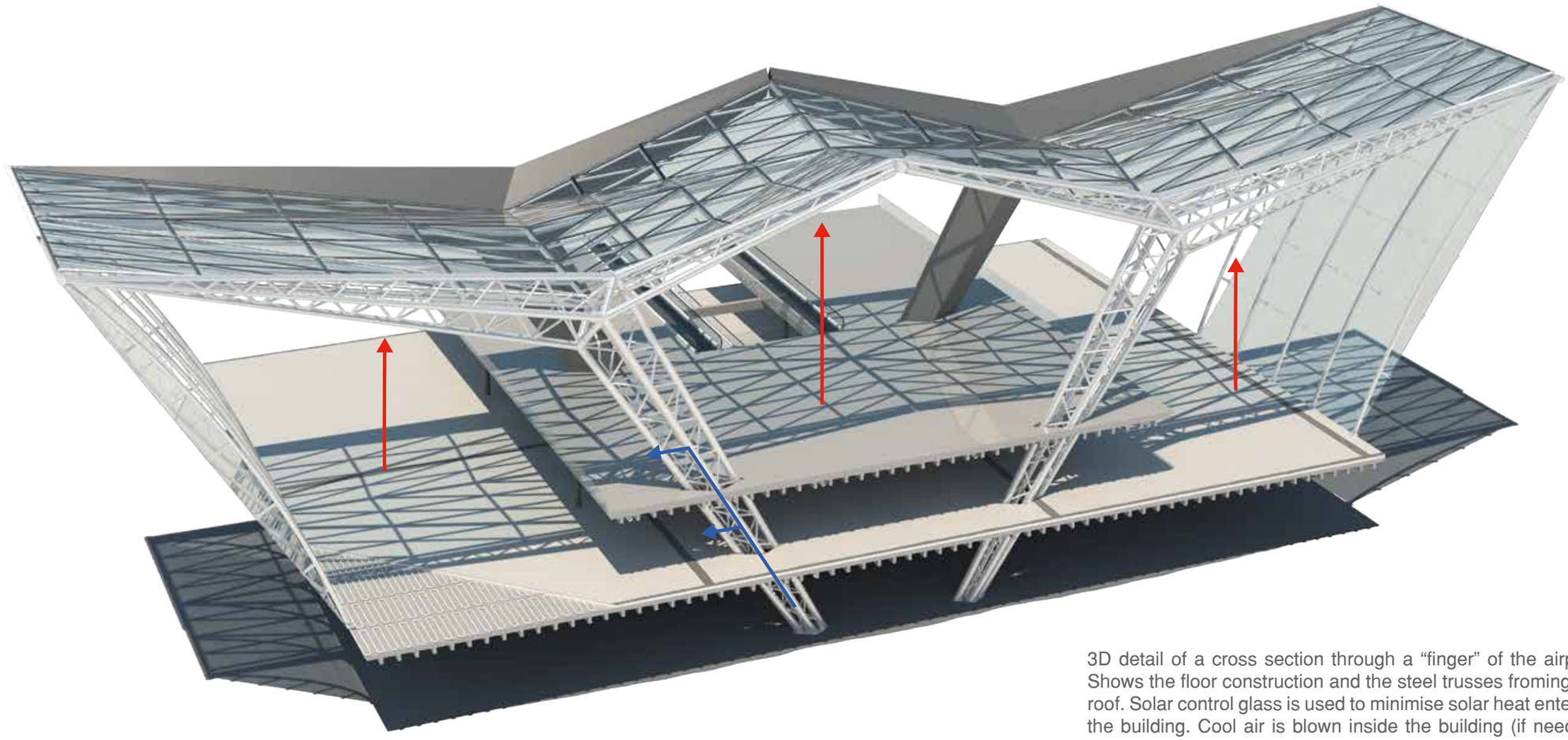
View along the spine of the building looking towards the control tower

View inside the main arrival/departure towards the arrivals exit



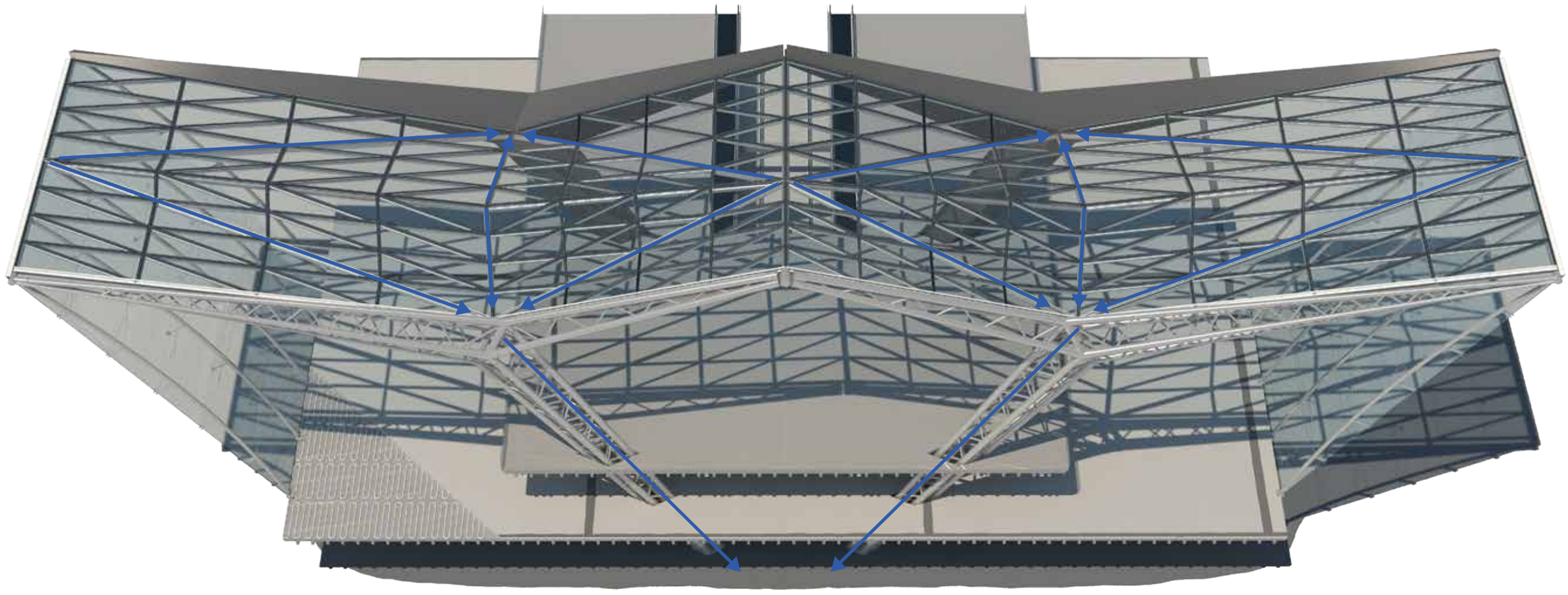
View inside one of the “fingers” where passengers wait to board their planes

CONSTRUCTION



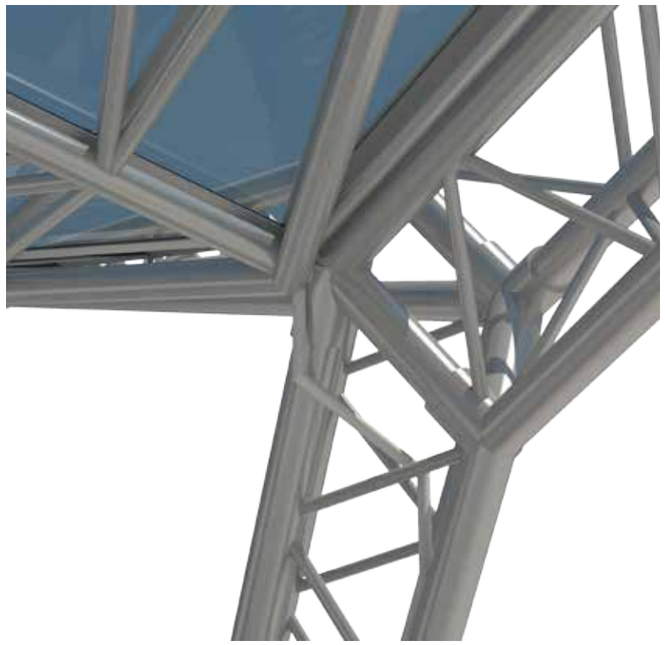
3D detail of a cross section through a “finger” of the airport. Shows the floor construction and the steel trusses froming the roof. Solar control glass is used to minimise solar heat entering the building. Cool air is blown inside the building (if needed) through opening in the vertical parts of the frames. Excess warm air is vented through glass elements which open and regulate themselves according to temperature. Floor cooling/ heating is used to obtain a temperate ambient temperature throughout the building.

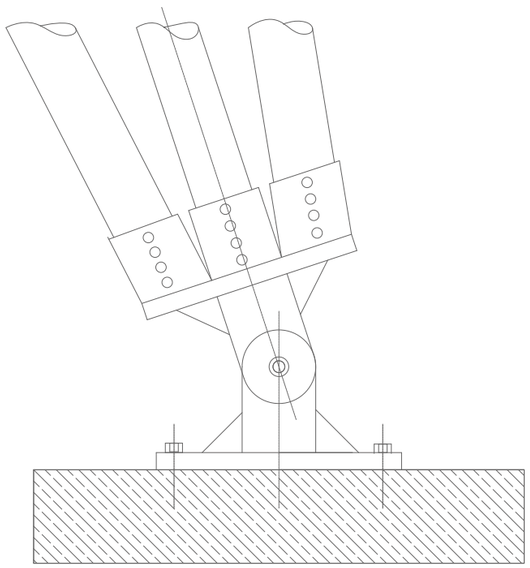
Image showing the drainage system of the roof. Blue arrows show the movement of water towards the four drainage points found in each section of the roof. The water is then drained inside the steel-clad truss frames. Heated drainage canals are used to melt static snow or ice.



◄ *Cut away image of the underfloor heating and cooling throughout the terminal building.*

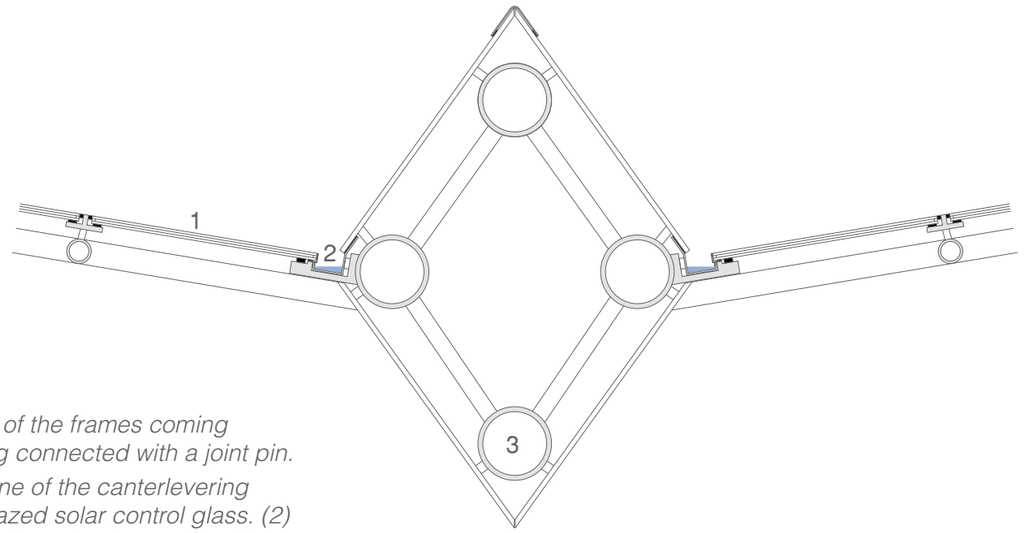
► *3D detail of the joints in the steel frames. All joints are rigid cast steel joints connecting all the members of the frame.*

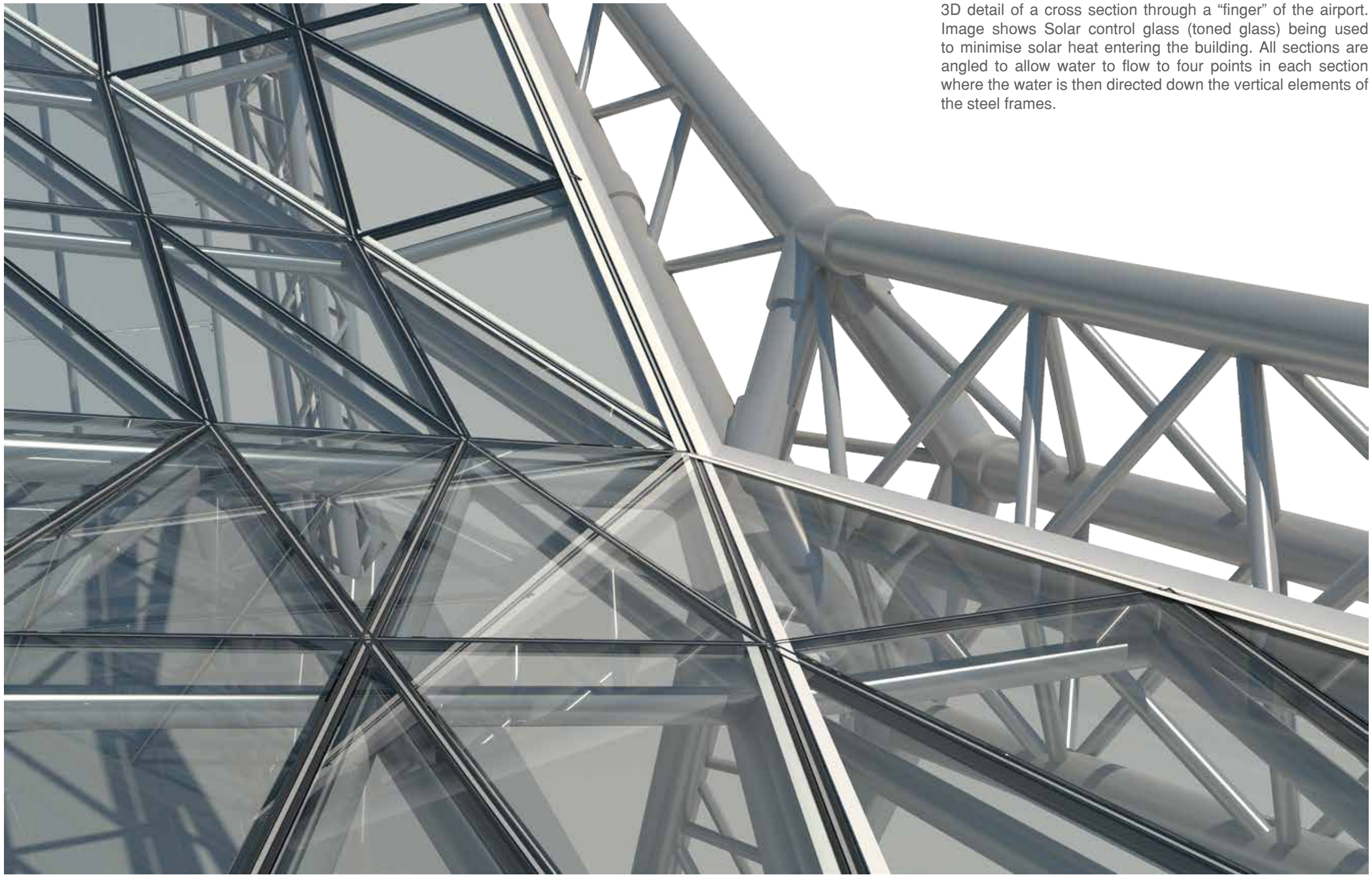




◄ *Detail (1:25) showing the base of the frames coming together at one point and being connected with a joint pin.*

► *Cross section detail (1:25) of one of the canterlevering steel truss arms. (1) Double-glazed solar control glass. (2) Heated drainage canals. (3) Hollow circular steel profiles forming a compressed square truss.*

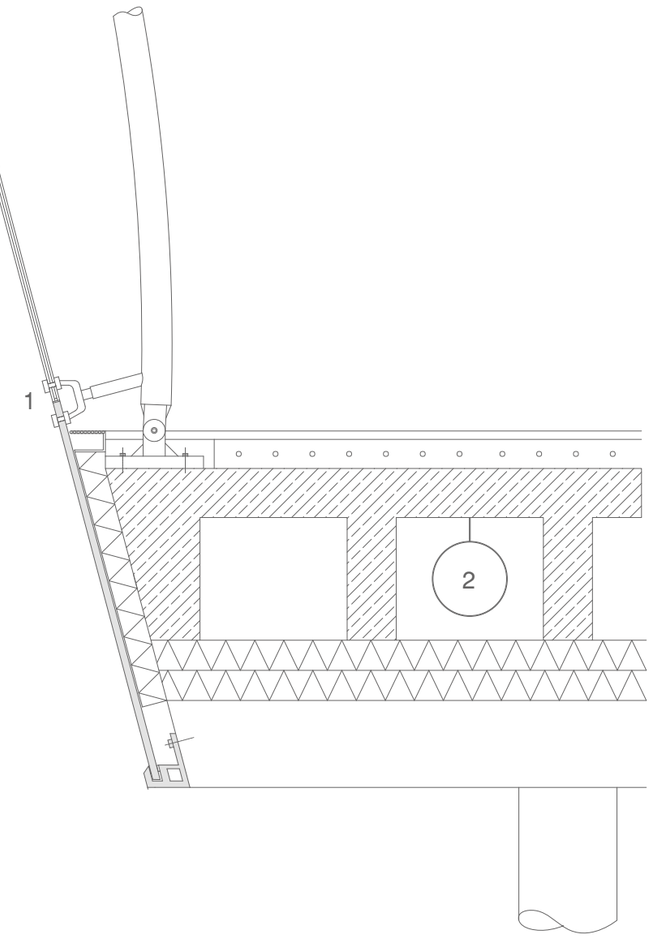


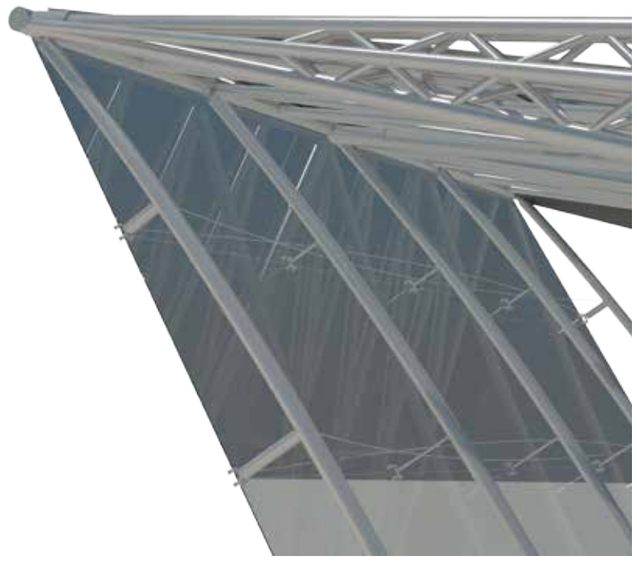


3D detail of a cross section through a “finger” of the airport. Image shows Solar control glass (toned glass) being used to minimise solar heat entering the building. All sections are angled to allow water to flow to four points in each section where the water is then directed down the vertical elements of the steel frames.

◀ *3D detail showing the secondary steel construction holding the glass roof as well as the rigid cast steel joints in the steel frame construction.*

▶ *Facade detail (1:25) showing the base of the curtain-wall facade. Also seen is the t-beam ceiling/floor construction and insulation as well as the underfloor heating/cooling.*
(1) 4-point curtain-wall glass connecting assemblies.
(2) Ventilation ducts / general space for other building services.





◀ *3D detail of the connection between the canterlevered steel truss arm and curtain-wall. Also seen are the elements in the facade to cope with negative and positive wind loads.*

1 - Articulated joint connecting two rigid t-frames.
2 - Reinforced concrete columns.
3 - Reinforced concrete t-beam ceilings/floors.
4 - Ventilation ducts / other building services.

3D detail showing various elements of the frame constructions. Two rigid t-frames are connectd at the top (1) via an articulated joint. This forms a perfectly balanced double t-frame unable to move. The stiffness in the opposite direction is obtained by forming a spatial steel truss as part of the secondary construction holding the roof.

Picture of B777 wing coming in to land at London Heathrow

APPENDIX

SOURCES

Literature

The historical summary at the beginning of the thesis comes primarily from:

Alastair Gordon, 2008. Naked Airport: A Cultural History of the World's Most Revolutionary Structure. University of Chicago Press Pbk. Ed. / Edition. University Of Chicago Press.

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http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_079.pdf

Images: (All images not marked with a "Fig." were made by and belong to the author of this thesis.)

Fig. 1-24, 28: Alastair Gordon, 2008. Naked Airport: A Cultural History of the World's Most Revolutionary Structure. University of Chicago Press Pbk. Ed. / Edition. University Of Chicago Press.
Fig. 25: http://upload.wikimedia.org/wikipedia/commons/b/ba/Suvarnabhumi_Airport,_Control_Tower.jpg
Fig. 26: http://wikitravel.org/upload/shared/b/b7/Dubai_Airport_DutyFree.JPG
Fig. 27: https://www.google.at/maps
Fig. 29: http://i.imgur.com/Ndb6oSj.jpeg
Fig. 30: http://www.coloringchaos.cc/wp-content/uploads/2014/04/Screen-Shot-2014-04-30-at-9.10.49-AM.png
Fig. 31: http://www.flavum.com/Picts/TWA.jpg
Fig. 32: https://farm1.staticflickr.com/174/417081233_6c43f719eb_o.jpg
Fig. 33: https://bt301.files.wordpress.com/2011/12/stansted-airport.jpg
Fig. 34: http://static.guim.co.uk/sys-images/Guardian/Pix/pictures/2014/9/23/1411485569884/London-Stansted-Airport--014.jpg
Fig. 35: http://www.gcgp.co.uk/wp-content/uploads/2015/01/London-Stansted.jpg
Fig. 36: http://www.fosterandpartners.com/media/Projects/0300/img2.jpg
Fig. 37: https://g4mikey.files.wordpress.com/2013/01/o9bt5.jpg
Fig. 38: Avedition, 2007. Suvarnabhumi Airport Bangkok Thailand. Edition. Avedition Gmbh,Csi.
Fig. 39: http://www.justwalkedby.com/wp-content/uploads/2012/11/Suvarnabhumi-International-Airport.jpg
Fig. 40: http://www.die-neue-sammlung.de/press/wp-content/uploads/2012/03/suvarnabhumi-airport-bangkok.jpg
Fig. 41: http://en.wikipedia.org/wiki/Indiana_Harbor_and_Ship_Canal#/media/File:Indiana_Harbor.jpg
Fig. 42: http://mesonet.agron.iastate.edu/sites/windrose.phtml?network=IL_ASOS&station=ORD

THANK YOU / DANKE

An alle Familienmitglieder welche mich jahrelang unterstützt haben.

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