Brett Rathbone
Thesis Booklet

Figure 1 707 tail

AERONAUTICAL DESTINATIONS

A design thesis submitted to the Department of Architecture and Landscape Architecture of the school year AUGUST 2013 to MAY 2014 BCE

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In partial fulfillment of the requirements for the Degree of Master's of Architecture.

Primary Thesis Advisor

Thesis Committee Chair

May 2014

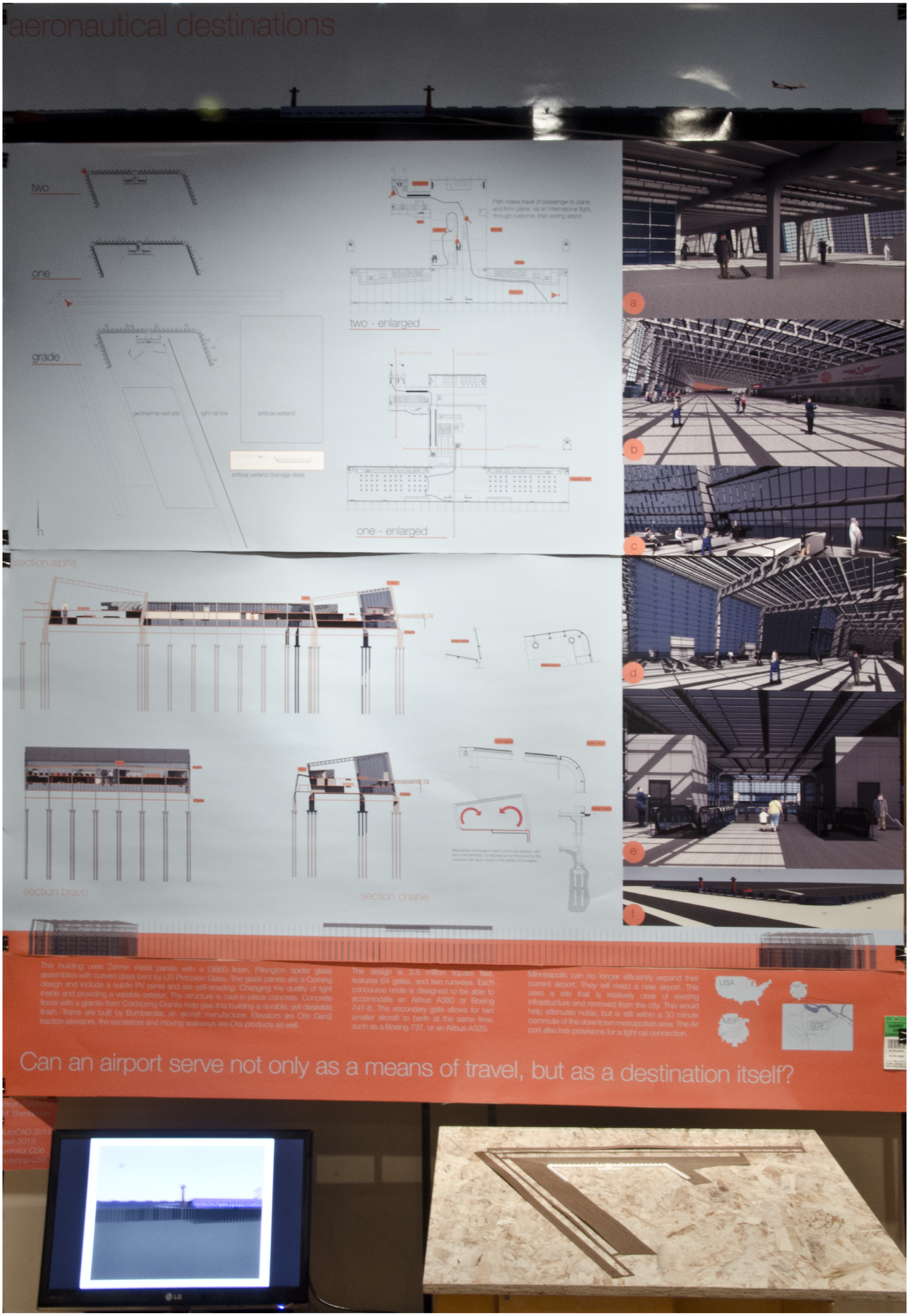


Figure 2 : Board Installation

Tables and Figures

Abstract

Aeronautical Destinations

One can arrive at as many as three or more airports on the way to their destination with two layovers during the trip, KFAR to KMSP to KSLC to KPSP for example. How can an airport design be more than just a vehicle for aviation, but serve as a desirable location to be, rather than just one more step along the path. It can have such a lack of circumstance that you only remember menial inconveniences, rather than a positive experience. With effort, can an airport be made to evoke a similar set of circumstance as a national landmark when seeing it? Perhaps to a select few, but the airport could have a grand sense of arrival instead of a mere step along the path.

Economic expansion would benefit the expansion of existing infrastructure to be able to better support the local business hub that is the Twin Cities.

Arrive sooner, forget the details along the way. Get in, get out, don't care about surroundings. These are phrases that could be used in a critical manner to describe some airports. Statements that should not be used. Ellis Island and Angel Island had grand senses of arrival. However these are on a different scale from an airport but the sense of arrival from an airport should be carried over to the most popular form of overseas travel.

square footage
5,400,000

site
Minneapolis, MN

key words
Airport, destination, transportation, transit, flight, southeast Minneapolis, Hastings

Problem Statement

An airport is only a means to an end for most, but it should provide a location that people want to attend as well.

Statement of Intent

Typology

Airport

Site

Minneapolis, MN

Claim

Through design, an airport can serve not only as a hub, but as a destination giving travellers a sense of arrival and of the local community

Actors

Transportation industry

Action

Facilitating aeronautical traffic

Object

Transportation destination

Premises

1. Some airports can be so bland that one doesn't remember the airport, just how bad the seating in the lounge was. This is an example of poor design making an airport a means to an end.

2. Airports are the primary means of transportation currently for transcontinental transportation.

3. A new terminal with good expansion will be beneficial for the area both economically and politically.

"Sir, the Air Force can deliver anything." -General Curtis LeMay, June 25, 1948. Berlin Air Lift (Hearn, 2008)

Theoretical Premise/Justification

Theoretical Premise

Economic expansion would benefit the expansion of existing infrastructure to be able to better support the local business hub that is the Twin Cities.

Justification

Arrive sooner, forget the details along the way. Get in, get out, don't care about surroundings. These are phrases that could be used in a critical manner to describe some airports. Statements that should not be used. Ellis Island and Angel Island had grand senses of arrival. However these are on a different scale from an airport but the sense of arrival from an airport should be carried over to the most popular form of overseas travel.

Proposal

Narrative

Today, an airport serves as a means to an end for most travellers. But can it be made to be a destination that provides an event on arrival?

In 2012, 813,247,338 people travelled by air in the United States alone.(BTS) In 2012 it was estimated to be a 711 Billion USD industry. (prlog.org) With this, the current airport in Minneapolis, KMSP, moved 33.170.960 passengers in 2012 (mspairport.org) The large number of passengers that the Minneapolis airport is handling is increasing, and more runways cannot be added.

Many other cities have two or more airports, Washington DC, Los Angeles, or New York City to name a few. Why not Minneapolis? Minneapolis handles 33 million passengers a year. Minneapolis is the 12th busiest airport in the US, 47th worldwide.(50 busiest airports in the us.)

I was an aviation major prior to switching to architecture. Planes have always interested me. I have my private's pilot's licence. I've also experienced the Minneapolis airport quite a few times. We always flew Northwest out of Grand Forks, to their hub in Minneapolis. I was very lucky as a child that my parents took me on many trips, to see relatives back home in Canada, and to travel for the sake of travelling. I've always been interested in planes. I've drawn them for years and years. Biplanes, triplanes, wide-body passenger jets, smaller business jets, large cargo planes, supersonic jets, the list goes on. An airport will be the perfect combination of architecture and aviation.

The shapes of planes are one of the most beautiful things to me, sleek and elegant. I want to design a building of that sort. Something that is striking standing still. An exercise of elegance from function versus form in terms of aerodynamics.

Minneapolis has need of a new airport. A new site for one specifically. I firmly believe that in the future we will see a new one open up simply due to the fact that Minneapolis cannot add more runways without being extremely invasive to the local surroundings.

As recently as 1997, Minneapolis chose to expand their current airport, rather than develop a entirely new airport. This was estimated to be sufficient until 2020. This was not a sustainable solution in terms of accommodating Minneapolis for a longer period of time. Nor was it a fine choice architecturally as it has led to a myriad of architectural designs crammed behind parkades.

People remember an airport that is impressive, and it can say a lot about the local community. Serving as that city's gateway to their opportunities, much as Ellis and Angel Island did in the early 1900s. Now an airport serves that purpose, international travel abounds for pleasure and business.

User Client Description

The Owners

MAC would be the owners of this project, a public agency maintained by the state of Minnesota.

The Clients

These are the travellers. The red-eye warriors who brave early flight times to get to the business meeting in Dallas on time. Those who save points from every flight for that fun trip to Orlando for the long weekend. These are the people that this project caters to. People using airlines to go somewhere, people using them to come into Minneapolis. These are the people that ultimately bring in the business that keeps Minneapolis' need for an expanded ability to accept air passengers. The city is a hub for business, and as such it will need the ability to satisfy the traffic going into the city. Parking will be provided by a parkade to facilitate the large need for people to park, but public transit will also be linked.

Ground Crew

This is who makes the magic happen. These are the people who (hopefully) get your bag from one flight to another. They're the people that put the peanuts and ginger ale back onto the plane, make sure it has fuel, make sure you have a gate to depart from, make sure that your flight has a clear path to the runway, and controls how quickly you get off the ground.

Airport Staff

When you go to the current Minneapolis Airport, it's not just a terminal. There's shopping, restaurants, coffee shops, rental car agencies and bars. There are baristas, bartenders, waiters, chefs, managers, sales associates, and cashiers. That's just the commercial aspect of it. There's also TSA and USCBP consider. People to screen the individual, check the bags with the x-ray machine, check tickets, and customs officials for international arrivals.

Airline Staff

The airlines will also hire staff. They'll hire people to check you in for your flight, to print your boarding pass and check your bags. They also have pilots, airline attendants, and more staff to check you in for your flight so that it can be on its way.

Major Project Elements

Terminal

This is the primary area that will need to be developed. It is the place that everything happens in. Under one roof, baggage handling, food, check in, security, ticket counters, the lot.

Tower

Needs to be tall enough to show where planes are and coming into land.

Security Checkpoints

Baggage movement

Storage

Parking

Transportation

Site Information

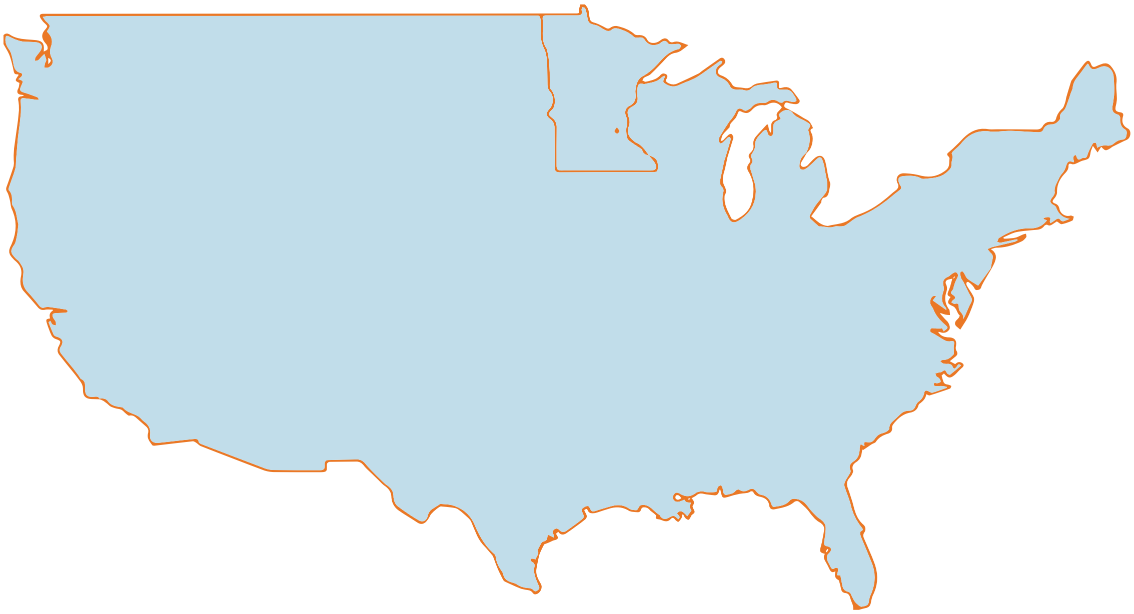


Figure 3: Site National

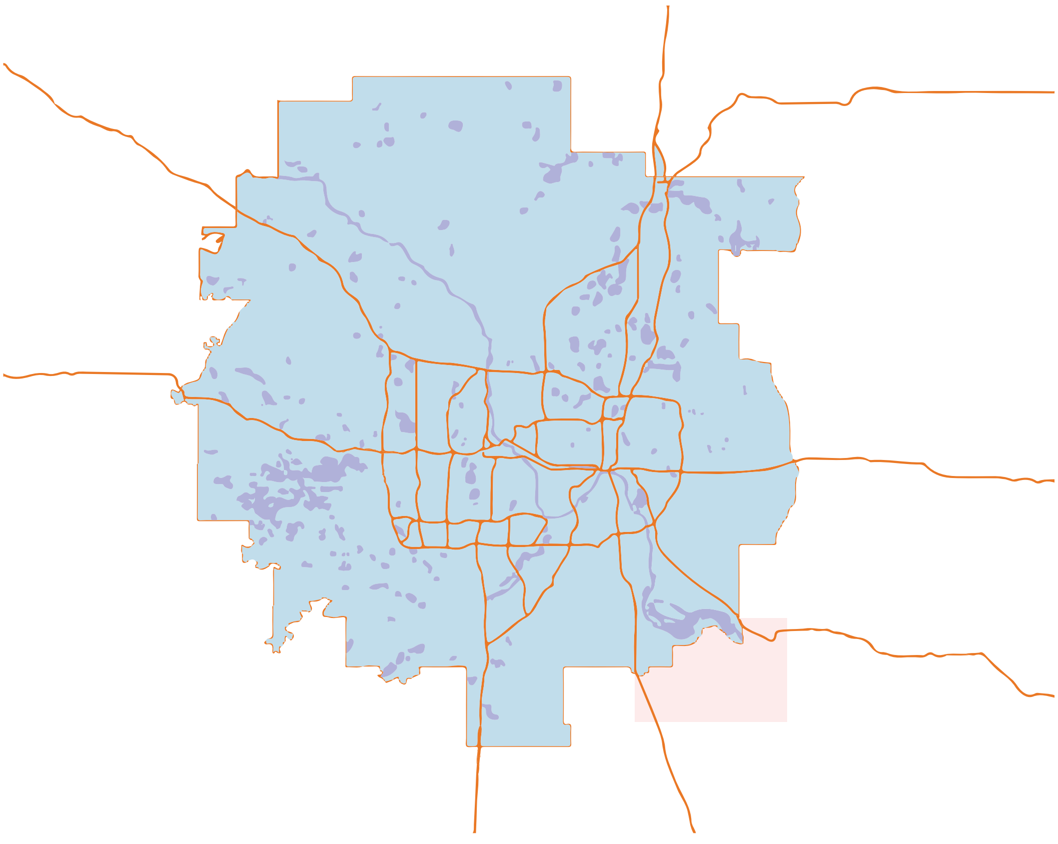


Figure 4: Minneapolis Area
with site highlighted

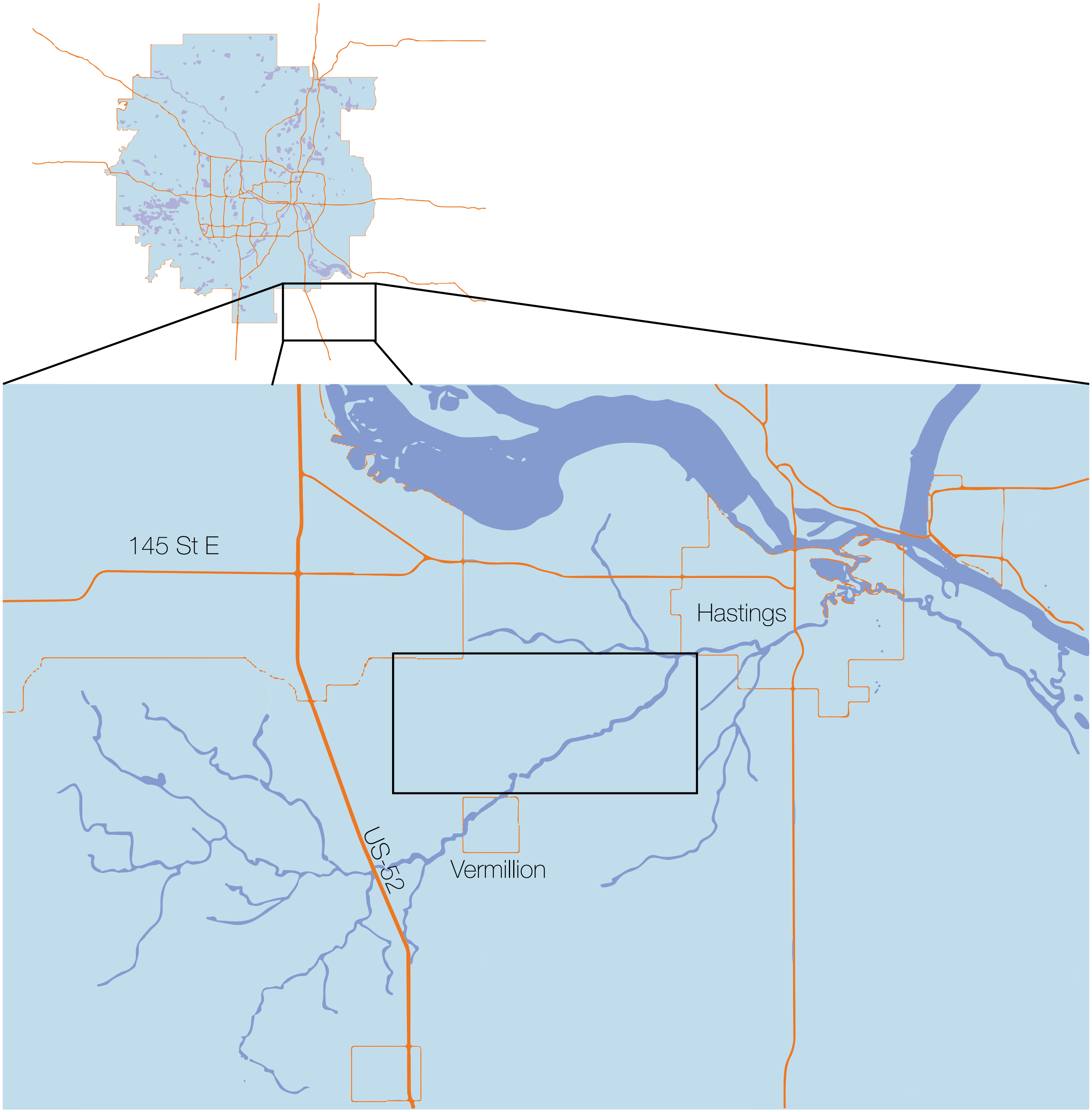


Figure 5: Site

Upper Midwest

This region encapsulates eastern parts of Montana, the whole of North Dakota, South Dakota, Minnesota, Wisconsin, Michigan, and the northern parts of Illinois, Indiana, and Ohio.

Minneapolis, Minnesota

The greater Twin Cities area is home to 3,348,859 people according to 2010 US Census data. There are also 27 Fortune 500 companies headquartered in the greater Twin Cities areas, and countless others. The area is a business hub.

Thesis Site

The Site is southwest of Hastings in Dakota County. This is the site selected for the proposed new airport that was shut down in 1997.

Transportation Links

US-52 Passes directly to the west of the site allowing for good vehicular access.

Figure 6: Site with flag

Project Emphasis

This project investigates how an airport can be a destination in itself. To actually create something memorable than just a means through or a place to leave as soon as you deplane, but also tackling an issue with the original Humphrey Terminal at KMSP, the lack of ability to easily expand.

Beautiful functional architecture cannot be easily designed, but beautiful functional architecture that is expandable is something an airport demands in a city where business is increasing, and so are the passengers demand on an airport.

A Plan For Proceeding

Research Direction

In order to gain an understanding of what exactly needs to go into this design, a consistent effort will go into research. Case studies will be conducted in order to understand the complexity of design. The site, once chosen, will be documented and design work will be influenced by the findings. An investigation into the benefits of an airport, to prove that it would have beneficial impact on the community using the current airport as context, historically.

Design Methodology

Quantitative and qualitative research will be conducted using a concurrent transformative research strategy whenever possible. Quantitative data will be scientific and statistical data. Qualitative data will be gathered from direct observation, a local survey, an archival search, or a direct interview. Graphical analysis will be conducted to deem design work appropriate or not. If possible, interviews and tours will be conducted.

Documentation of Design

All digital records of this project will be backed up into the cloud. Any physical media will be scanned in or digitally photographed and backed up across two or more hard drives so that data failure does not inhibit my means to successfully complete this project. It will be presentable for scholars through the Institutional Repository. Relevant documentation will be presented in the thesis booklet, on boards, and in my presentation verbally.

Spring Timeline

Project Documentation	89	Tue 1.14.14	Fri 5.16.14
Conceptual Analysis	28	Tue 1.14.14	Thu 2.20.14
Context Analysis	5	Tue 1.14.14	Mon 1.20.14
Spatial Analysis	29	Mon 1.20.14	Thu 2.27.14
ECS Passive Analysis	5	Wed 1.22.14	Tue 1.28.14
ECS Active Analysis	5	Wed 1.22.14	Tue 1.28.14
Context Redevelopment	5	Wed 1.22.14	Tue 1.28.14
Envelope Development	20	Thu 1.23.14	Wed 2.19.14
Structural Development	10	Tue 1.28.14	Mon 2.10.14
Floor Plan Development	15	Mon 2.10.14	Fri 2.28.14
Structural Redevelopment	15	Tue 2.11.14	Mon 3.3.14
Materials Development	15	Tue 2.11.14	Mon 3.3.14
Project Revision	34	Wed 2.26.14	Mon 4.14.14
Section Development	10	Thu 2.27.14	Wed 3.12.14
Midterm Reviews	5	Mon 3.10.14	Fri 3.14.14
Preparation for Presentations	31	Wed 3.12.14	Wed 4.23.14
Presentation Layout	5	Mon 4.14.14	Fri 4.18.14
Plotting and Model Building	7	Fri 4.18.14	Sun 4.27.14
Exhibits Installation	1	Mon 4.28.14	Mon 4.28.14
Thesis Exhibit	3	Mon 4.28.14	Wed 4.30.14
Final Thesis Reviews	6	Mon 5.5.14	Mon 5.5.14
CD Due to Thesis Advisor	1	Mon 5.12.14	Mon 5.12.14
Final Thesis Document Due	1	Fri 5.16.14	Fri 5.16.14
Commencement	1	Sat 5.17.14	Sat 5.17.14

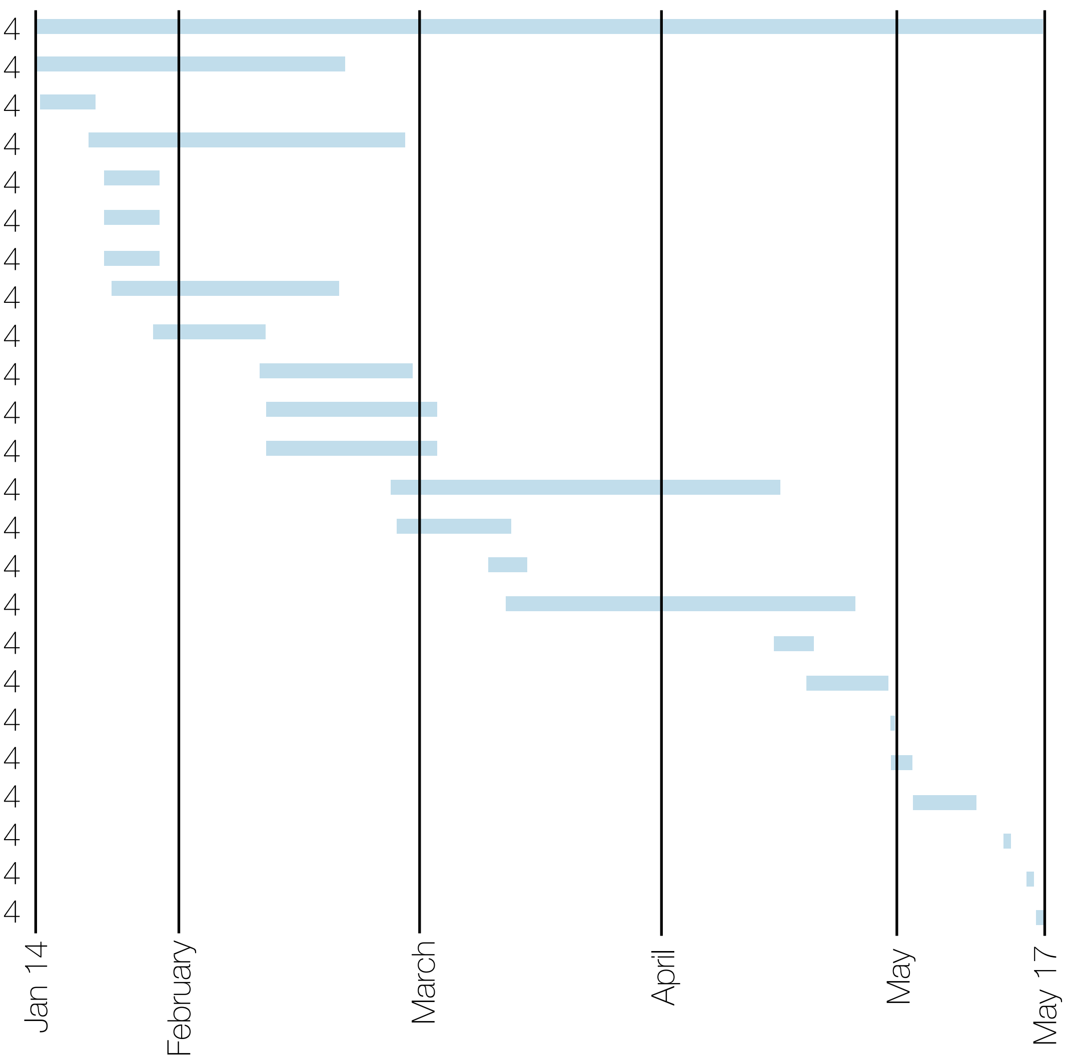


Figure 7: Spring Timeline

Previous Studio Experience

Fall 2010	ARCH 271	Darryl Booker	Tea House Boat House
Spring 2011	ARCH 272	Joan Vorderbruggen	Montessori School Bird House Dwelling
Fall 2011	ARCH 371	Mike Christenson	Corbusier Museum Modification
Spring 2012	ARCH 372	Milt Yergens	Ag. Research Facility Urban Infill
Fall 2012	ARCH 471	Cindy Urness	High Rise
Spring 2013	ARCH 472	Don Faulkner and Frank Kratky	Hope's Journey Ghana Marvin Windows Competition
Fall 2013	ARCH 771	Mark Barnhouse	Water Animation Wetlands Research Lab

Program Document

Theoretical Premise
Unifying Idea

Figure 8: Jet in the sunset

Narrative

Bill Average is on a business flight out of Fargo to Minneapolis, it's a red eye flight since Bill is a more frugal man. He wakes up at 3, readies himself in 30 minutes, and is out the door by 3:30AM, at the airport at 3:45AM. He finds a parking spot in long-term and winces at the cost of the daily rate. Bill walks from his car to the terminal, relieved to be out of the cold. He walks up to the ticket counter to check a bag. Bill doesn't need to print a boarding pass since he's using the Delta app on his phone. Bill checks his bag, and proceeds to go through security. He doesn't have to wait for a long time since it's so early in the morning, but Bill likes to be prepared and not have to worry about missing his flight because of security queues. He takes off his jacket, shoes, belt, and watch. He puts his keys, phone and wallet into the bin, and removes all liquids and his laptop from his bag and places them in a separate bin. He is motioned to walk through the security checkpoint and stands in the body scanner. Five seconds later he's through security and trying to get all of his stuff back on enough to stumble over to the recuperation area to properly redress.

Once Bill has redressed, he decides a soy latte is in order. He would've liked to have grabbed a coffee from his favorite coffee place in town, but couldn't since that wouldn't be allowed through security. So he goes to the airport's coffee shop inside security and treats himself to a soy latte. Once he has burned his tongue and imbibed the dark caffeinated liquid that keeps him fueled, it's his turn to board. Zone 2 has finally been called and Bill can get on the plane. He scans his phone, walks down the jetway and goes to his seat. He places his briefcase on the floor under the seat in front of him, then he pulls out a book and begins to read while the safety procedures are being read. Bill pays this no heed, for he is a rebel without a cause. After the plane has taxied and taken off, he pulls out his phone, turns it back on and puts it in airplane mode. He settles into some pop music and reads. Forty minutes later the plane is on final approach and electronic devices must be turned off. Bill waits patiently for the plane to land, taxi and have the jetway moved into position. He leaves the plane and walks from the gate, through the security area, and collects his baggage and hails a taxi to take him to his destination, luckily there are some taxies waiting for passengers there so Bill is not inconvenienced by a long wait

This story demonstrates the typical commute that a business person would take to a meeting in a different town. There are a few concerns that are consistent throughout any airport experience: the cost of parking, getting through security on time, and not accidentally leaving a Leatherman or something of that nature in a briefcase. There will always be a coffee shop or a place to grab a bite to eat, or in larger airports, there's a place to buy a belt in case you forgot to pack one before a three-week trip to France … Thank you Land's End.

Theoretical

To get from New York to LA, most people would immediately consider a plane as the first mode of transportation. Air transit is a driving force of tourism, business, and anything that can possibly relate to moving people or cargo quickly over long distances. In 2012, 813,247,338 people travelled by air in the United States alone (BTS). In 2012 air travel was estimated to be a $ 711 Billion USD industry (prlog.org). This is a huge industry and losing business due to poor planning is poor form indeed.

Philosophical Aesthetics

Through my case studies I have noticed that in the terminal areas, baggage check-in, and congregation areas there is a lot of natural light. The Queen Alia airport and the Kuala Lumpur airport have large areas that are covered, but have skylights in them so that the space does not seem foreboding. The skylights open the space up, creating a light and airy feeling. Dulles is another example; the design is very fluid and open. The building itself resembles a wing, which is very beautiful. The airport serves a monumental capacity, one that I don't think is egotistical, but symbolic.

Sustainability

Airports generate groundwater pollution and air pollution. Aircraft are becoming more and more efficient, but they will need the most thrust on take-off, therefore generating the most pollution on take-off. This is an issue outside of the realms of architecture's ability to fix, but it is something that must be dealt with. The other issue is runoff from Jet A fuel and Avgas, along with deicing fluid. A wetland treatment area would be excellent for this area and serve to benefit it. A wetland would also be necessary due to the surrounding water table and the proximity to the Mississippi River. The building itself can offset pollution by PV panels and efficient design.

Urban Design

This project has many aspects of a small urban design project. The scope of this project and its impact is quite large. The terminal, the main focus on architectural design, is a function of the runway location. The runway location and orientation is a function of the wind. So this project is very naturally influenced in its scope. Albeit, one must exercise diligence while executing this concept so that the final result's connection to nature is not perverted by poor intentions. There is access to the site via US-52, a four-lane highway that is about 10-15 minutes south of the interstate system that rings around the Twin Cities. To get to the site from downtown takes about 35 minutes, so there is good access via current vehicular arteries. The design would also benefit from connectivity by the light rail. One of the nicest things I found about one of my case studies,Ronald Reagan National was that the transit system was immediately connected to it, and I could go anywhere from the airport.

Symbolism

The symbolism behind an airport is critical in this day and age. An airport is the terminating point of a journey somewhere. It is the place people realize that they have truly arrived. It has a great significance of a journey. Even if a person, such as Bill Average, has to drive somewhere else after landing, or take a different means of transportation. The symbolism carries over to the shape of the structure. Dulles International is a great example since the shape of the building references the shape of an aircraft wing. It is a very beautiful and flowing shape. The very nature of large airports serves to have a great symbolism about al of them.

Considerations for Future Operations

Airports need to be designed to accommodate things efficiently today, but be prepared for more tomorrow. An airport must be prepared to deal with an increasing amount of people throughout the lifespan of the structure. The security area has drastically changed over the past two decades, and will continue to change in the face of terrorism. But the aircraft have also changed, which is a direct result of more people travelling by air. An airport must be configured to have the capacity to grow for larger and larger aircraft. The Boeing 747 and Airbus A380 are two aircraft that come to mind, their wingspans are much larger than previous aircraft, the weight put down by these aircraft could potentially be larger per square foot as well. Aprons and Gates need to be designed to have the aircraft fit at the airport. Facilities need to be capable of handling the people coming off the aircraft as well. The expansion of runways, either in individual length or in overall amount must be thoughtfully considered as well. Runways may be able to be added in large number, but if the runway is never into the wind, or stops operations at many other runways, then it really can be detrimental to airport operations. This air traffic control aspect plays into how well the airport will run. All future growth needs to be considered as a whole.

Economics in a Regional Scale

One case study that I did purely from an economic standpoint was that of Dallas Fort Worth. The airport was originally conceived in the 1940s but WWII put it on hold. Post-war there were local political differences that caused a delay in implementation. In the 1970s that plan was finally put into action. The airport was gigantic, with runways larger than Grand Forks Air Force Base made to handle KC-135 Stratotankers. The four runways at Dallas Forth Worth (KDFW) are 13,000 feet long. This airport was designed with capacity for current and future aircraft. The airports' layout makes it an improper case study in terms of security and modern airport layout. Their security is irregular and decentralised. There are many access points into a "secure" area. The region though has benefitted from the airport. Annually it generates 31 billion dollars for the greater Dallas-Ft. Worth area. (Graham, Nov) Nine billion of that goes into wages, so that is nine billion dollars right into the local population's pockets. This generates a positive gain for the area as well (Graham, Nov).

Commercial Aspect

An airport can be owned by a series of airlines in conjunction through a group management. An airport has many avenues of revenue. There are five ways for an airport to make money. Landing fees for commercial operations are one source of income. Leasing arrangements with airline operators, the lease of non-airline operations such as car parks, and equipment rental by an airline such as baggage handling are additional ways for an airport to create a revenue stream (Edwards, 1998). The percentages a terminal will make for a profit depends on the quantity of traffic in that airport. A busy regional airport, where people don't transfer flights, they arrive and leave. These airports will generate more money as a percentage than an airport by parking revenue than where they would transfer between flights and a car isn't involved, unless they really want it to be. The sale of concessions in terminal buildings is an excellent point of sale. It's a high traffic area that people waiting in the area will want something to do. It will purposefully be designed to pull people past shops at all parts of their terminal experience. (Edwards, 1998) Smaller airports will generate more money, as a percentage, from landing fees than larger airports. The reason for that is a larger airport will have a larger amount of people passing through and will generally have more people with longer wait times, and the larger airports will have shops and eateries for people to spend money at, to pass the time, or to grab a bite to eat because they know all too well that the airline won't be giving them a meal.

Figure 9: Inverted roll

Research

Twenty percent of an airport is circulation. There are many levels of security a person may need to pass through either leaving or entering an airport, whether it's an international arrival or a domestic flight. International and domestic arrivals need to be kept separate for people to get through customs properly. This necessitates the use of design to move people through the area properly. Exits must be reconfigurable for the movement of people straight to baggage claim or customs. Domestic arrivals would use the same exit that departure flights would be using as well. The domestic flights arrival passengers are considered clear to walk around the terminal since they made it through the security screening at their departure destination. The international passengers, flights that are from a different country with differing security standards, are rescreened, both the baggage and the person, to make sure standards are up to the operating country's standard. This is complicated because the jetway used for this is the same for arrivals and departures. The area immediately outside the jetway must be reconfigurable. I noticed at Minneapolis when flying back from Canada that I walked out of the gate and instead of going through the terminal normally, I walked along a corridor for quite a distance to get to customs. This was a very specific setup to make sure that people arriving on an international flight would have to go through customs. There were fire exits along this way of course, but in the event of a fire the airports' security would be compromised in the interest of removing people from this area, so that people can exit quickly and safely. That fire exit bit aside, this paragraph highlights the importance of a clear way of movement through an area.

The movement for a smaller airport can be all done on one level. The one-level is the domain of a very small scale airport concept. The two-level setup gives a clear separation of movement of baggage; the complexities of the mechanical arrangement have a clearer path of movement. And there usually does need to be some height addition to access the airplane, so that is an added benefit. A clear example of this would be Fargo's Hector International Airport. The vertical stack of arrivals and departures could be separated completely at the gate on a split-level arrangement. The third option is to stack arrivals and departures, so that people arriving are immediately separated from departures. This assumes the same jetway is used, so there are still some common spaces. There is also the vertical segregation, but it is more costly to duplicate different services for embarking and disembarking from an aircraft (Blow, 1996).

This arrangement is all relevant to the linear arrangement where a transition of a level isn't as easy to gradually occur. For a system of hub terminals where people would access this secondary area via a tunnel, the separation must be consistent throughout; this becomes harder to do throughout a split-level design. Large terminals that were previously developed in the 1970s are still widely used today with new expansions and some remodeling. This means that an airport can still be useful and versatile enough after the building has been around for a while. Detached satellite piers can be a very effective means of expansion when there is proper transport provided. Dallas Fort Worth has a transit system going between the satellites of their airport. Other services such as baggage movement and vendor supplying must be considered too when moving away from a centralized design.

Moving passengers between different terminals or long distances within terminals can be done a few ways. The use of a tram system like in Delta's Detroit terminal or Minneapolis' terminal are excellent systems and can reduce transit time, when they are working. This highlights the need for a system in place that does not rely on 100% mechanical function. Minneapolis has moving walkways that help move people along at a higher speed without causing the person to become fatigued. This only covers movement along a linear level. To move between levels as is necessary with some airports, elevators are required to the handicapable, but an escalator does a pretty good job of moving people vertically, and when those break, they're stairs! Pretty much foolproof. I have yet to see ramps in common use due to the extremely large amount of space they would use considering how high the floor to floor heights are in an airport.

Baggage systems are one of the hidden wonders of an airport. Luggage moves onto the plane, from one flight to another, off the plane to baggage claim, or off the plane to customs where the passenger would recheck their baggage after a security screening. These systems must be as simple and straightforward as possible. Complexity creates problems when the system is over capacity, and when a breakdown occurs. Typically baggage is sorted by a digital scanner after the bag is checked then the bag moves through the system and through a security scanner. Once the luggage has been checked, it is processed to the appropriate staging area if the flight isn't going to take off for another few hours or if that flight is going to take off very shortly with a quick layover. This necessitates a rather large area available to store and organize all this baggage until the appropriate time. A domestic arrival will take baggage that has arrived and put the baggage into the system without additional scanning. There it will be sorted for destination or transfer. The baggage from customs is deposited into the system in much the same way; it just passes an additional security screening.

Airport "codes"

These are some dimensions which are covered on the ICAO Aerodrome Design Manual. Taxiways must be 23m wide at a minimum, and the taxiway centerline must be 182.5m away from the adjacent runway centerline, and 80m from a parallel taxiway. To add some perspective, the wingspan of an Airbus A380 is 80m, and a Boeing 747-8 is 68m. An A380 going one way on a taxiway and another going the opposite direction could easily cause a ground collision. In a sense, the same care must be taken for aircraft maneuvering range that one would have to do for ADA compliance (Edwards, 1998).

Additional Facilities

These facilities must be considered, and would largely be storage and maintenance. But the sheer variety of vehicles to make an airport function is vast. A tug to push the aircraft, a honey wagon to empty the aircraft's sanitation tanks, a baggage tug, fuel truck, and a conveyor vehicle to move luggage out of the aircraft, de-icing vehicles, plows to clear the runways, a large snow-blower to remove the snow piles from plowing, catering vehicles, a truck to test the grip on a runway, (which will have special equipment mounted in it), these are just some the vehicles needed to allow an airport to function. Additionally, starter vehicles to start the engines of aircraft may be required.

Landing indicators must be installed along with clear and distinct markers defining the taxiway and runway exits so that when tower tells the pilot of N229ND to exit runway 17L at A9, the pilot can immediately understand where to go. Landing indicators include visual cues in the form of light arrangements that track the aircraft coming into land. These systems are called VASI and PAPI. There are other systems, but those are commonplace and ones that I am familiar with. They tell the pilot if he is on a proper glide path so the pilot lands on the runway 200ft past the numbers (17L) rather than before the runway or halfway down the runway. The quicker an aircraft clears the runway, the more planes that can be handled.

Physics behind flight

The physics behind lift, the principle that defines heavier-than-air flight, is pressure differences. This pressure difference is relative to the top of the wing and the bottom of the wing. The air over the top of the wing will need to take a longer path around the wing in contrast to the bottom. This can be accomplished either by an angle of attack greater than zero, or an asymmetrical airfoil shape. The air flows over the top faster because of the longer path, which creates a low pressure area on top of the wing in relation to the high pressure on the bottom of the wing. A wing can generate more lift by going faster, or creating a larger surface area of the wing. This is done by flaps and leading edge slats, most of which are deployable in low-speed maneuvering situations, but retractable for a more aerodynamic flight configuration.

Figure 10: Dulles International

Summary

An airport is a place that people can appreciate, but when push comes to shove, they will want to move through it quickly and efficiently to avoid missing a flight. I will always remember the Frankfurt airport though; they had a wall of mechanically driven flight arrival/departure boards. Every minute amidst a wondrous whirring sound, the board would update with a few delinquent letters rotating a time or two again to get the proper character.

The airline industry may be seen as a very poor industry to make money in, but they are playing with very high stakes and some small margins depending on fuel prices. People still need to fly, as a means to get to a place for a family reunion, to travel, for business, or any multitude of reasons.

Airports like Saarinen's Dulles International terminal are beautiful symbols of airport architecture. Palm Springs has a lovely airport with tensioned fabric covering large open circulation spaces. This is in a different climate, but it is a wondrous experience and reinforces experiences that I enjoyed in an airport, feeling open to the sky, and I personally enjoy the smell of Jet A fuel since it brings back many happy memories of travels.

Airports do generate pollution from air travel. That is a condition of the means to power a jet engine. The power plant could be revolutionized, or the means of fuel production could change so hydrogen is a viable option, but the airport would still need a runway for planes to take off, and services for it currently provides. Runoff from the de-icing activities must be considered as well with treatment for it being present.

Expandability must be considered when designing an airport, both in space available, and in terms of flexibility of design. Berlin's Tempelhof operated for 60 years, largely made possible by the space set aside when the airport was first designed.

An airport brings a slew of money into the region. This provides a great deal of jobs in terms of staffing for the airport, but also brings in business due to the connectivity and centrality a well-connected airport provides. To consider only the immediate needs of a region would be a poor choice and one must plan for the future so they do not fall behind.

A great deal of an airport is circulation and this is because people need to be moved into very specific areas in a very specific pattern to keep a working separation of airside and landside passengers. An airline could want their own terminal to set themselves apart from others, so a satellite arrangement could work best to make that work in a business-sense. The facilities must be made to work with future expansion without completely revamping an entire multi-million dollar baggage handling system. Simpler is better in this sense though. The linear terminal has the advantage of being one simple setup with clear avenues of expansion and aircraft movement, but this requires a long linear space available and not taken up by runways. An airport can be so large that it has an augmented circulation system, a tram or a series of moving walkways may be required to help people get from one end of the airport to another. This can be especially frustrating in large terminals that have had a series of expansions which results in the terminal becoming a maze.

Care must be taken when designing the airport and the facilities to appropriately allow for movement of aircraft. There are "codes" for aircraft written that dictate distances between taxiways and runways, and minimum apron sizes with gate spacing. There is a lot of activity in these areas and cramping them for space would do nothing to help safety. There are specific systems that are the aviation standard that should be installed at any airport that must be made present and accounted for.

Airline travel is some of the safest, fastest, and quietest means of travel available. This connects the world like it never was dreamed 100 years ago. Before World War I, the plane was primitive, now there are planes carrying spacecraft, like the Antonov An-225 Myria and the Buran or the Boeing 747 and the Space Shuttle. Planes can also fly themselves across the ocean with autopilot engaged. It is a very exciting thought to think what aviation and aviation architecture I will experience in only 50 years from now.

Kuala Lumpur International

Kuala Lumpur, Malaysia
Kisho Kurokawa

The airport is part of a much larger new "Silicon Valley-esque" city that Malaysia is trying to develop. The airport has the capacity to serve 25 million people annually currently with capacity for expansion up to 120 million (estimated). This capacity is built to anticipate the use of HSTs and still have appropriate services for subsonic commuter flights. The airport has been open for 15 years, and was built to create demand rather than respond to demand. I think it's a bold action, and sometimes bold actions can pay off. Much like Dallas Ft. Worth did and the major airline centre it has become.

Trees were closely incorporated with the area in an attempt to reduce noise in the site. This is all around their rather large master plan. The main terminal as seen in this case study is what was built as phase 1, but four satellite terminals each accommodating around 20 aircraft could be at a gate simultaneously. Four to five runways between 9,000-13,000 feet would allow for expansion for the HST aircrafts expectedly long take-off and landing distances (due to the shape of their wing, these landing speed and Vr would be rather high.)

Figure 11: Kuala Lumpur International

Image by Karrie Jacobs

This airport differs in dimension as seen by being relatively square in contrast to Reagan National. This is for expansion purposes. The area is to accommodate the large amount of proposed gates. The baggage system would be central to the main terminal where people would recover their baggage or deposit it, so it is that large to house infrastructure.

This airport is a good case study because it deals with a few key issues that face Minneapolis' current airport. Noise abatement, subsequent expansion, and expansion for economic reasons are concepts carried through the design of this airport. Noise abatement is done by having a green buffer zone around the airport. This is a good idea except in the areas over the takeoff and landing avenues. Granted, the area nearby is natural vegetation as well. The expansion is done by giving the airport a large amount of space, just as Tempelhof did in 1938, it allowed for expansion to meet future needs. And finally the attitude of "build it and they will come." The area is a developing region with greater and greater businesses headquartering themselves there, like Petronas and their towers, the Petronas Towers.

Elevation

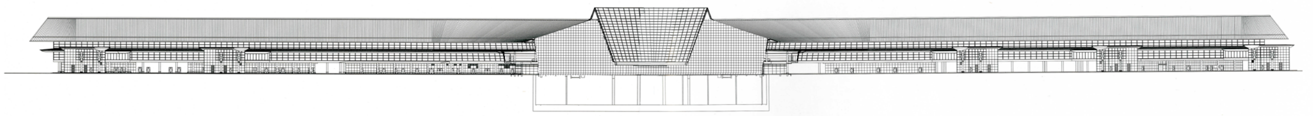


Figure 12: Kuala Lumpur Elevation

Floor Plan

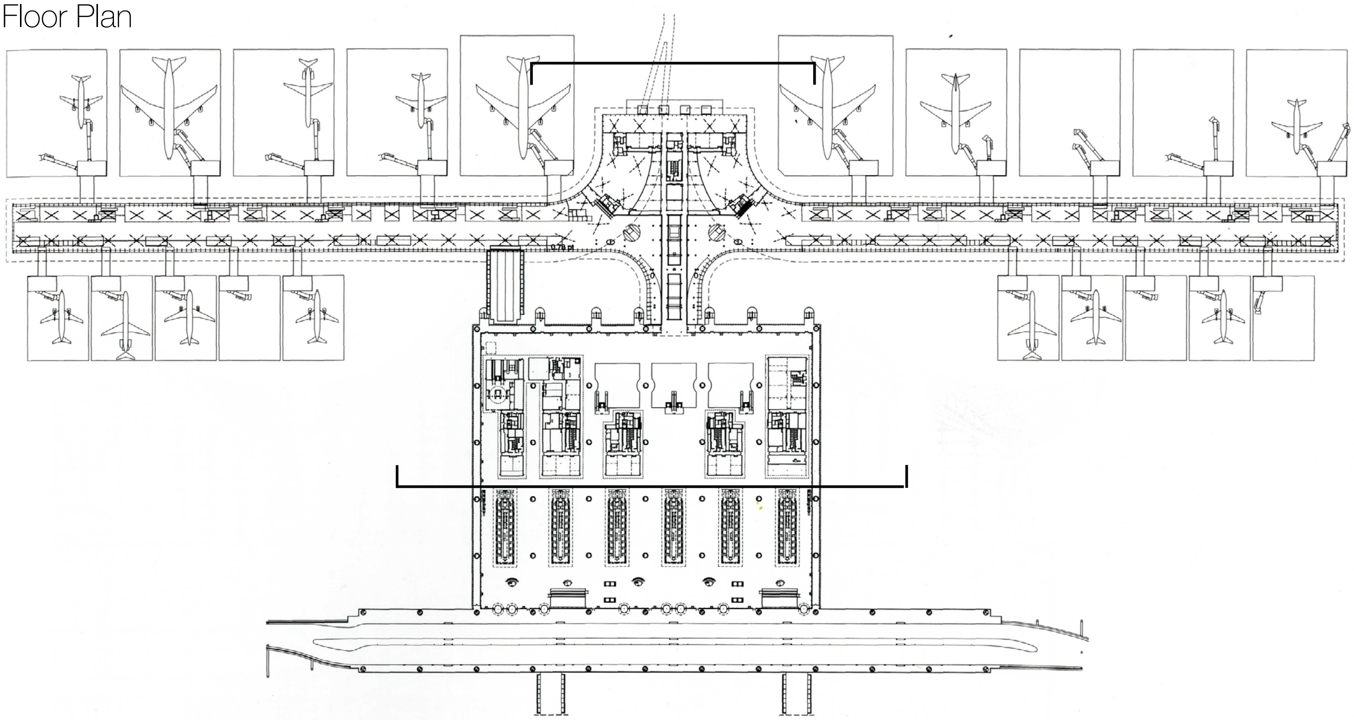


Figure 13: Kuala Lumpur Plan

Section

Figure 14: Kuala Lumpur Section

Structure

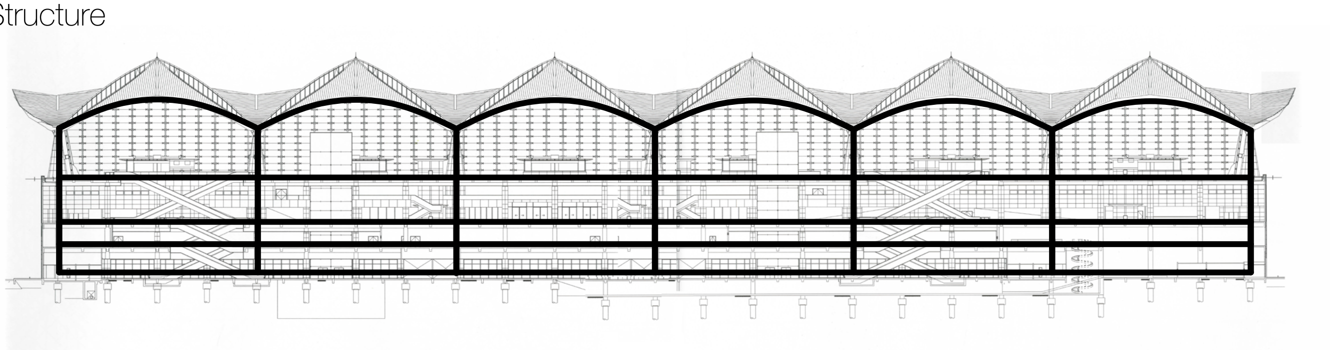


Figure 15: Kuala Lumpur Structural Diagram

Geometric Forms

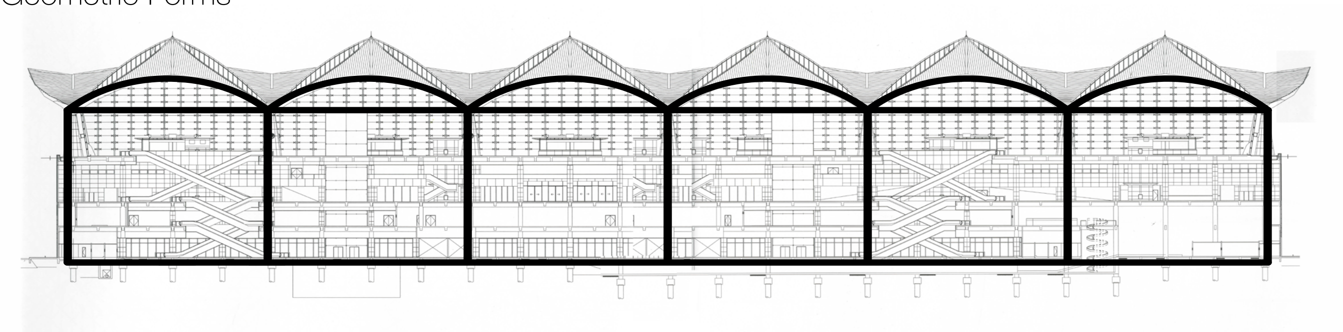


Figure 16: Kuala Lumpur Geometric Forms

Geometric Forms

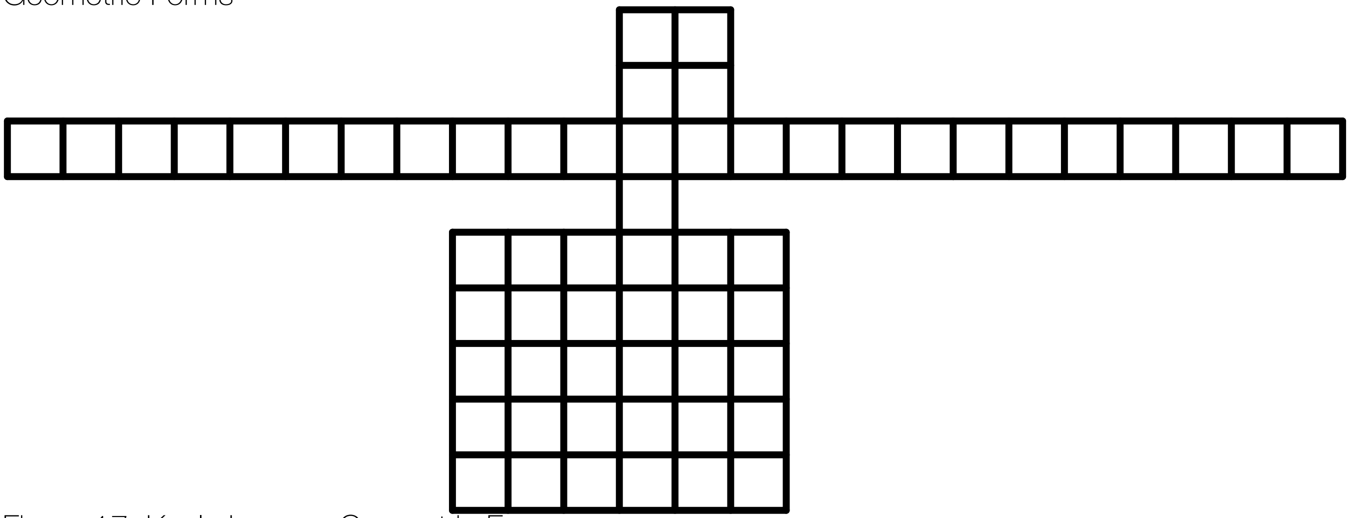


Figure 17: Kuala Lumpur Geometric Forms

Massing

Figure 18: Kuala Lumpur Massing

Hierarchy

Figure 19: Kuala Lumpur Hierarchy

Light Study

Figure 20: Kuala Lumpur Light Study

Circulation

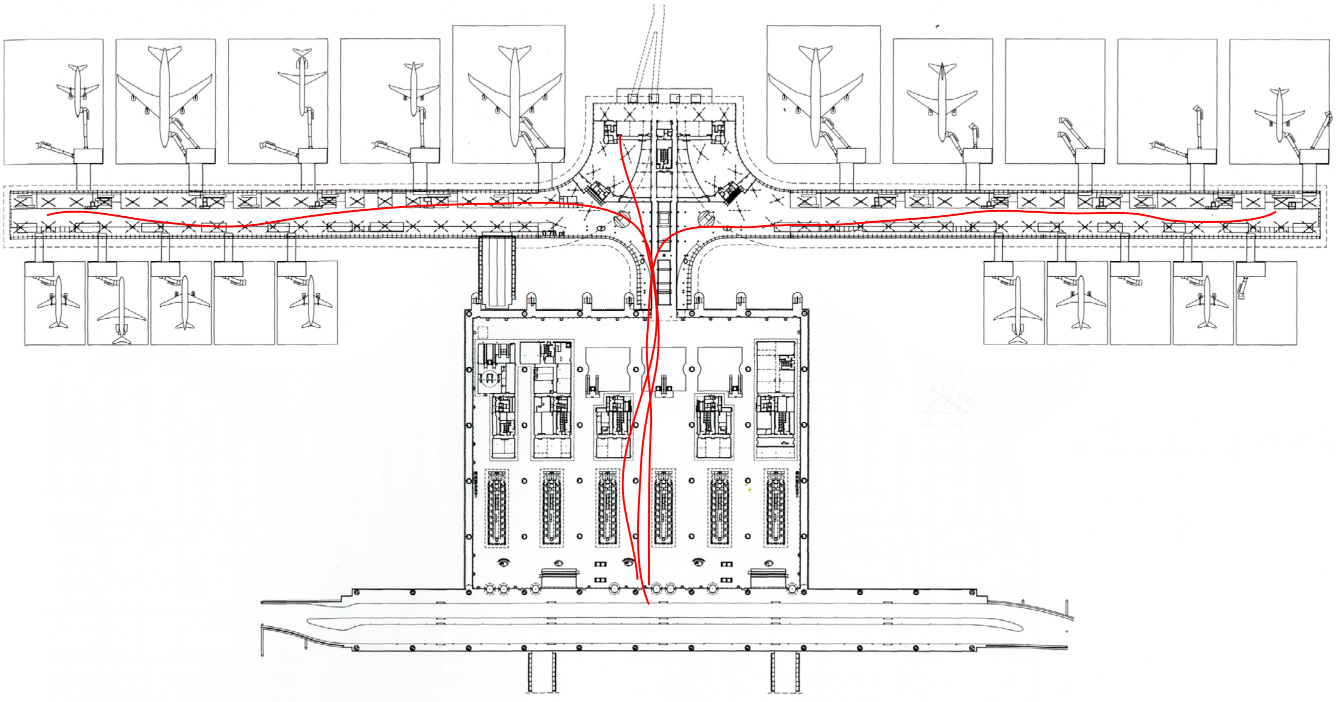


Figure 21: Kuala Lumpur Circulation

Ronald Reagan Washington National

Washington DC
Cesar Pelli

Ronald Reagan National Airport Terminal is the main airport to serve the DC area, it's certainly closest to the mall. Dulles and Baltimore serve the region very well too, but this airport not only has the added convenience of being right there within town. The airport is extremely well connected via the WAMTA. The airport has a metro stop just for the airport. When I travelled to Reagan National, I only rode the metro system around town, and not having to slog a suitcase, and briefcase wearing a suit through Washington's unnecessarily muggy weather to the nearest metro station. I would have still taken public transit, but I was ecstatic that it was that convenient. To get to Dulles, and the Smithsonian Air and Space Museum, a car was necessary or it would've taken over an hour to get out there through various routes of bus and metro with a taxi being necessary.

In terms of architecture of Reagan National, the most striking thing was the light throughout the terminal; it's not a sprawling terminal, so there's good access to natural light, and views. There is a lovely view across the Potomac of the Jefferson Memorial, Washington Memorial, and the Capitol Building on take-off and landing and some from the terminal itself. The terminal is arranged in a pier layout. To the East it connects to the older Washington National Terminal. Reagan is divided into two levels of use. The second is namely access. Each pier has its own security area and is not connected between all of them. This decentralizes security and is a move that is currently being avoided in airport design in each pier there are spaces for shops going down to the end of the pier. There's a coffee shop, and some place to get a bite to eat as well. This airport doesn't host a great deal of transitional traffic, since Dulles or Baltimore are more than capable of handling this, but this airport serves as the destination for the flights usually. Hence the connection with the transit system, and the ubiquitous title of "National Airport"

Figure 22: Reagan National Interior

The building is primarily steel and could be compared in some aspects to gothic cathedrals with their very tall and slender columns. The building does have some sun shades on it, and fritting on the glass to reduce glare. The building is an open plan within the split level, so the upper level doesn't extend completely to the ceiling. It is a very open floor plan that allows for people to understand that the way through the terminal is dead ahead. This is also aided by the lack of a wall of airline ticket booths. They're on the wall behind when walking into the terminal. This keeps the area open for light. This only works due to the very shallow constrained nature of the airport. The materials used are not expensive, but are done tastefully.

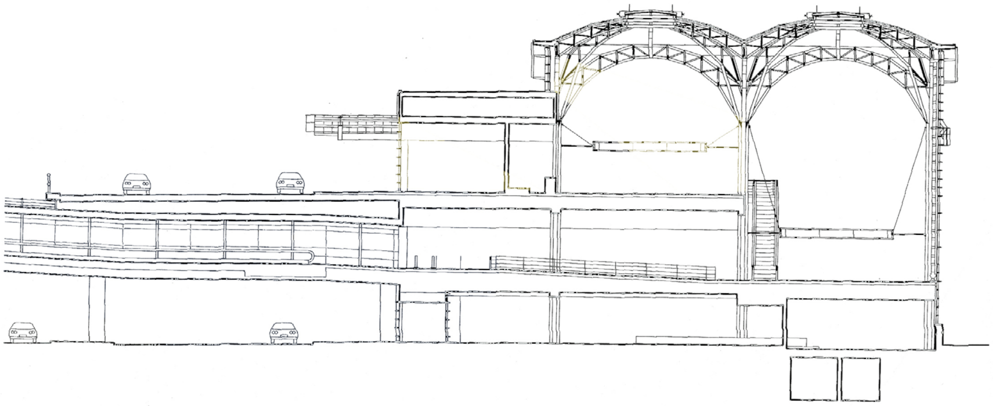


Figure 23: Ronald Reagan Section

Floor Plan

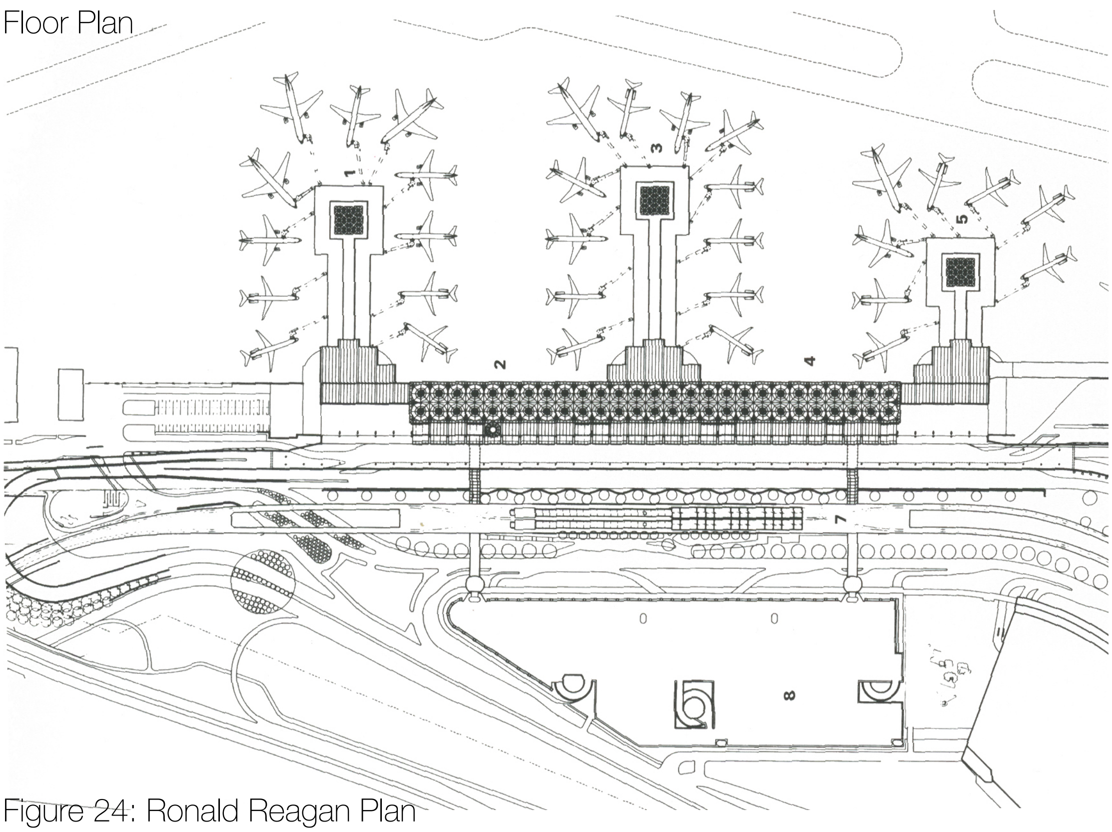


Figure 24: Ronald Reagan Plan

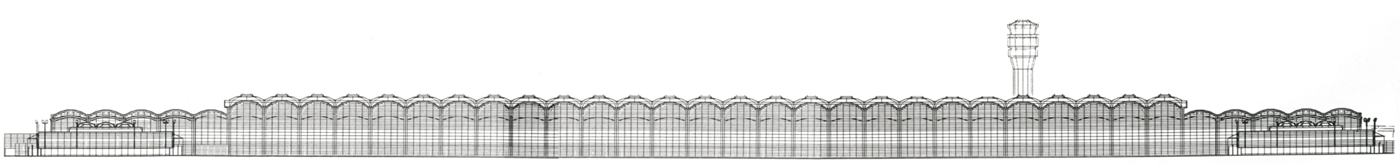


Figure 25: Ronald Reagan Elevation

Light Study

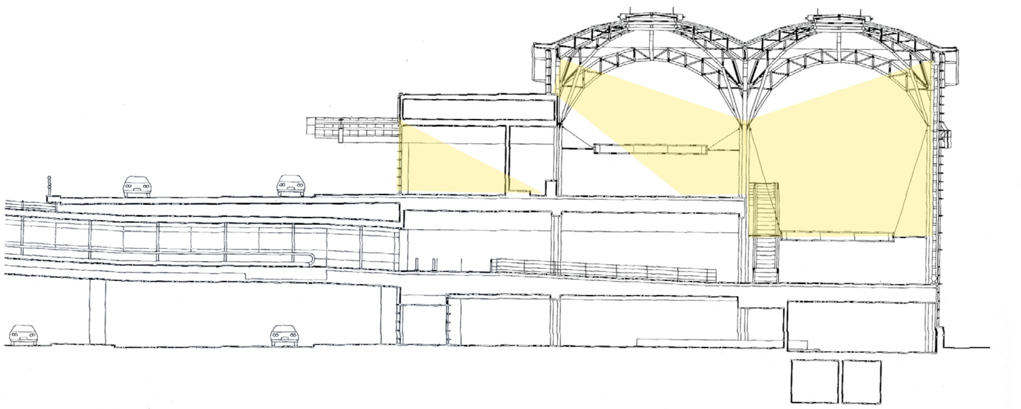


Figure 26: Ronald Reagan Light Study

Hierarchy

Figure 27: Ronald Reagan Hierarchy

Geometric Shapes

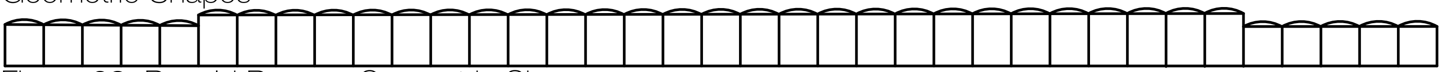


Figure 28: Ronald Reagan Geometric Shapes

Massing

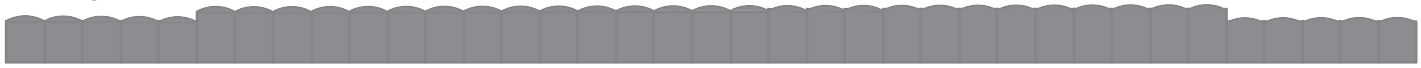


Figure 29: Ronald Reagan Massing

Structure

Figure 30: Ronald Reagan Structure

Circulation

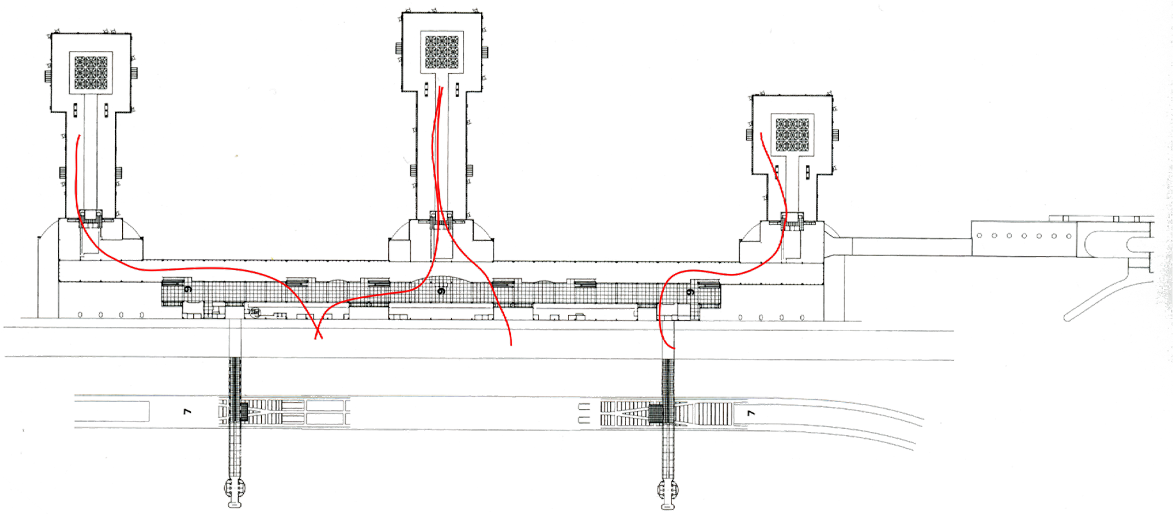


Figure 31: Ronald Reagan Circulation Diagram

Queen Alia International

Zizya, Jordan
Foster and Partners

Queen Alia International is built in Amman Jordan. It was finished in 2012. The airport has the capacity to handle 3 million passengers with provisions in the design to be expanded up to 12.8 million annually.

The building is made of concrete. This is not usually the norm, but it is done in response to the local climate. The climate is a dry arid climate, so high daytime temperature with a dramatic swing to low nighttime temperatures. This allows for passive heating and cooling of the building throughout the day. The building is a seemingly large square footprint in contrast to Reagan. Seeming much more similar to Kuala Lumpur International, but on a smaller scale. Light is let into the building by skylights near the columns that allow the interior to not be blanketed by light, but have areas of sunlight. This helps to break up the large interior level those benefits from this sunlight. The central area handles baggage as the place where the baggage goes to be sorted and recovered by passengers. The gates are located in the wings alongside. Expansion would be down these wings or as a separate satellite terminal, possibly both. The means of planned expansion are not immediately apparent, but there are definitely avenues to expand upon. The main limitation is what the terminal can handle for people moving through it, parking, and baggage. The old saying goes, "The seal in a cylinder is only as good as the weakest piston ring."

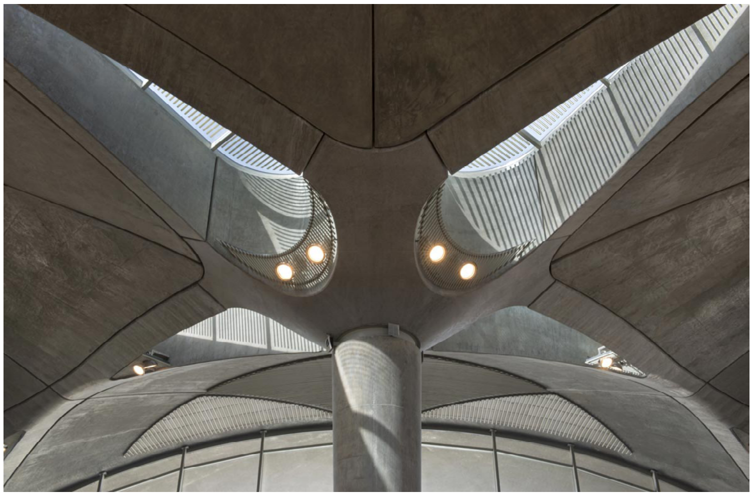


Figure 32: Queen Alia Interior

Image Courtesy of Foster and Partners

In a rendering of the building at night, it seems to be almost glowing. The building uses light, it has views, these are examples I have described as desirable aspects of an airport. The structural system is a series of bays with arches in them, similar to Reagan International. It's modular in a sense, if it needs to go 60 more feet, add another bay. These bays are finished with a finishing bay of sorts that is smaller and oblong in shape that terminates the shape. These airports are buildings that will be appreciated from the air, so the "money-shots" well-above the ground actually have some reality to them concerning these types of project, and I'm certainly seeing it with this rendering set developed by Foster and Partners.

Floor Plan

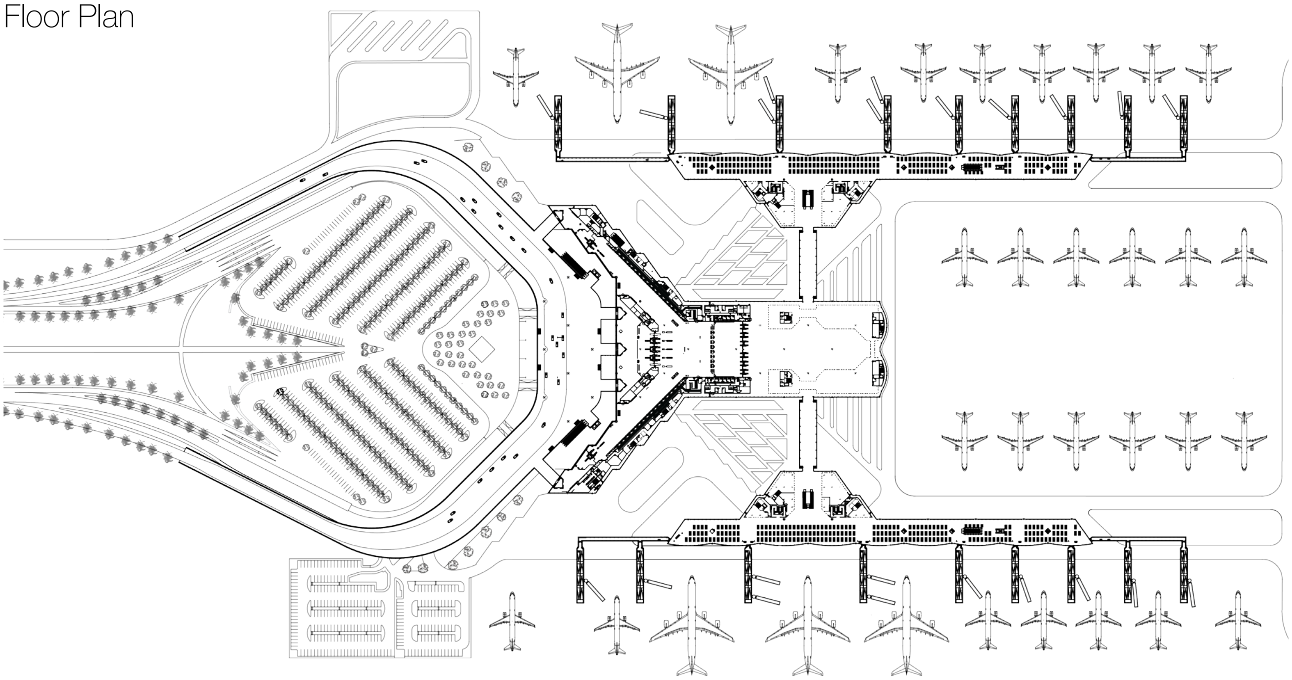


Figure 33: Queen Alia Plan

Section

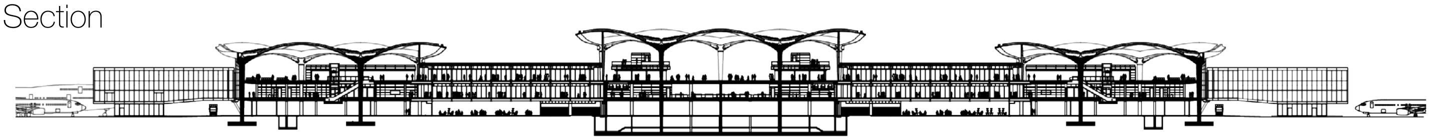
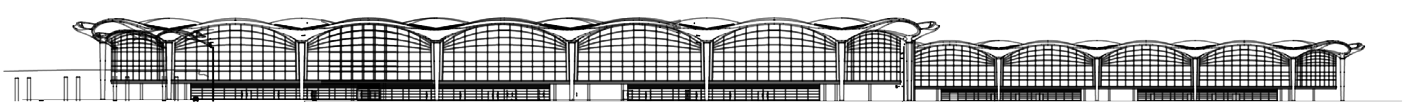


Figure 34: Queen Alia Section



Elevation

Figure 35: Queen Alia Elevation

Circulation

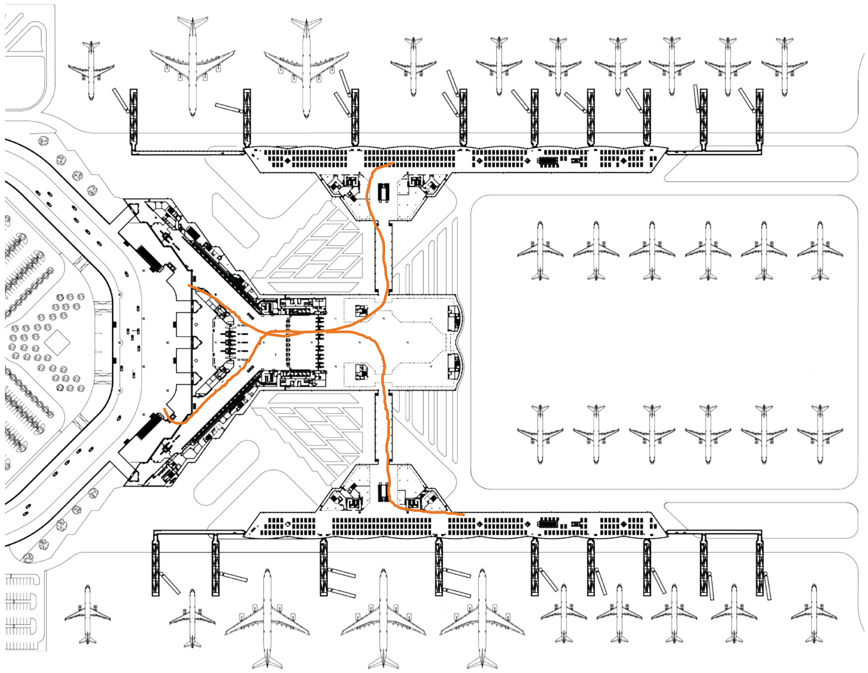


Figure 36: Queen Alia Circulation

Hierarchy

Figure 37: Queen Alia Hierarchy

Structure

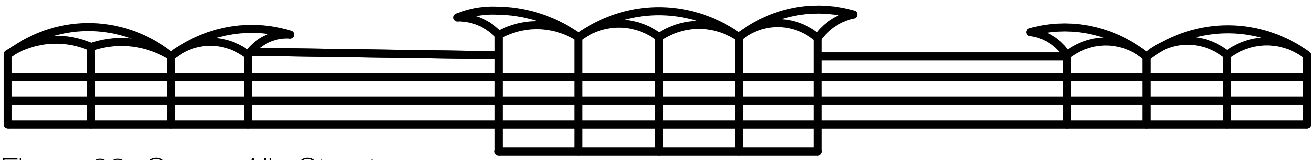


Figure 38: Queen Alia Structure

Geometric Shapes

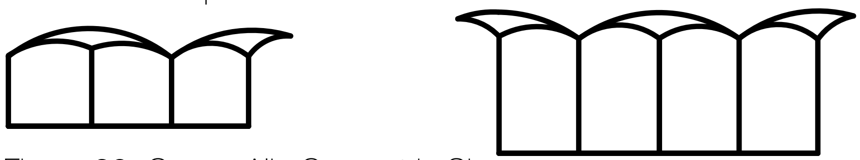


Figure 39: Queen Alia Geometric Shapes

Light Study

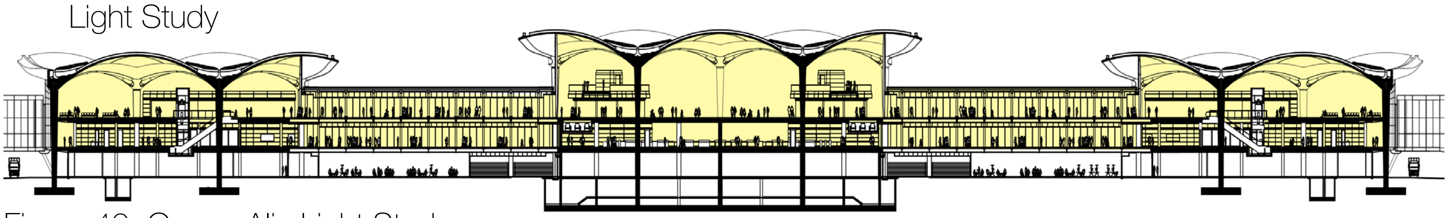


Figure 40: Queen Alia Light Study

Massing

Figure 41: Queen Alia Massing

Historical Context

History of Flight

The history of manned flight is a very recent one. But manned-flight needs to be defined as well. For the sake of this project, manned-flight not only requires a man to fly a plane, but be able to control it once in the air, something the Wright Brothers were the first to do with their 1903 Wright Flyer. This is specific to heavier than air flight, but lighter than air flight had been around for quite some time

Lighter than air flight had been proven in 1783. the Montgolfier Brothers proved this with their flight of the Etienne. That was in essence a hot air balloon though. The dominating craft in the lighter-than-air category would be the zeppelins or airships. The Zeppelins were named after Graf Von Zeppelin, a Prussian count (Perman, 2004). These craft can be described as cigar-shaped with bladders filled with hydrogen or helium. Their physical properties cause them to float much in the same way that a birthday balloon does. Their sheer size was due to the amount of air needing to be displaced. They are different than blimps; blimps have no rigid structure holding the bladders together. A zeppelin has a superstructure around it and is clad in a material to make it more aerodynamic, usually cloth. These were extremely long crafts, and since they had a rigid structure, they were not be able to be deflated and stored. They required a hangar of equally large proportion.

The airplane was a novelty at first, an amazing invention without a known application until the technology improved. It was a spectating event. So the first airfields were set up like racing tracks, with spectating area around the edges and the planes parked in the middle for all to see. This was the age where the airplane was not for everyone. The airplane was for military men and heads of state.

Pre-WWI travel was primarily the domain of the airship. The *Deutschland*, was the first commercial aircraft. Starting operation in 1910, The *Deutschland*, and eventually three others, had carried 19,000 passengers by 1914 to destinations within Germany (Perman, 2004).

The First World War developed the aircraft much further. It also gave Europe a much more built air-based infrastructure. This conflict gave the airplane range and payload ability. The first passenger planes were converted bombers. Passengers sat where the bombs previously were. These planes, such as the Vickers Vimy, had the duration to make travel by flight possible and somewhat practical at this point in time.

A Vickers Vimy, piloted by two Englishmen, was the first aircraft to successful cross the Atlantic non-stop. No small feat, this crossing was essentially from Newfoundland to Ireland between the 14th and 15th of June in 1919. This was a time when the fastest pre-WW1 passenger ship, Cunard's *Mauritania*, made the crossing in four days and 10 hours. The real show-stopper was the 1927 flight of Charles Lindbergh's *Spirit of St. Louis*. His aircraft crossed the Atlantic with him as the sole occupant of the plane. He flew from Roosevelt Field, New York to Le Bourget Airport outside of Paris in 33.5 hours (Perman, 2004). This was a turning-point for the prospects of air travel. The plane had arrived to the world-stage of transit. Not only did it prove the machine could cross such vast distances, it could be navigated as well, over featureless terrain.

The pre-World War II era was the golden age of propeller-driven aviation. Some of the most beautiful aircraft, the Curtis CW-20, the Boeing 247, and the Douglas DC-3 were produced during this era. These aircraft served a variety of roles, carrying passengers, cargo and mail. These aircraft were unpressurized, so the cabin crew would not only serve a fine meal and wine, but also provide an oxygen tank to the passenger if they began to feel unwell. The technology of passenger comfort needed to catch up to the aircraft technology of the time.

Two concepts of aviation that have not withstood the test of time but which provided data that needed to be considered for architecture were the flying boats and airships. Airships in the 1930s were in their heyday. A zeppelin could fly across the Atlantic and the passengers could sleep in a cabin, enjoy fine dining and walk around. The other aspect was the flying boat, beautiful craft such as the Boeing 314 or the Short Sunderland, the Spruce Goose was a flying boat since it would be able to supply much more remote areas that lacked the scale of a prepared landing strip required for such a plane.

There is another aspect of aviation, seaplanes. The Schneider Trophy was a competition developed to test aircraft manufacturers' ability to make a fast aircraft. Offered on and off, it was an annual competition of seaplanes that ran from 1913-1931. These aircraft would test not only aerodynamic design, but engine manufacturers' ability to produce a high-powered engine.

World War II saw many developments that would change civilian aviation and air travel. Long-range bombers were being used and produced en masse. The technology developed would be put to use in long-range air transit. Large four-engine aircraft were the mainstay of the Allied bomber force. The other technology that would come into play was the jet engine. The jet engine had matured from Frank Whittle's first jet-engine prototype. The first US jet fighter, the Bell P-59 Airacomet, flight tests was conducted during WWII. The test was done at Edwards Air Force Base, with the aircraft being transported under a tarp with a wooden propeller propped up onto it. The test pilot flew past a group of training pilots in a gorilla suit, in an aircraft that had no propeller.

There were a few propeller-driven aircraft developed during or immediately after WWII that were suitable for passenger service. Boeing developed the Stratocruiser, based on the B-29 (Airbus expanded these aircraft and used them to ferry Airbus aircraft fueslages for many years. So for a while, all Airbus aircraft started out in a Boeing). Douglas had developed the DC-5, and Lockheed had developed the Super Constellation. These aircraft filled the void for the years until other aircraft were developed. These aircraft, along with the DC-3, and the Curtiss CW-20 were pressed into service during the Berlin Airlift. It was one of the biggest triumphs of aviation, when Gen. Curtis LeMay was asked if the USAF could supply Berlin with coal and foodstuffs during the winter, he proudly replied, "Sir, the Air Force can deliver anything."

The first commercial jetliner was the DeHavilland DH 106 Comet. The DH 106 was first flown as a prototype in 1949 and entering service in 1952. It really ushered in the modern age of jet travel. Quiet, smooth, and pressurized for comfort, this was the new gold standard of travel. But, in 1953 three of them broke-up in mid-air. This was due to the shape of the windows, they were square. This caused metal fatigue and caused the airframes to fail when they were under the most stress: during flight, at altitude. This allowed other aircraft manufacturers to take a larger role. Boeing was developing the Dash-80, or the 707. Its first flight was in 1954. The test pilot was a former USAF fighter pilot, during a publicity flight over their Everett facility; the pilot did a barrel roll, in a large 4-engined passenger jet. Meanwhile Douglas was developing the DC-8. These aircraft would become the mainstay of North American passenger aviation.


Figure 42: Concorde

But there were large changes on the horizon. In the mid-60s it was envisioned that subsonic flight would become the way of the past for longer routes. The future would be SSTs, or Super Sonic Transports. In the 1970's, this started to become a reality. Boeing had been contracted by the government to develop an SST, the British and French were both working on the Concorde. The Russians were developing the Tupelov Tu-144. Out of this, the 747 was developed. The two decks were made so that the lower-deck would be for cargo only. Boeing's projectsuffered multiple setbacks and budget overruns, so that project was cancelled. The Tu-144 project suffered a crash at the Paris Air Show in 1973, and that project was put on hold as well. The French and British successfully developed their project and used it. Air France and British Airways had Trans-Atlantic flights that would take only

Figure 43:Pratt and Whitney logo

a few hours, half the time of the Boeing 747. The Concorde was permanently grounded in 2003 after an accident involving some debris on the runway that caused a tire to explode and take out two engines, causing a crash immediately after takeoff. Ironically, the 747 that was originally developed to fill a cargo role became one of the most popular commercial aircraft.

The Boeing 747 and the Airbus A380 are the two of the largest passenger aircraft today, while Boeing and Airbus have a varied fleet of smaller aircraft that serve all kinds of routes and densities of flights. These are the two aircraft that an airport will need to be designed to serve. Considerations will need to be made with respect to the weight of the aircraft, and the size, both in wingspan and in length.

History of Airports

The first bases of commercial aviation operation were for zeppelins. These hangars were extremely long structures, primarily built on land, but one of the first was built on water. This was constructed by Otto Von Zeppelin on Lake Constance. An airship hangar needed a mooring mast to hold the zeppelin to while it was loaded and unloaded. This would be in close proximity to the hangar. So these hangars were the focal point of the first airports in a sense. This is the place that passengers would embark or disembark.

For heavier-than-air craft, the first airfields had a few hangars, and a large open grass field, usually tended to by cows or sheep so that it'd keep the grass shorter. With a lack of control surfaces for these first aircraft, taking off into the wind was paramount. Combine their usually light weight and a large field; it was a very versatile setup to take off from. As mentioned before, these early airfields were precursors to the airport, but served no other purpose than as a place to take off and land. Europe had much more development with their aviation infrastructure than America. This was due to a few reasons. The American government was not interested in this technology due to their policy of isolationism taking place pre-WWI. The distances between places were an issue. These planes didn't have the range to fly to most cities in America. These early aircraft were expensive things, and as mentioned before, aviation was for the military and heads of state. Since government investment was required, Europe was developing more aviation infrastructure than America.

Post-WWI, much more prepared landing areas were required, as planes became heavier and heavier and a grass field became unable to bear the weight of planes, especially on a rainy day. A pioneer of American Industry, Henry Ford, could be said to be responsible for the first airfield with concrete runways. The Ford Dearborn Airfield was developed as a corporate testing facility to test the Ford Tri-Motor aircraft, but it was also used as the airport for the city of Detroit. It featured a hotel, restaurant, and a limousine service. These appointments can be considered very modern for an airport. The concept of a private company building airports was not an odd occurrence in America at this time. The technology was there, but the infrastructure was not. American airports at the time consisted of a "hangar-depot" (Perman, 2004). The hangar-depot arrangement was a series of hangars that the passengers would then board the plane in the hangar. Passengers were sheltered from the elements mostly by a roof over their heads, but had to contend with loud radial engines in an enclosed space, exhaust fumes, and the temperature. The airfield operations concerning a passenger were still centralized around storage of the aircraft.

The first premonitions of a modern terminal were at Konigsberg (Kaliningrad) in East Prussia (Russia), the passengers and administration were all placed in one building, with the hangars next to it. But passengers would still have to move from one building to another or outside to board a plane.

The concept of shelter to the plane had first been tried at Boeing's United Field in Burbank, California. The construction of these was a series of telescoping canopies that would give people a cover over their heads on their way to the plane. London's Gatwick Airport also attempted this, with telescopic tunnels extending on rails along the apron to meet nearer the aircraft. London's Gatwick was also one of the first to be connected to a rail network, something that is present in Minneapolis currently, but a critical consideration in airport design. Times to get to the airport 25 miles south of London left something to be desired though.

Gatwick also featured a radial design; this had capacity for six planes concurrently with immediate service to the terminal. This design was flawed though, it did not allow for graceful use of larger and larger planes, and did not work with the boom of post-war aviation becoming a means of transit for the masses, not just for the bourge.

Paris Le Bourget was the first terminal to use the linear terminal shape we are all familiar with today. This terminal housed much more than the earlier 1920 design placed on the site. The rate at which aviation's impact was growing and the impact on the economy and national pride prompted these terminals to be replaced in under two decades. It was a rampant time of aircraft development and facilities needing to catch up.

Berlin's Tempelhof airport is an important development in the history of airfield design. The design was an arced design that could have been expanded, and this is a very key aspect of the design. This expansion for future aviation needs is a key development. Most of the buildings of the time were so rigid in their construction that it was easier to build a new terminal altogether, but Tempelhof remained largely unchanged for 60 years. It was designed to work until the year 2000 and largely did. This was due to a few political reasons and another airport taking on the role of larger aircraft. But Tempelhof had a large amount of expansion space, for the building as mentioned, but also for the runways. This meant it could handle larger aircraft. They handled the Junkers planes commonplace in civil aviation at the time of its construction, but also the 747-100, two very different aircraft, in both scale and demands placed on facilities.

Throughout this time period, the tower was always given a sense of hierarchy over the design. This was for two functional reasons: one being radio range so that pilots could communicate properly with the tower and the other being visual range for the people in the tower to actually see the aircraft. Airports have been built on reclaimed land for a long period of time. This was at first because a water-landing could be considered a "softer crash" than into the ground if there were testing failures. But as aviation expanded, the flying boat became a much larger player. Since landing strips were few and far between, landing on water was a much more available option in both Europe and America. New York's La Guardia was built on water for that reason. This airport served flying boats from Pan American Airways and other airlines. There were separate terminals for each type, marine and land-based. Being built on reclaimed land, La Guardia had no easy expansion avenues and was over-crowded soon after being built.

Pre-World War II aviation was a very romantic period and futurist visions must be mentioned. The top of the Empire State building was proposed to be capped with an airship mast so that people could disembark from the airship via a gangplank and be on the street within seven minutes. Frank Lloyd Wright proposed the same types of connections on top of his Futurist modernist designs. The practicality of dealing with wind at that height rules this out as a viable method of mooring. The lack of commercial airship travel rules out the need to consider winds for mooring as a whole!

World War II stopped the airship development as a whole; they were too slow. In America, many airfields were built; many large bomber bases that would handle large heavy aircraft were built in the Pacific and in Europe in Allied areas of operations. This combined with the new technology introduced that made the standard aircraft a much larger machine, with respect to weight and dimension. The flying boat was made redundant for large airlines because of the modern aircraft range and the modern facility's availability. The way forward for design would be to cater to larger land-based aircraft.

Post WWII saw the final completion of Tempelhof and the role that an airport could serve with the Berlin Airlift; this was a firm statement that the aircraft was not just a devastating machine for war, but also a machine for peace. The aircraft had a much larger role to play in travel and business. The immediate post-war period did not redefine aviation architecture drastically, but the advent of the Jet Age produced some striking icons.

The Jet Age introduced a new aerodynamic concept to aviation, the swept-wing design. Planes become sleeker to improve aerodynamics, they look like they are moving standing still. The Jet Age also made the use of aircraft a means of viable transport for many. The technology was proven, cabins were pressurized, and planes were large enough so that the cost per passenger was much lower than before. There was economy brought to it, and with that came demand. These new airports would mark a dramatic turning point in design. No longer would they be dwarfed by most train stations and piers, but the would take on a dramatic size of their own.

Idlewild Airport, now known as John F. Kennedy International, was being developed almost immediately during the post-war era, with large amounts of space marked for expansion of runways and additional facilities. The method of terminal development taken at airports like JFK, Dulles, Chicago, and Dallas/Ft. Worth is the multi-terminal design. For example, there would be a few common terminals with gates being rented out by the airline on a flight-by-flight basis, and then larger airlines Like Pan American would have their own terminal at JFK (Perman, 2004).

The jetway was developed as we know it today because of the noise of early jet engines. Modern jet engines have a turbofan engine that have a quieting ring of compressed air exit around the exhaust gases. The early jet engines were turbojet engines, so they were much louder, so to access the plane, there needed to be an enclosure to abate noise.

The facilities within an airport were honed and developed in this time, it became a commercial venture, and shops became an important part of the business as well.

This individual terminal arrangement gives multiple security checkpoints to get onto a secured tarmac. This issue was really clamped down on post-9/11, and airports are either remodeling to reduce security checkpoints so that things are more secure, or replacing the terminal as a whole.

Terminals produced in the late 1960s and early 1970s are at some of the busiest airports in the world are currently in use. The main difference between these terminals and the ones designed previously is the centralization of security. They have been remodelled over the years to stay current, but some parts of the design are rigid in their dimensions.

History of Minneapolis Airport

Minneapolis' current airport was built on the site of the first airport. Originally built in 1920, the airports needs expanded, and it subsequently built a new terminal in the 1960s, the Lindbergh terminal. NorthWest Airlines had their world headquarters in Minneapolis. Minneapolis is currently expanding as well. But the airport had become hemmed in by development. They are currently expanding their terminal to not only add more gates, but more parking, a centralized security layout, more shoppes, areas to spend time, and additional facilities.

> Passenger growth continued to exceed expectations in the 1970s and 1980s. To address this growth, the Minnesota legislature passed the Metropolitan Airport Planning Act in 1989, establishing the Dual Track Airport Planning Process. Conducted by the Metropolitan Airports Commission and the Metropolitan Council, the seven-year planning process explored options for providing needed air service capacity and facilities for the region. Specifically, competing plans were developed to either expand MSP at its present site or build a new airport elsewhere. (MAC)

In 1997, an airport planning commission decided that an additional runway at Minneapolis would be added and the terminal expanded. This was in lieu of a new site. A new airport would have been built had two runways been required. There is no more space to add runways unless development becomes extremely invasive on the surrounding community.

History of Minneapolis

Minneapolis was first established as trading post set up near Fort Snelling in the years 1825 to 1860. Minneapolis was incorporated as a city in 1867. Rail service had connected Minneapolis to Chicago that year as well, supplying the Chicago area with goods. The city of Minneapolis had a large place in trade along the Mississippi River shipping flour. Their output in 1905 accounted for 10% of the wheat and grist in the US. (Minneapolis, Minnesota State History) This industry was a driving factor for development. The city became the financial centre of Minnesota because of the amount of businesses there during the period when wheat was processed into flour within the town.

Figure 44: United O'Hare terminal

Thesis Goals

This semester I am going set a goal, a goal to design an airport. I'm hoping to work in the professional field that combines architecture and a field I really enjoy, aviation. I'd love to work on these types of project because the combination of architecture and aviation is something I think I would really enjoy. I want to bring the perception of an airport from a pilot's point-of-view into the process as well. This is critical in taxi layout, and having a clear means of movement for aircraft.

Figure 45: Piper Warrior cockpit

I've attended NDSU since 2009. I have been enrolled in the architecture program since then. I transferred down to NDSU from UND for the architecture program and warmer climes. I was previously an aviation major and loved the flying aspect of it. I have volumes of books on aircraft and love to read them, doing this research I would often lose track of my goal and become lost reading about the history of airports or aviation.

I have always enjoyed aircraft, and the notion of flight. I find planes to be quite beautiful and would like to take that aesthetic into the design of the building. Aircraft have a function over form mentality, but the form is a function as well. The Concorde or SR-71 Blackbird had the shapes they did so they would go fast. The Concorde was polished before every flight to make it more aerodynamic. The SR-71 had no fuel tanks because it would expand so much that a fuel tank wasn't feasible. It'd leak jet fuel all over until it took off and got up to speed, having to refuel in air before getting up to speed. The F-117 Nighthawk was comprised of angular planes to reduce the radar cross section. These are some examples of extremes aircraft can take for function, but creates part of the form as well. I'd like to take that mentality into the design of my airport as well, but not just create a box; it must have the beauty of an aircraft.

This project will be a great departure from previous projects in scope. I hope to learn how to manage time better than ever before, use software more efficiently, and design efficiently as well. This project will need to be modular in design, from smaller things such as the gate to the overall gate area and terminal. These are areas that would need to be expanded. This will have a large scale in my design process overall with the site needing to be designed accordingly. I am going to gain a very good understanding of circulation systems with this design, since an airport is 20% circulation as a conservative estimate. There will also be knowledge gained on wetlands in design and other energy efficient systems to offset the pollution of the building and the surrounding activities.

Climate Data

The winds are primarily from the northwest and Southeast depending on the season. Wind is usually rather constant. A fair number of sunny days annually, well over half of the year is bathed in sunlight. The temperature makes a big swing on average annually, 84 degrees fahrenheit in the data supplied. The site slopes towards the Mississippi River to the east, With some local noise but the surrounding area is mostly farmland, so it's currently very quiet. Snow can accumulate rather quickly, and can also reduce visibilty with the wind.

A METAR is a common way for a pilot to reference weather. It should not be used in lieu of a proper weather briefing. the METER is valid for 1 hour. It is read as the first line of text and has been "deciphered" to explain what it means. These are conditions at Minneapolis-Saint Paul Airport.

KMSP 051553Z 26017G22KT 10SM FEW023 M14/M19 A3005 RMK AO2 SLP195 T11441194
Minneapolis-Saint Paul Airport
5th day of the month
15:53 Zulu
Wind 260 17 kts gusting 22kts.
10 Statute Mile Visibility
Few Clouds 2300ft MSL
-14 Celsius
-19 Dewpoint
30.05 lbs barometric pressure
REMARK
Senses dewpoint
Sea level pressure of 1019.5mbar
Temp - 14.4
Dewpoint -19.4

Figure 46:METAR

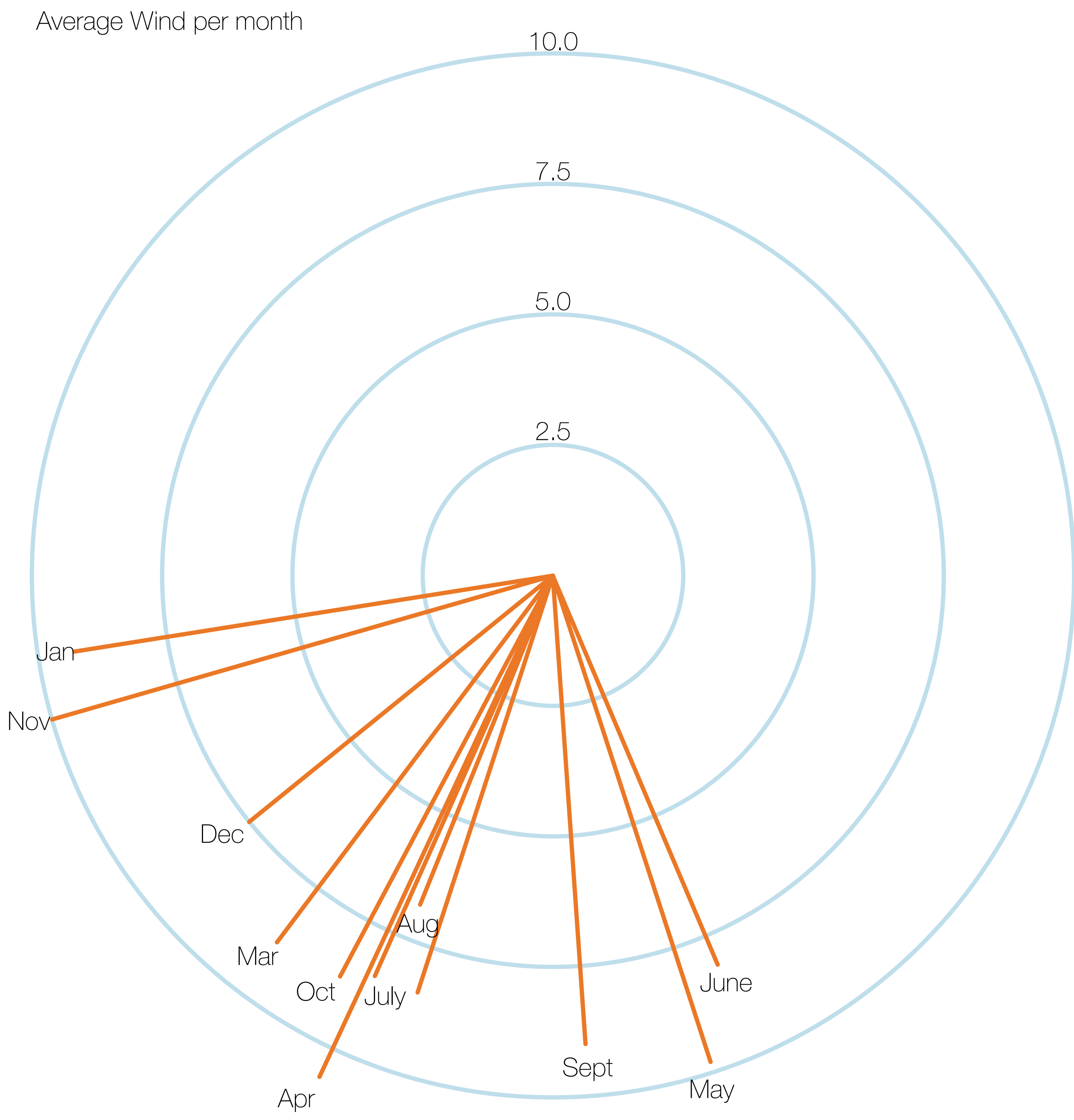


Figure 47: Wind Rose

Sun Diagram of Minneapolis

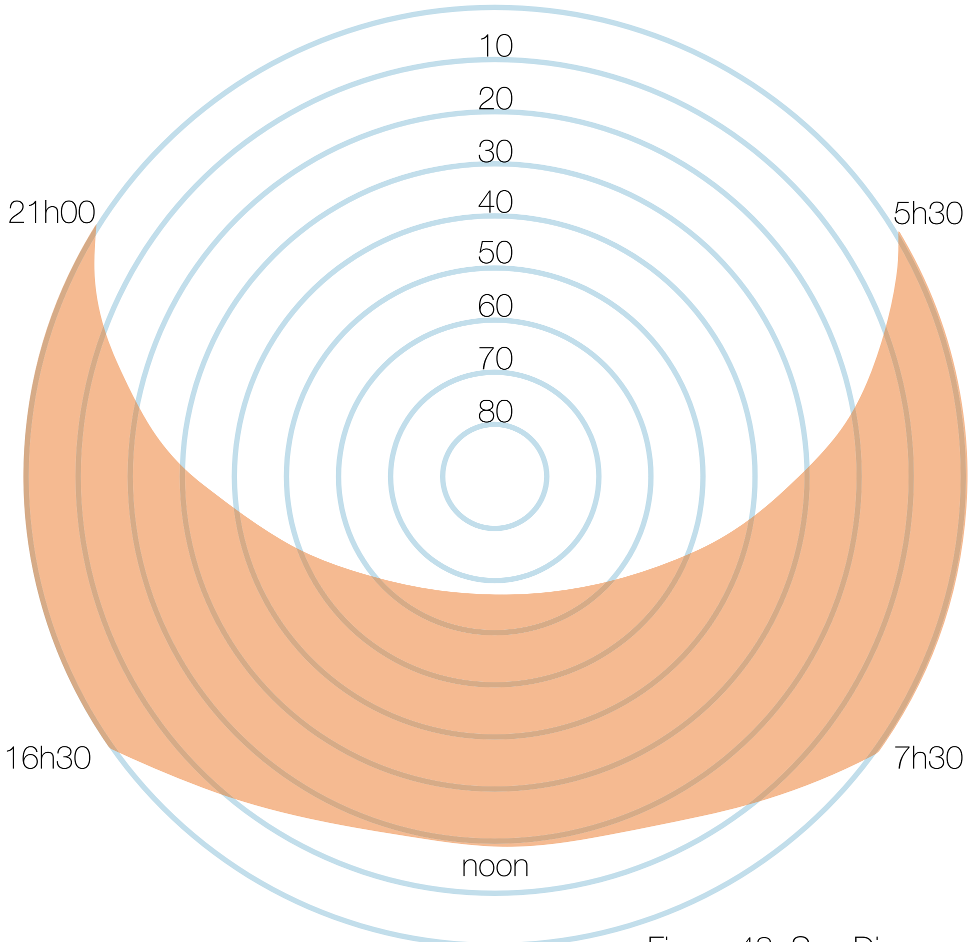


Figure 48: Sun Diagram

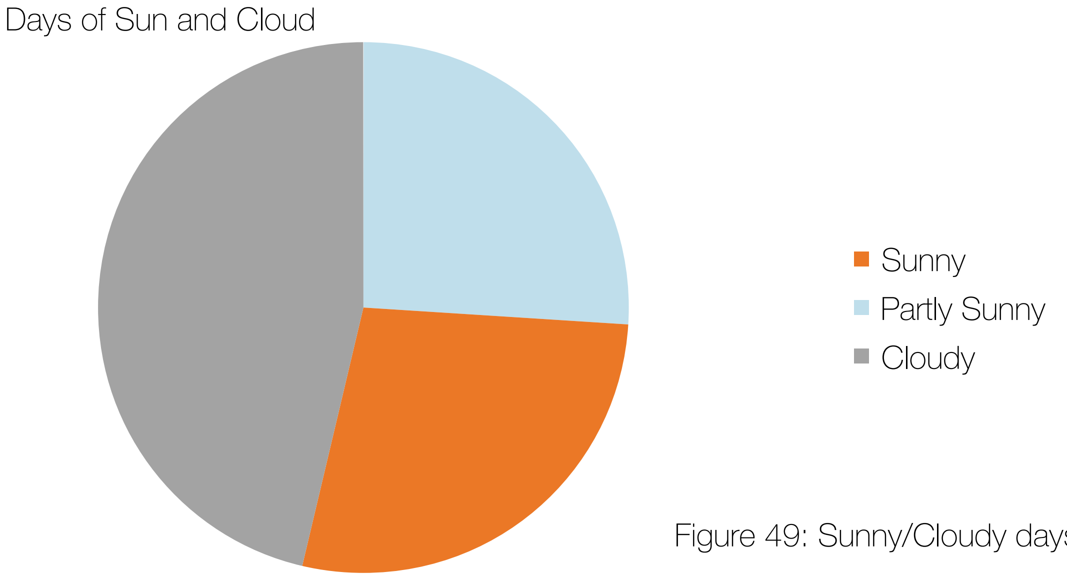


Figure 49: Sunny/Cloudy days

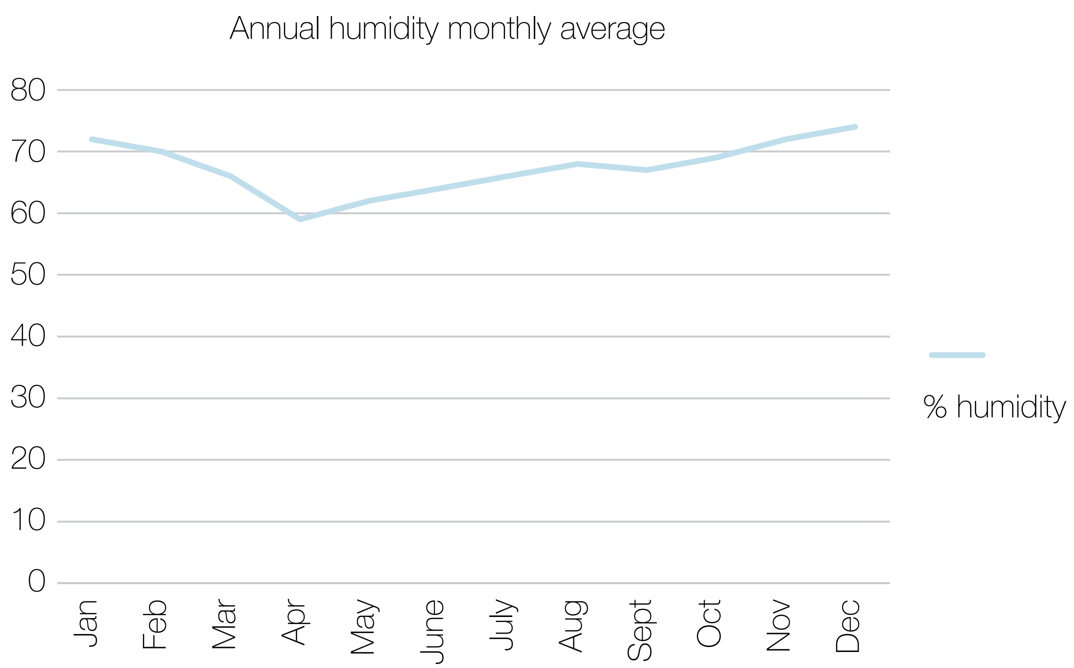


Figure 50: Humidity chart

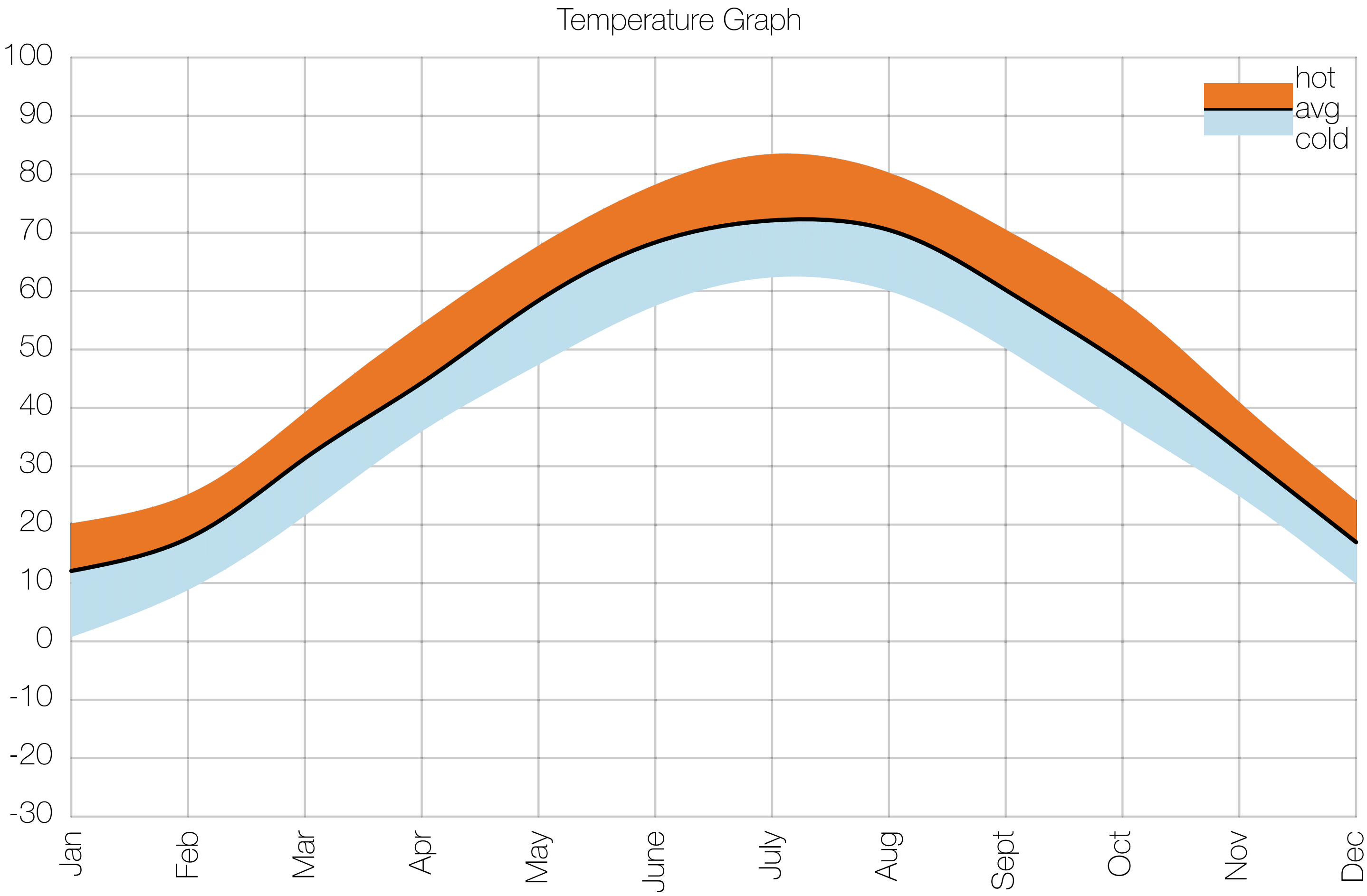


Figure 51: Annual Average Temperature

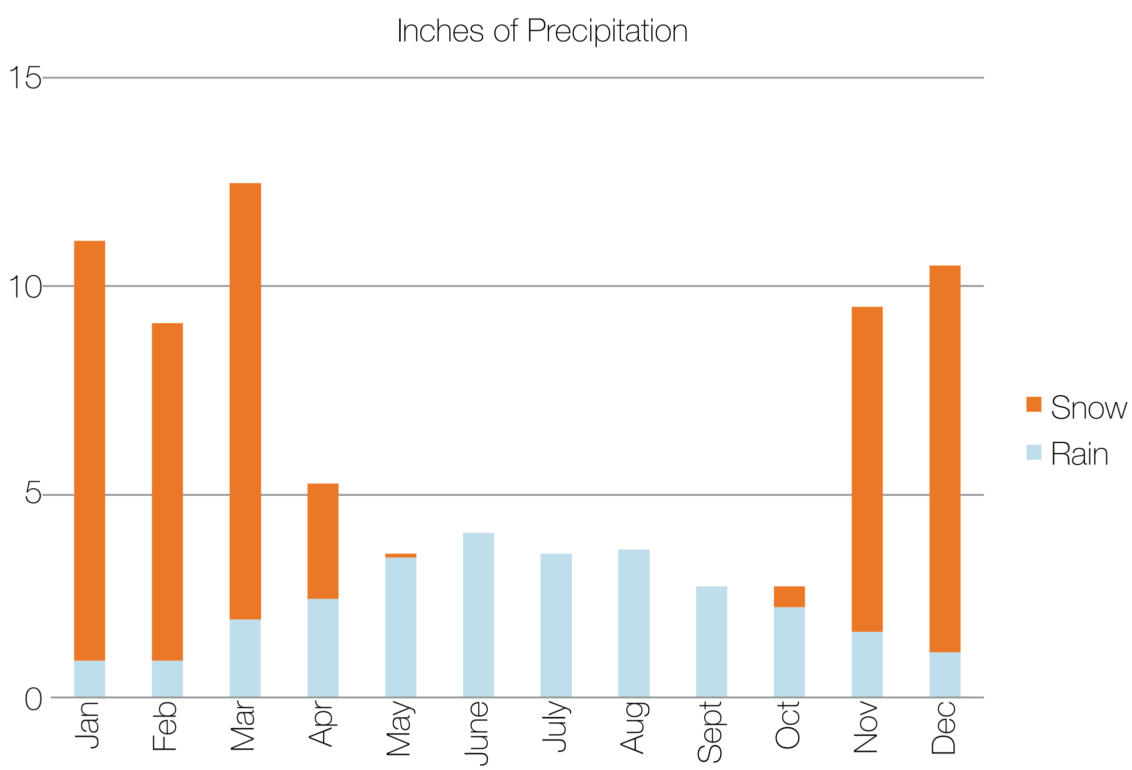


Figure 52: Annual Inches of Precip

Topography Map

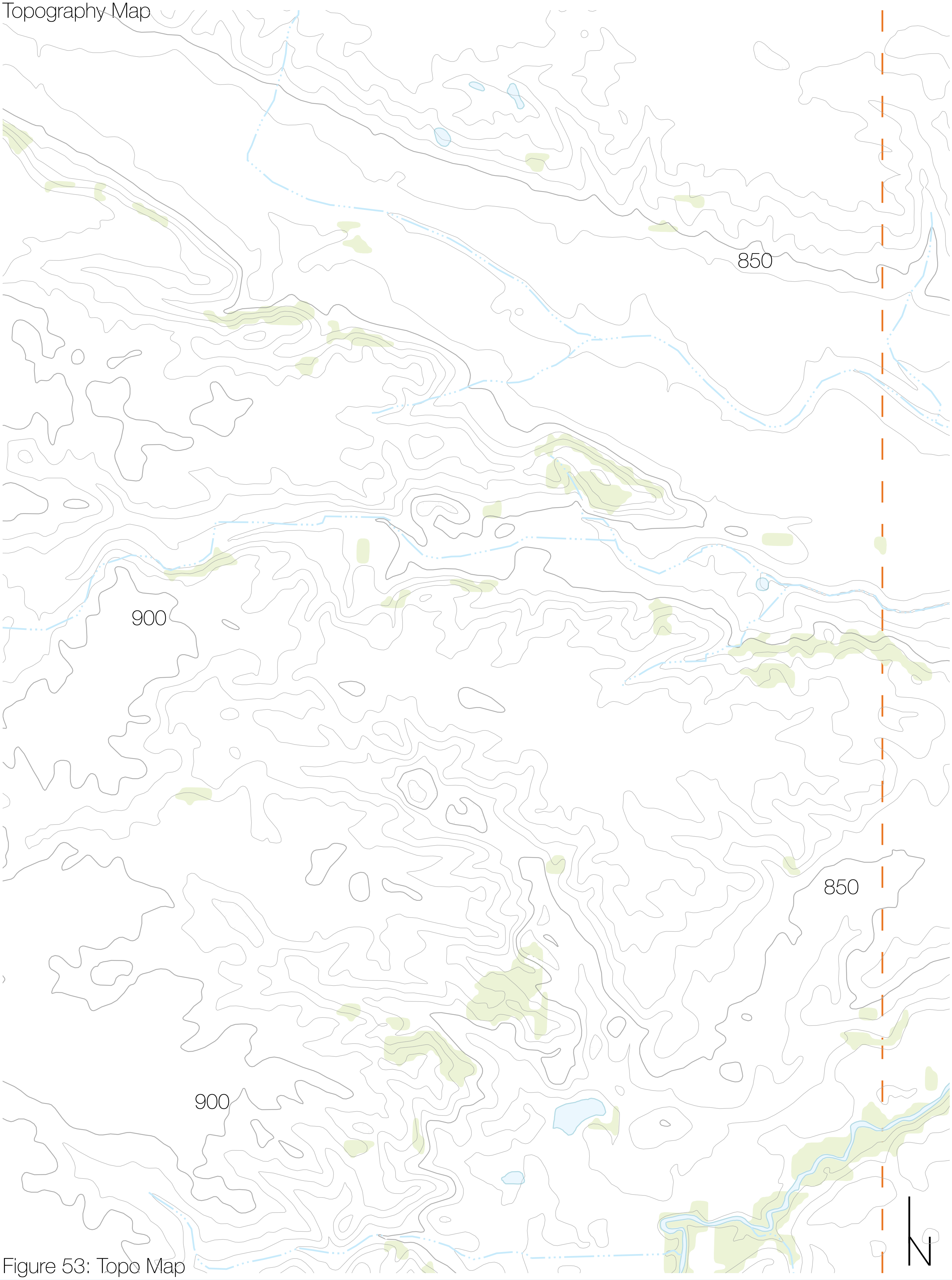


Figure 53: Topo Map

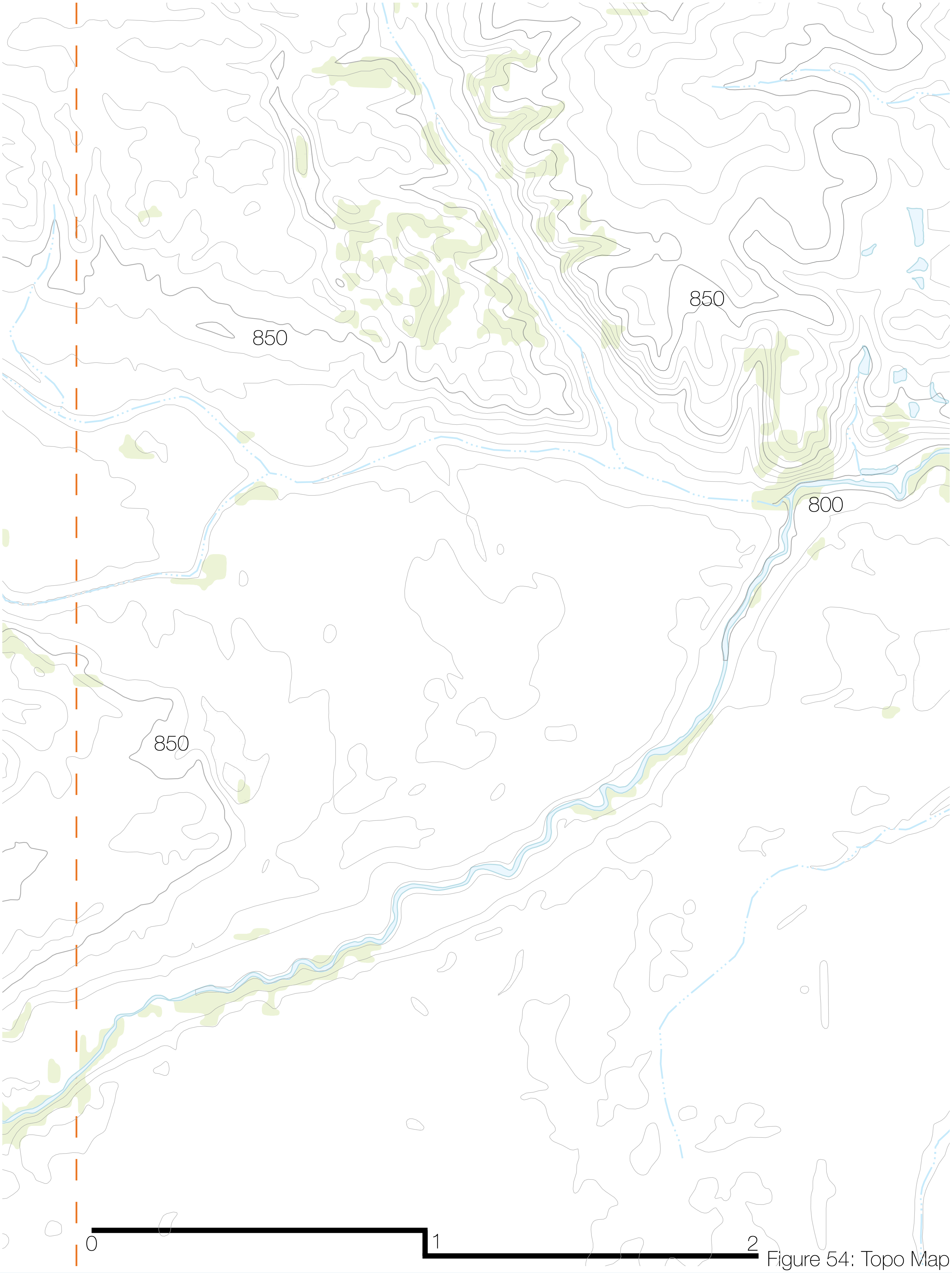


Figure 54: Topo Map

Wind Diagram

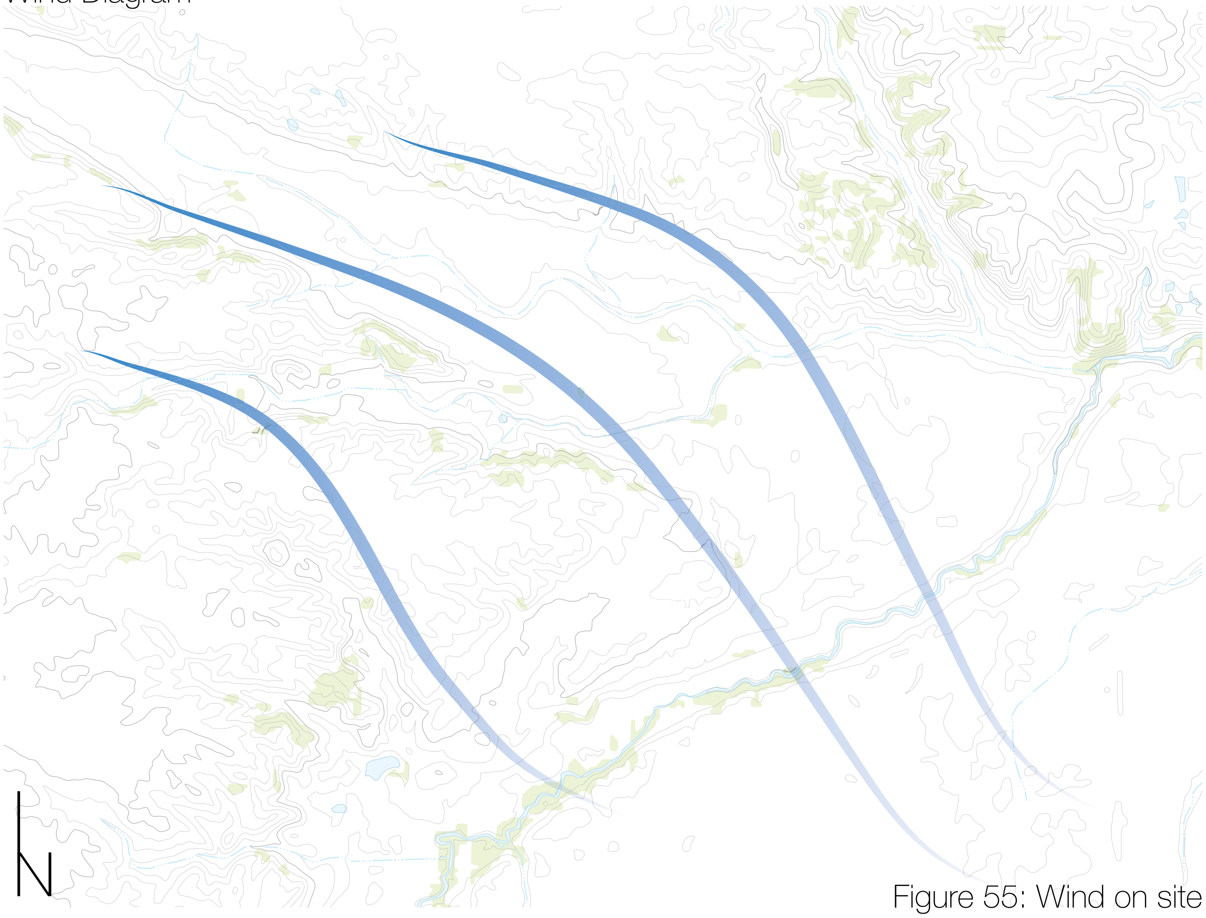


Figure 55: Wind on site

Noise Diagram

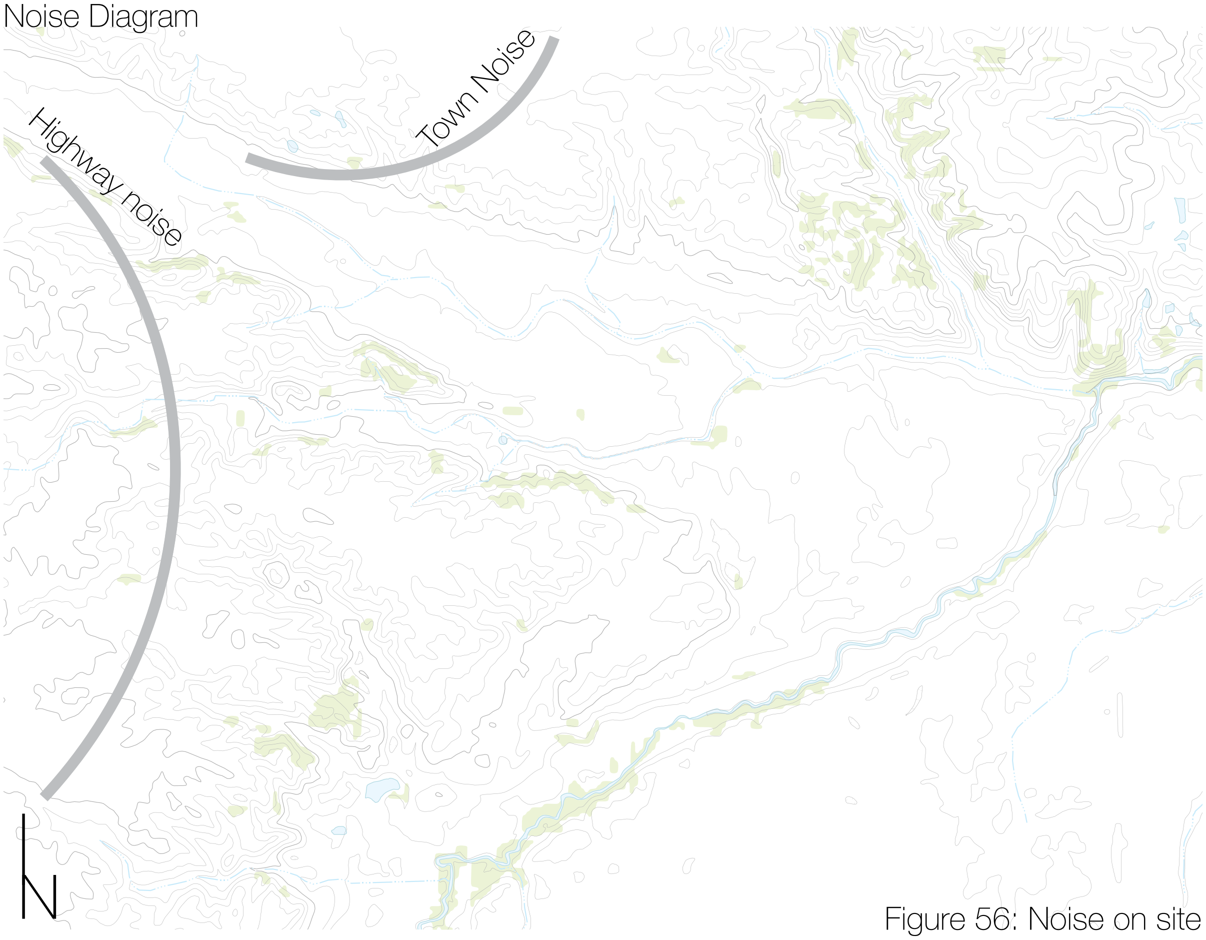


Figure 56: Noise on site

Figure 57: Site Section

Shading Diagram

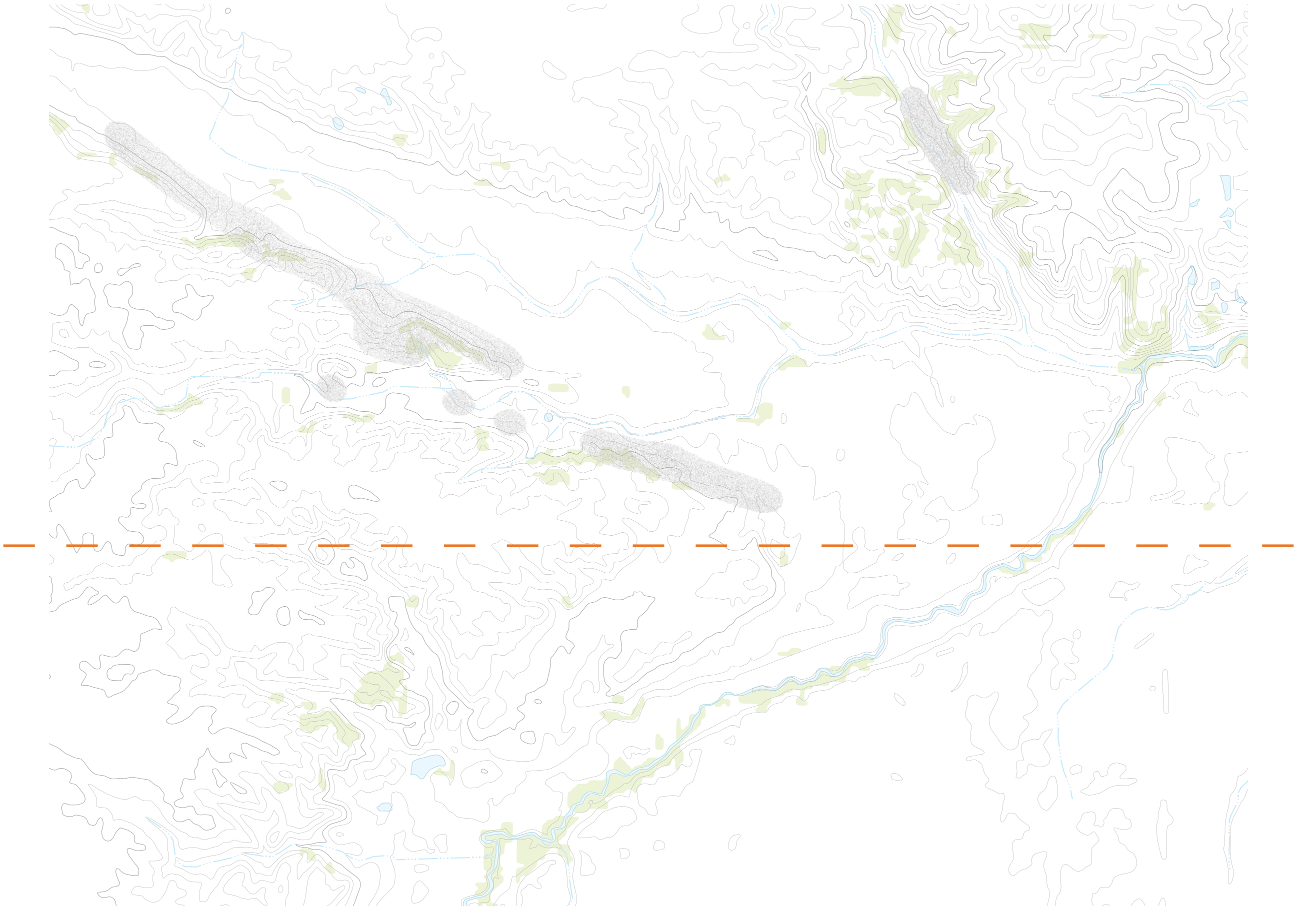


Figure 58: Shading Diagram

The site is open farmland, very little shading exists

Figure 59: Site Stereographic Pano

Site Analysis

Figure 60: Site Pano

The site is to the southeast of Minneapolis' downtown. It is to the souuthwest of Hastings. The general grade of the site slopes downhill to the east towards the Mississippi. There are some smaller runs in the site from water drainage. Most of the site is farmland.

CURRENT SITE

Currently, the site has enough terrain variation to obscure views around the entire site. Most of the site upon my visit was full of tall corn stalks, as seen in the pictures. This really made it hard to get a proper lay of the land with ease. I did find a few peaks in the area that had access up to them via a gravel road. Shelterbelts of trees exist dividing fields. Mostly corn was planted. Minimal utilities exist in terms of power due to the sparse population.

Figure 61: Corn Field

The current site has a grid of roads at a mile apart as the standard county road division goes. It is laid out in a north-south east-west grid pattern. The current texture in plan is really fields used for farming. The picture above illustrates a view from the road. The roads were two-lane gravel roads with no shoulder. The existing materials are a few houses and power lines.

The site ranges from 900 to 800 feet across the area.The site currently has some small streams on the far east edge of it. Most of this terrain variation is located near those streams and is not currently used as farmland.

The built features on the site consist of a few houses and the appropriate power lines running to them. I am relatively certain that infrastructure to this area would be in the form of septic tanks and minimal cables run underground.

The light quality on the site is wondrous. Beautiful sunlight is available since it is an open plain, as seen in figures above. It is a 6300K colour of light, natural sunlight. The intensity varies according to the day, on the METAR mentioned above it'd be a cool, but sunny day with a few clouds in the sky, stratus clouds judging by the height.

Vegetation on the site is mostly artifically planted crops, which seemed to be mostly corn in that area. That or the fields had been harvested and tilled by the time my site visit occurred. There were some tall grasses in the areas that had water. Colours of the vegetation ranged from the beautiful golden colours of ripened stalks to the lush greenery of tall grasses. There were also shelterbelt trees, probably quick-growing trees such as poplars. Poplar trees are horrid for any kind of longevity. The trees are in rows or thicker groves that still maintain a very linear quality. The fields are maintained in squares within the 1x1 mile grids. The taller grasses are naturally occurring around the streams.

The water on-site is seasonal, with the smaller streams drying up around July and appearing once again during the spring thaw. The main stream running from the southwest of the site to the northeast was quite minimal when I saw it on my site visit. Most of this water would be generated as runoff from the fields, and depending on how the fields are fertilized and maintained, it could be polluted.

The wind on the site is in line with regional norms due to the size of the site. It comes from the northwest during the winter months and the southeast during the summer months, with some variations. The shelterbelts control wind up to the tree height, probably 30 feet. But that is all.

The site definitely shows signs of human use, however, most of it is not inhabited. As mentioned before, it is farmland, a very deliberate condition of the site, but one that is not too intrusive on the site. There are some houses though, very few. I would hazard a guess as to the existence of ten houses.

The site would be described as distress-free. There will be a few dead trees, and older buildings as associated with some farms, but overall the site is very prim and proper. These issues are noted on a very critical level.

Soil type

Dominant soil order mollisols
Dominant suborder udolls
Primarily Sandy Loam soil
Slopes are 2-6%
Drainage class : Somewhat excessively drained
HYdrolgic group: moderately low runoff potential
When thoroughly wet, water transmission through soil is unimpeded.
Primarily Non-plastic clay

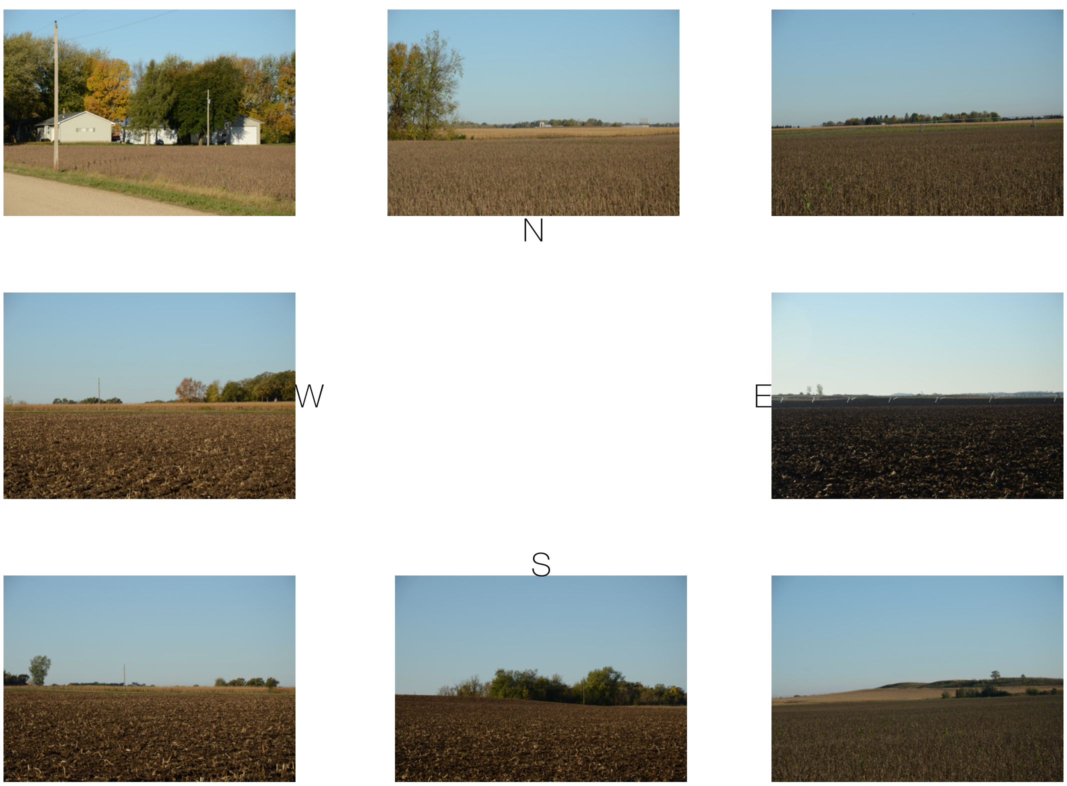


Figure 62: Site Photo Grid

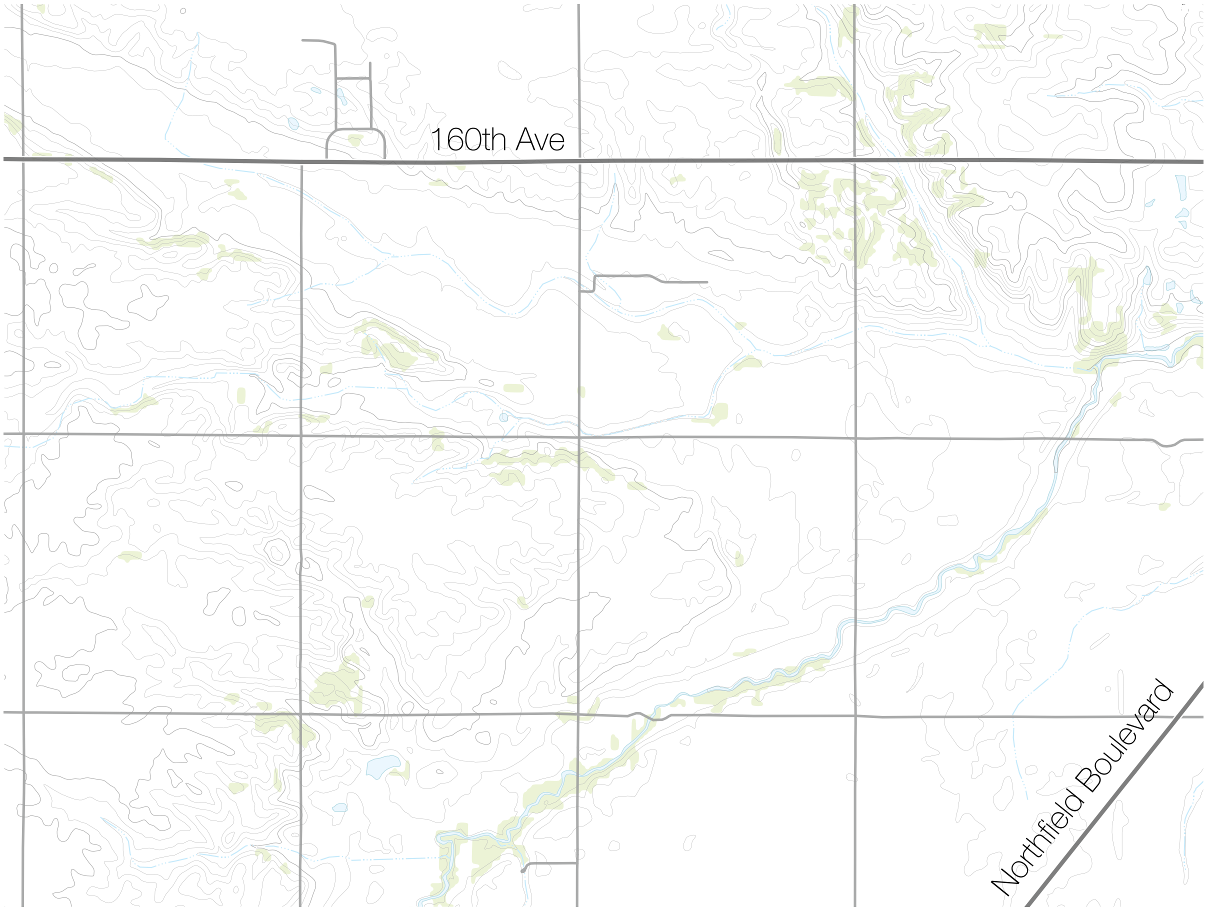


Figure 63: Site with gravel roads and main access

Spatial Allocation

Program Spaces

Check-in	350,000sf
Waiting Area	500,000sf
Hold Area	800,000sf
Baggage Reclaim	550,000sf
Gov't Inspection	800,000sf
Circulation	1,400,000sf
Retail	1,000,00sf
TOTAL	5,400,000sf

An airport handles a high volume of people, so a great amount of space must be set aside to handle these people. It isn't for an extended period of time though.

This project requires a large amount of circulation space in order to properly and securely control the movement of people for security purposes.

Spatial Relationships

	Entrance	Check-in	Gate	Baggage Claim	Security	Shoppes	Cafe	Restaurant	Customs	Viewing Deck	TSA/USCBP Office	Airport Operations	Flight Operations	ATC Tower	Mechanical	Maintenance
Entrance		■	■		■	□	□	□	□		■					
Check-in	■		■		■						□					
Gate	■	■				□	□	□	■	□						
Baggage Claim					■	■										
Security	■	■		■					■		■	■	■	■	■	
Shoppes	□		□	■												
Cafe	□		□													
Restaurant	□		□													
Customs	□		■		■											
Viewing Deck			□													
TSA/USCBP Office	■	□			■											
Airport Operations					■											
Flight Operations					■									■		
ATC Tower					■								■			
Mechanical					■											
Maintenance																

■ Critical

□ Desirable

Figure 64: Spatial Relations

Use Diagram

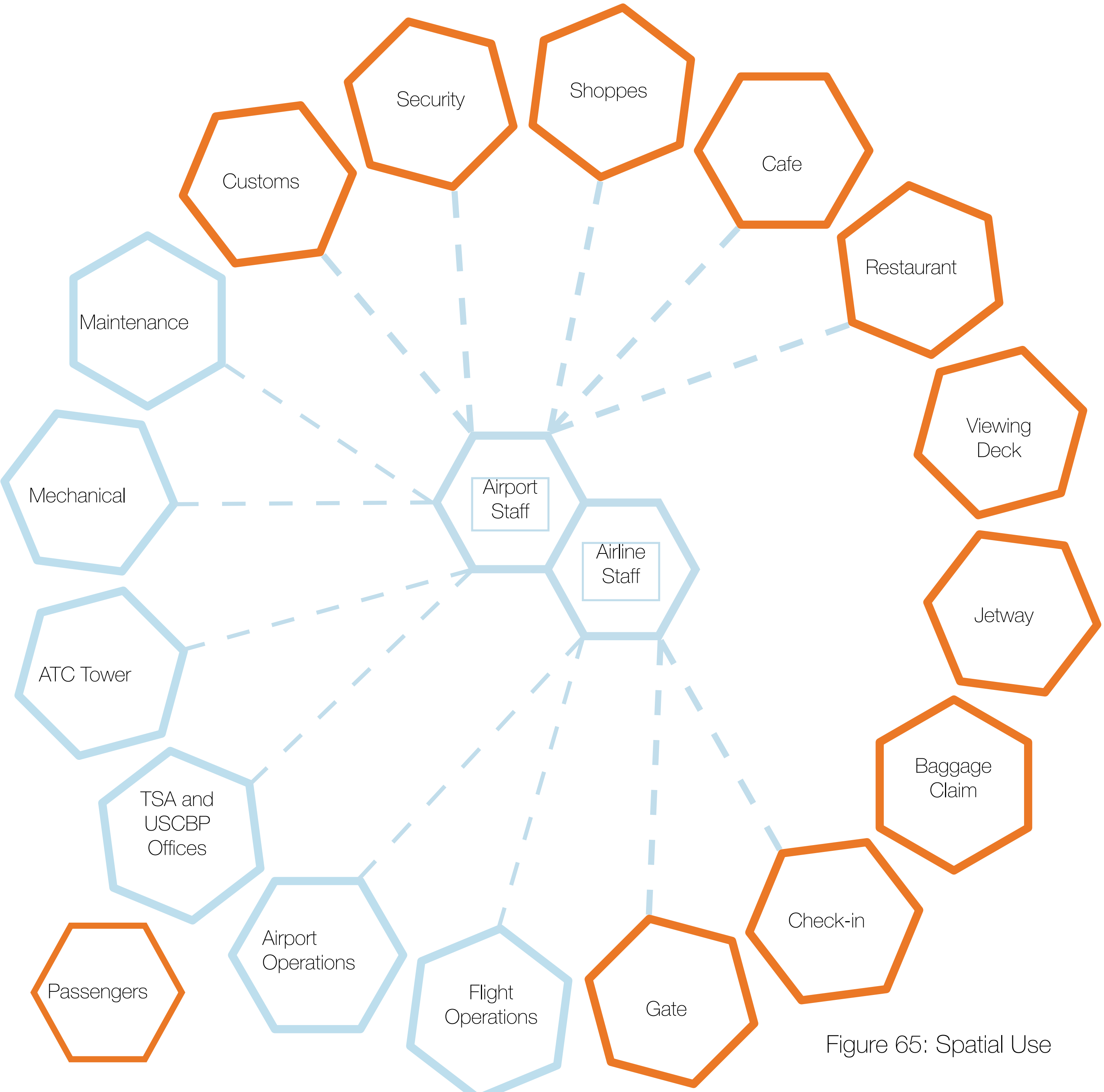
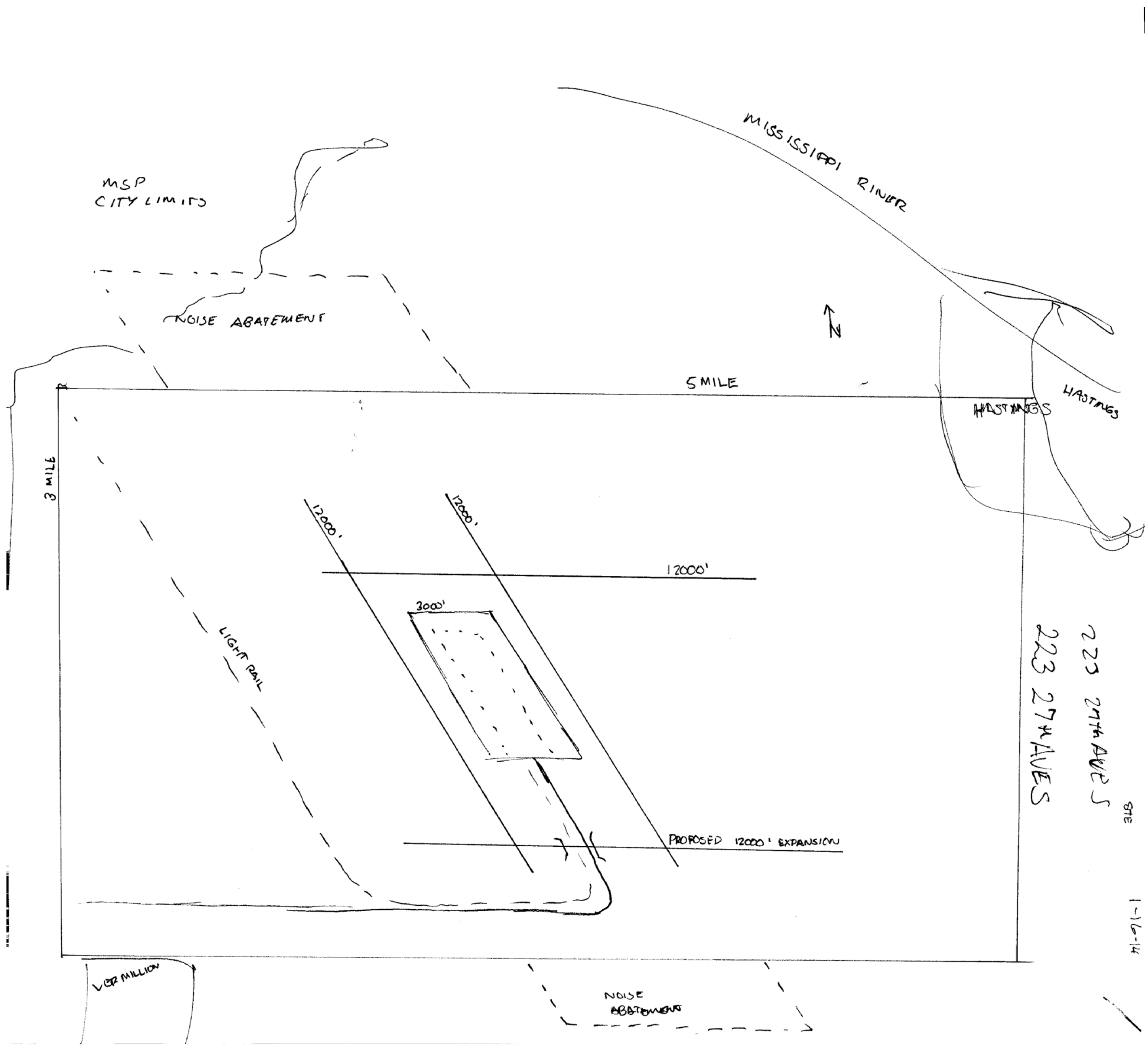


Figure 65: Spatial Use

Passengers interact with spaces in the orange hexagons. Airport or airline staff interact with certain spaces on a professional level.

Design Process



Sketch of the originally proposed layout.   Figure 66 : original site layout

This was a solid starting point, and I kept key elements of this design, the runway angles, and the terminals location. However the amount of runways and shape of the terminal drastically changed.

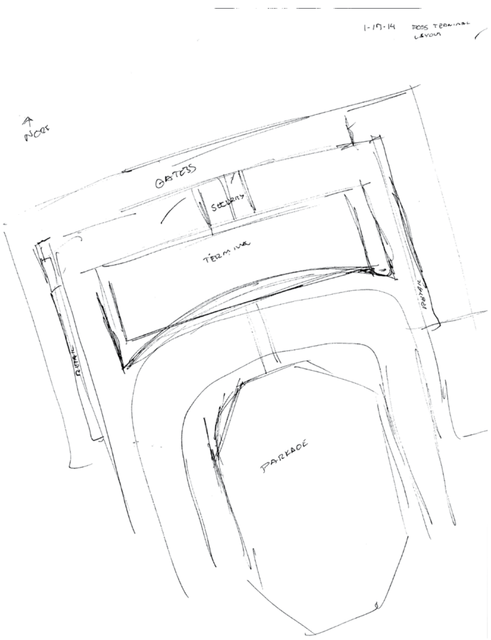


Figure 67 : design concept

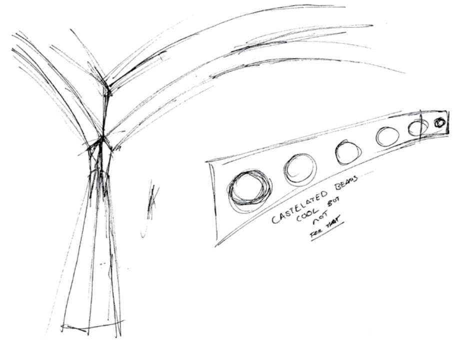


Figure 68:structural concept

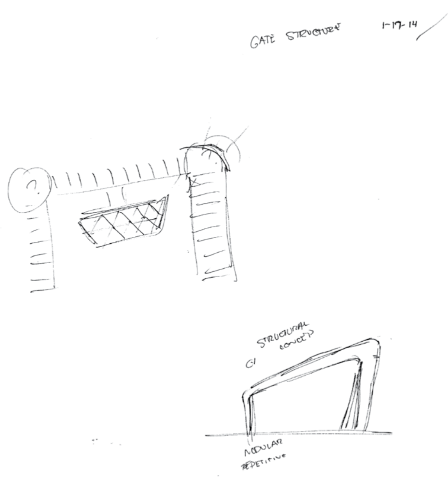


Figure 69: structural concept

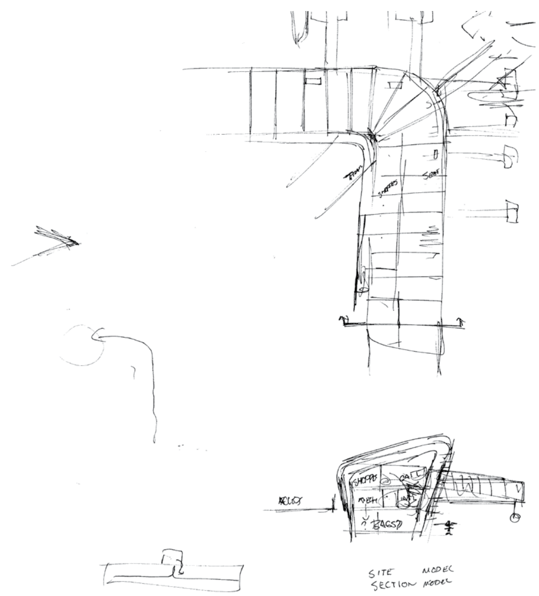


Figure 70 : layout concept

concepts of designs

These sketches ran through a few ideas with a diagramatic approach. A basic layout of the airport, that I came back to, with some revisions. An idea for a structural system in fig 67, but that was replaced with the concept in 68, which left the project much more open.

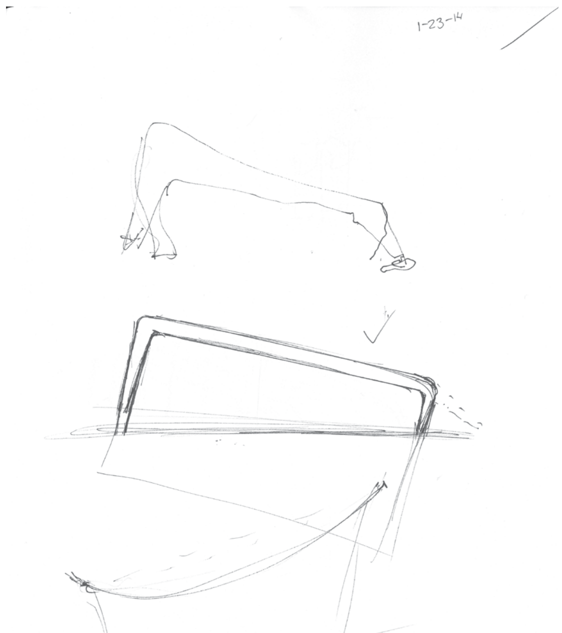


Figure 71: structure concepts

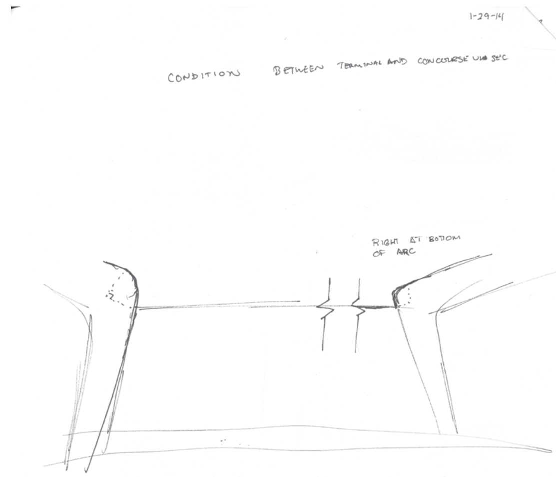


Figure 72: transition concept

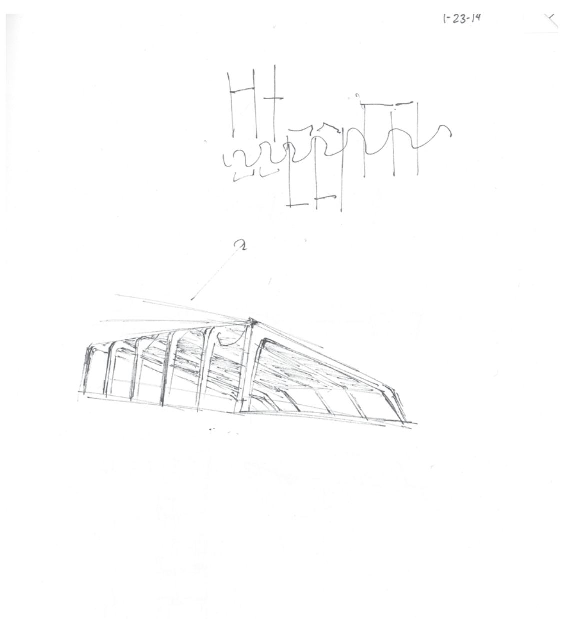


Figure 73 : structure sketch

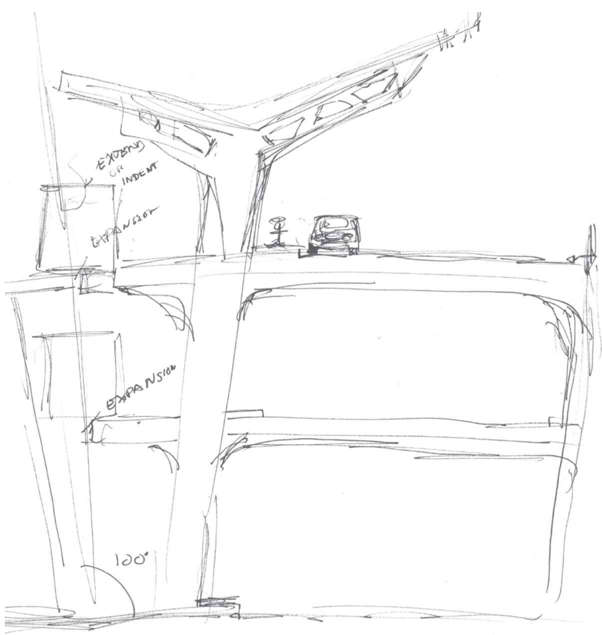


Figure 74: roadway access sketch

The structure changed a few times, and the design settled on a canted structural beam design. The sketch is of a competing design. The roadway was sketched at an angle from my seat, and all of it was meant to be perpendicular.

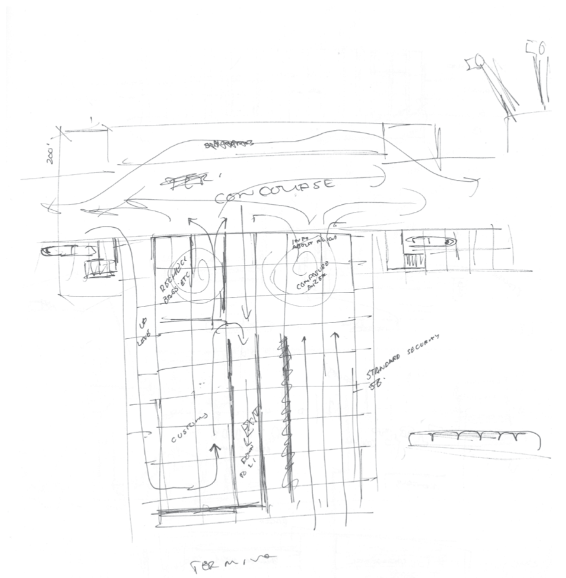


Figure 75: movement concept

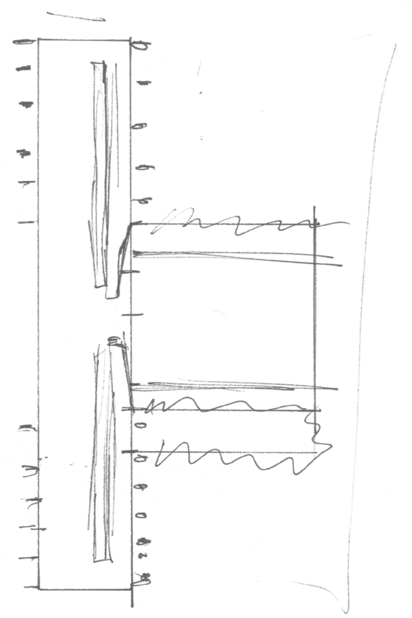


Figure 76: plan concept

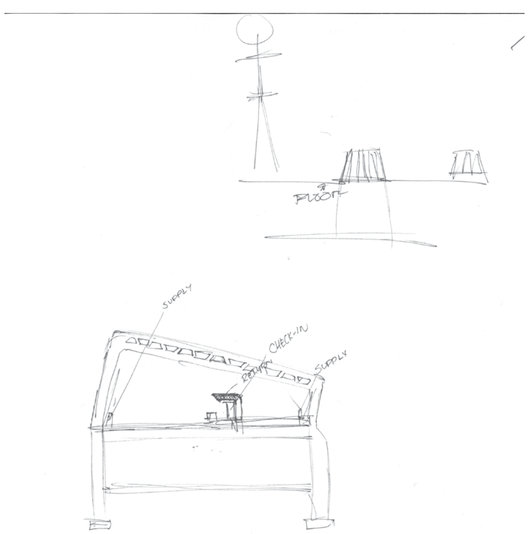


Figure 77: final structure concept

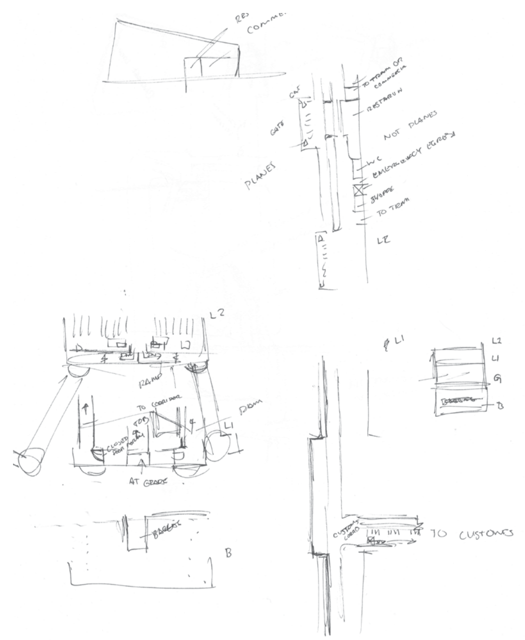


Figure 78: movement concept

Figure 74 is a movement sketch through the transition area. Figure 75 is a sketch of the layout of the check-in area. That was modified later in Revit. Figure 76 is a sketch of the mechanical system and the places it would be implemented. Figure 77 is further movement diagrams and basic floor plan layouts.

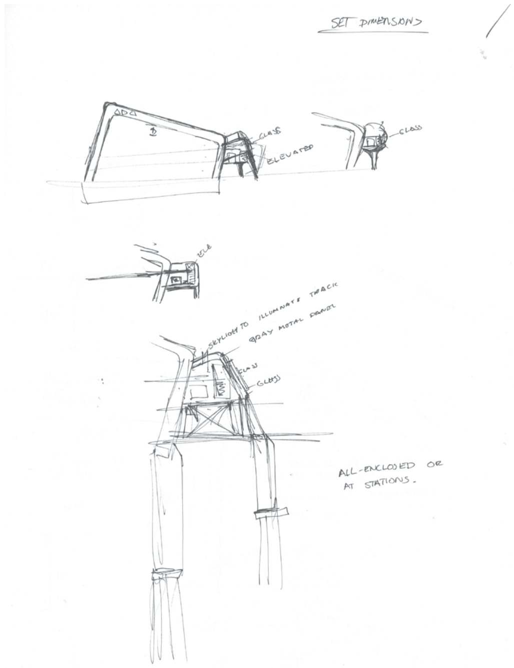


Figure 79 : tram diagram

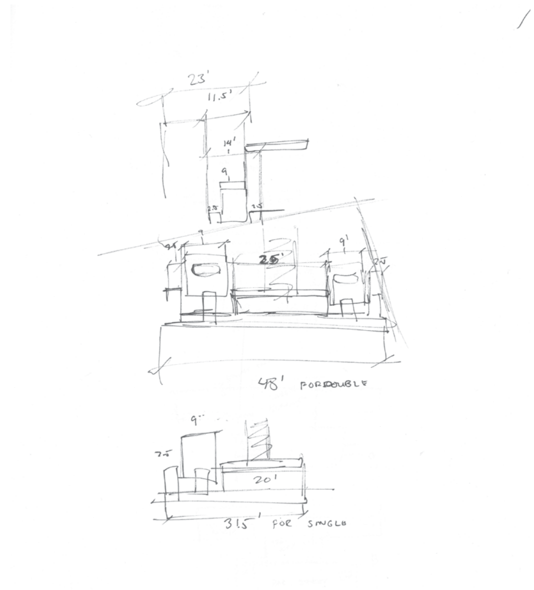


Figure 80 : tram space diagram

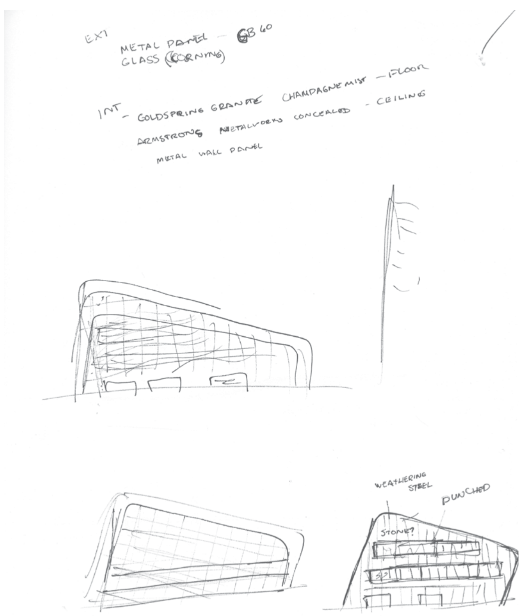


Figure 81 : material concepts

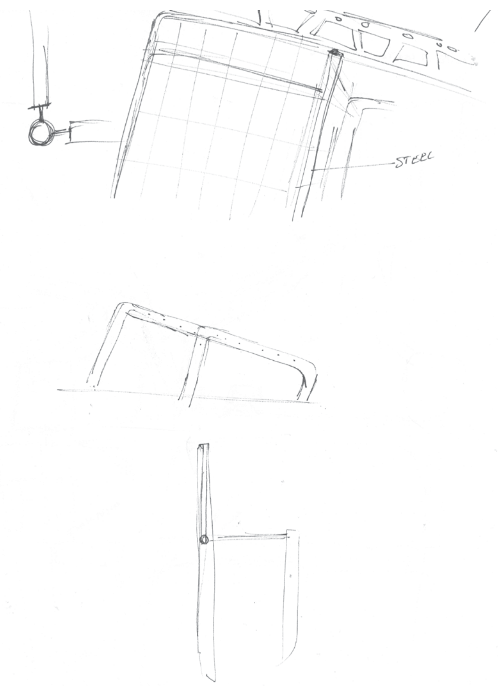


Figure 82: mullion concepts

Fig 78 is a section drawing of how the tram tunnel interfaces with the building. Fig 79 is the spatial requirements for two tracks abreast one another. Fig 80 is a sketch of how the exterior “caps” of the building works. and Figure 81 is a sketch of mullion connections.

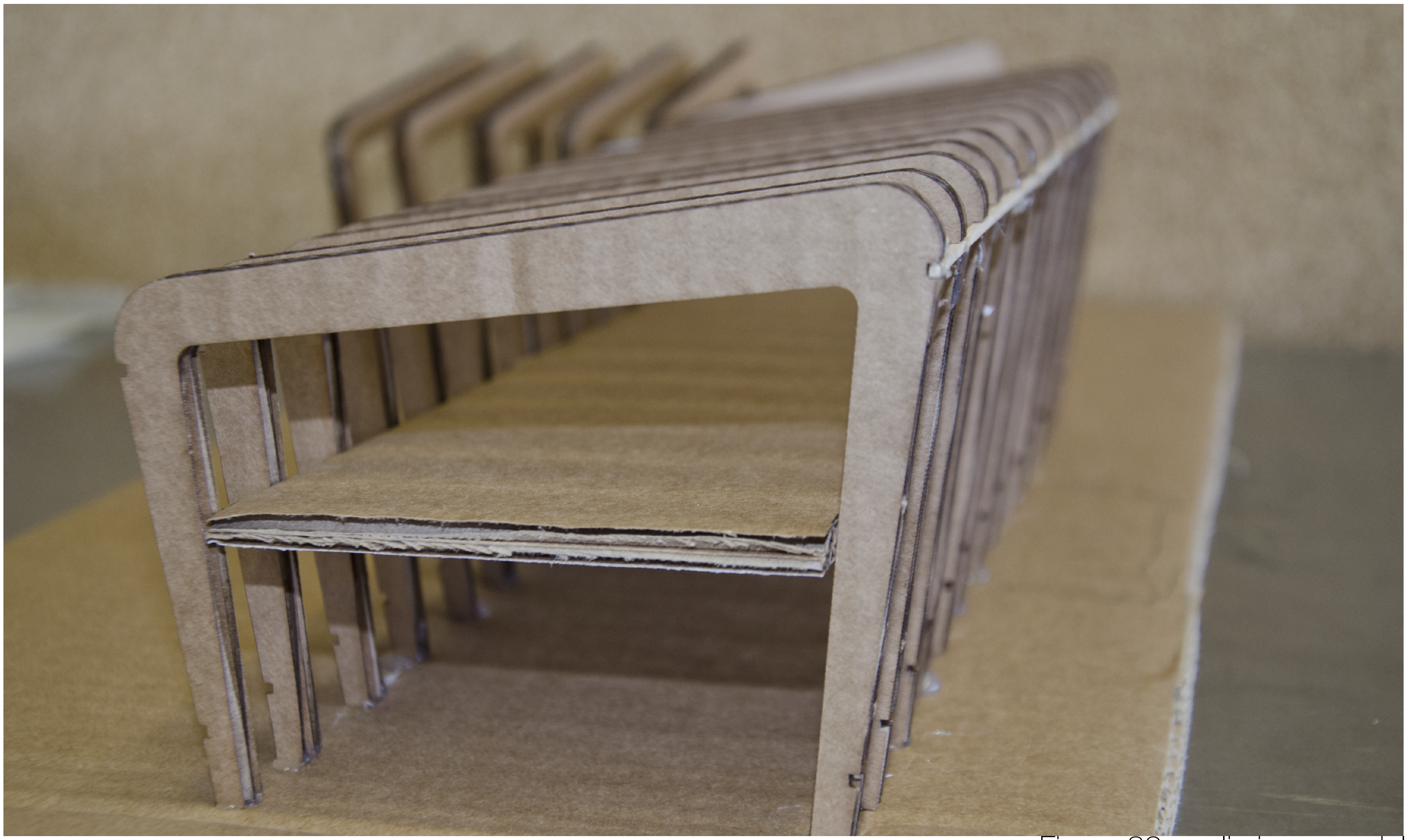


Figure 83: preliminary model

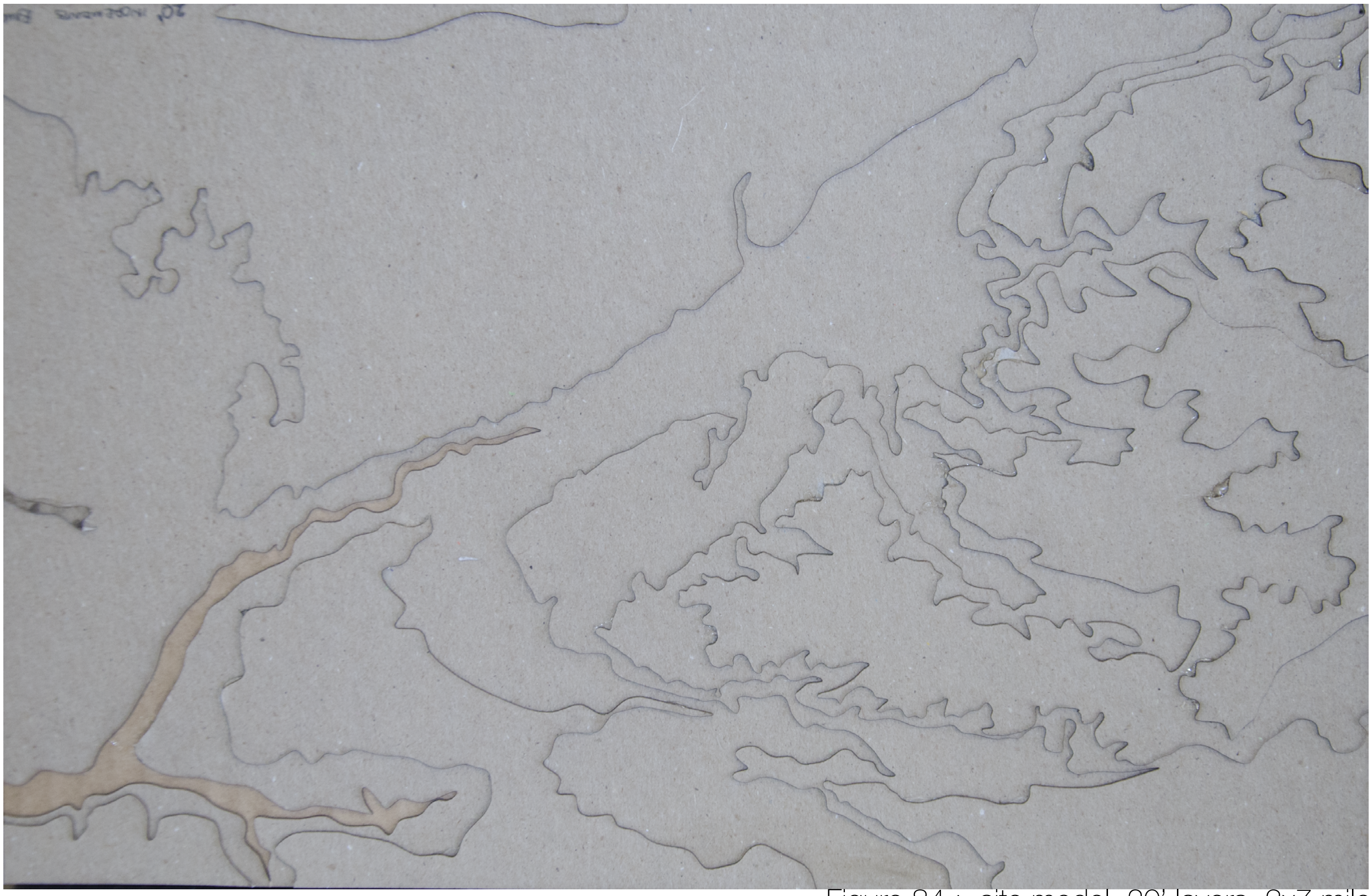


Figure 84 : site model, 20' layers. 3x7 mile

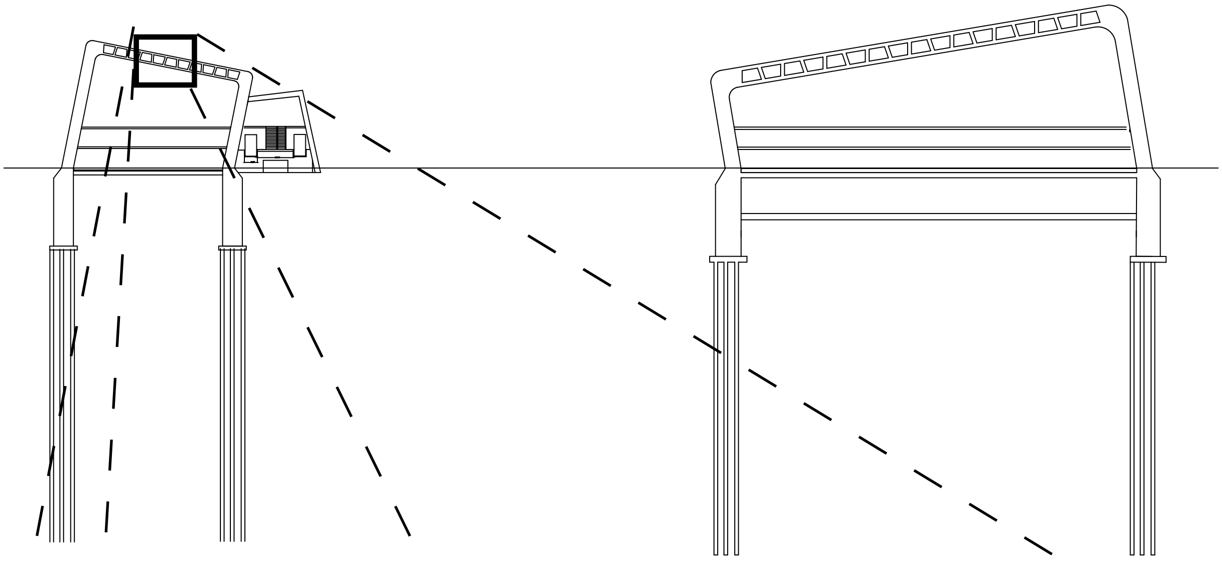


Figure 85 : sketchup model section

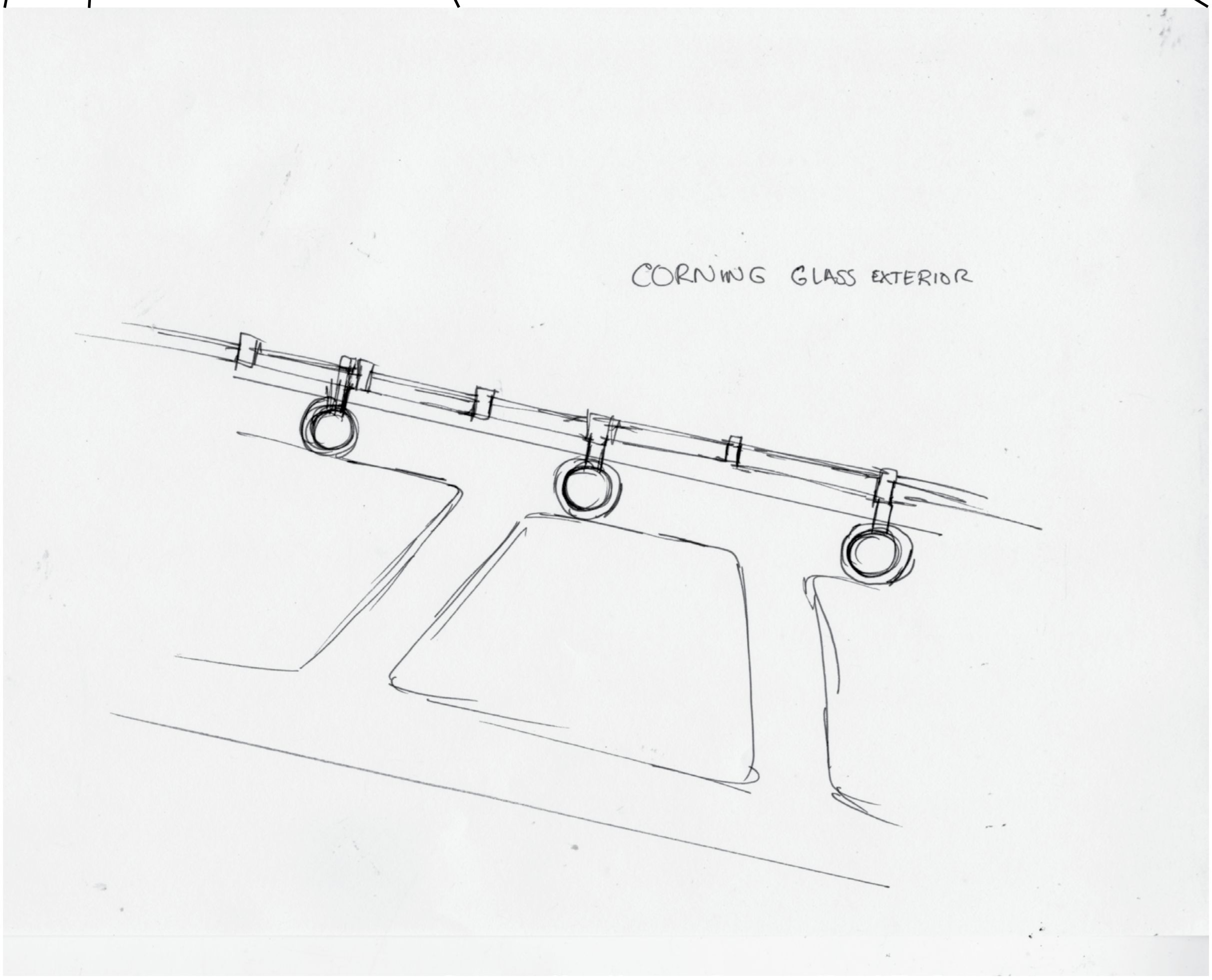


Figure 86 : structural silicon glass sketch

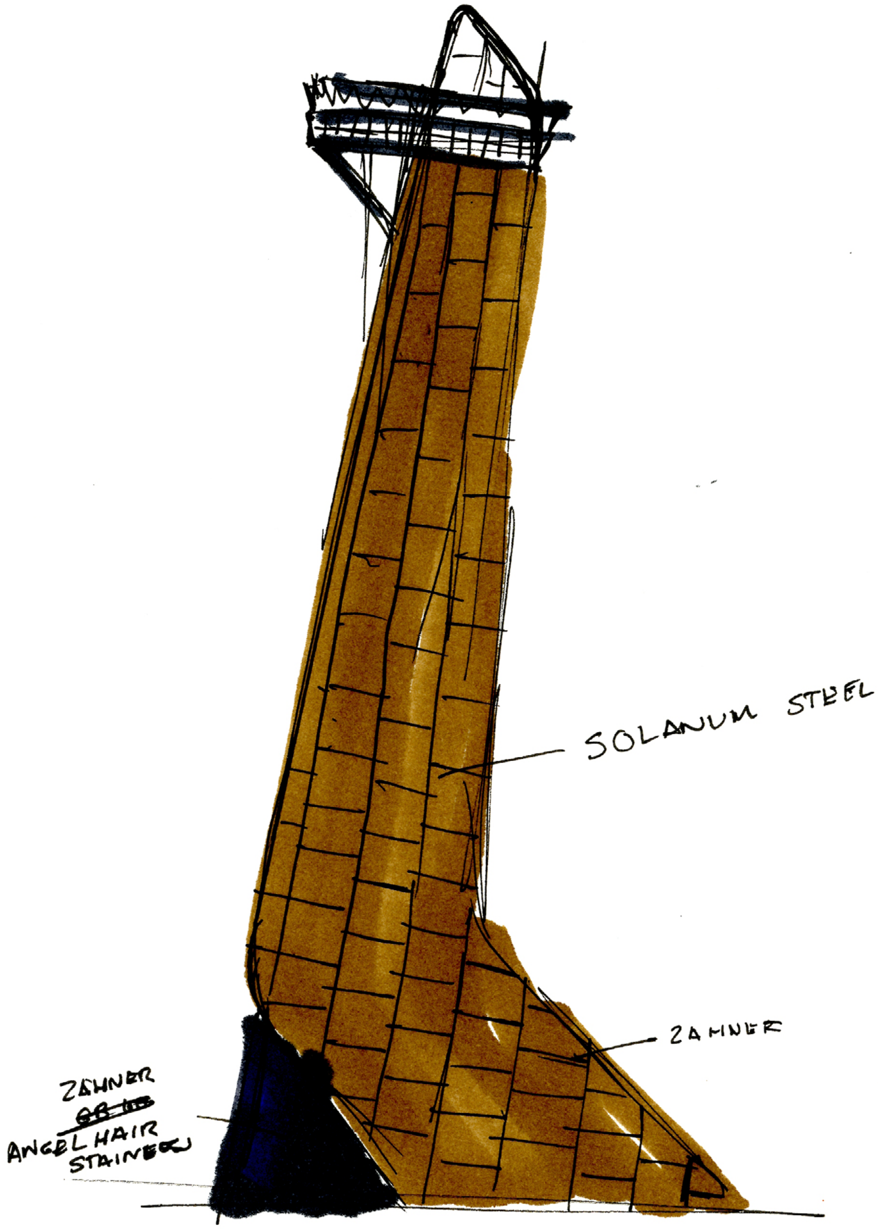


Figure 87 : conceptual air traffic conftrol tower rendering

Movement

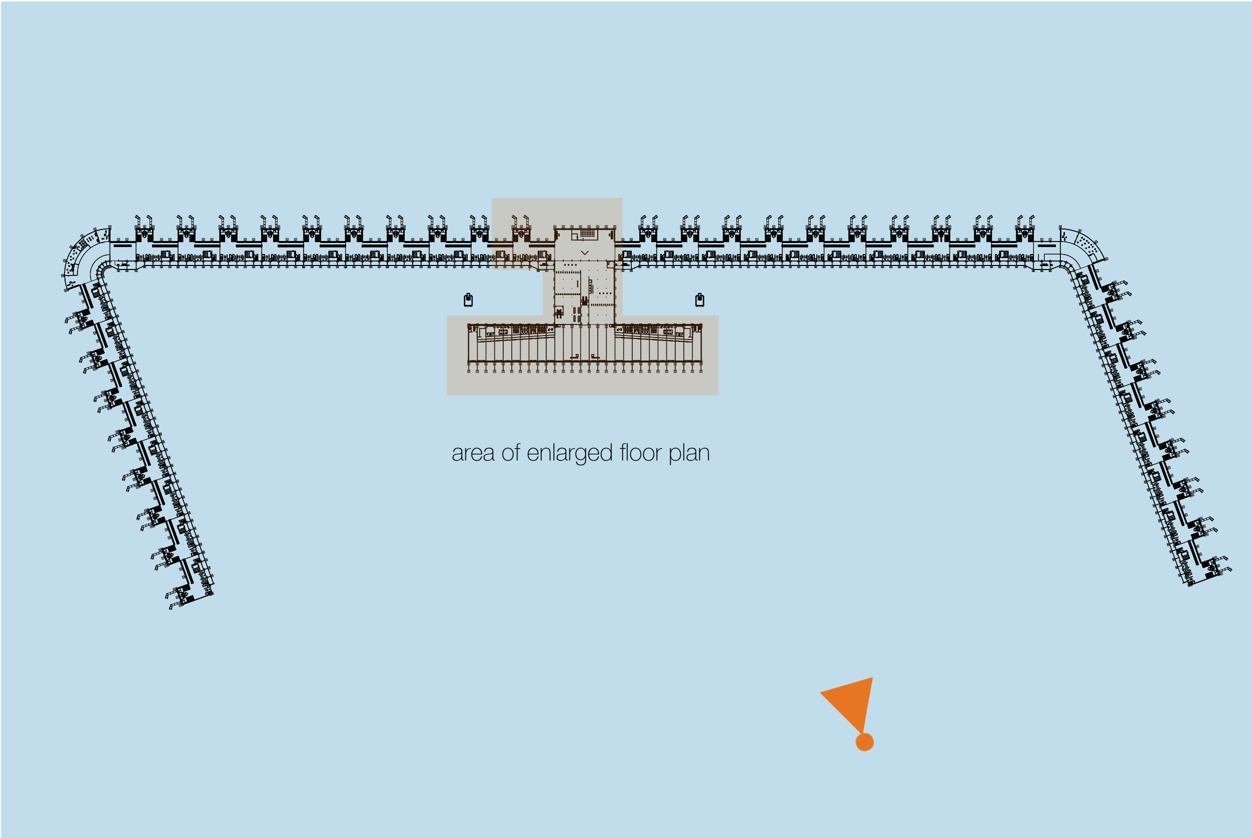


Figure 88: approach movement

Figure 89 : exterior approach

Approach to the terminal

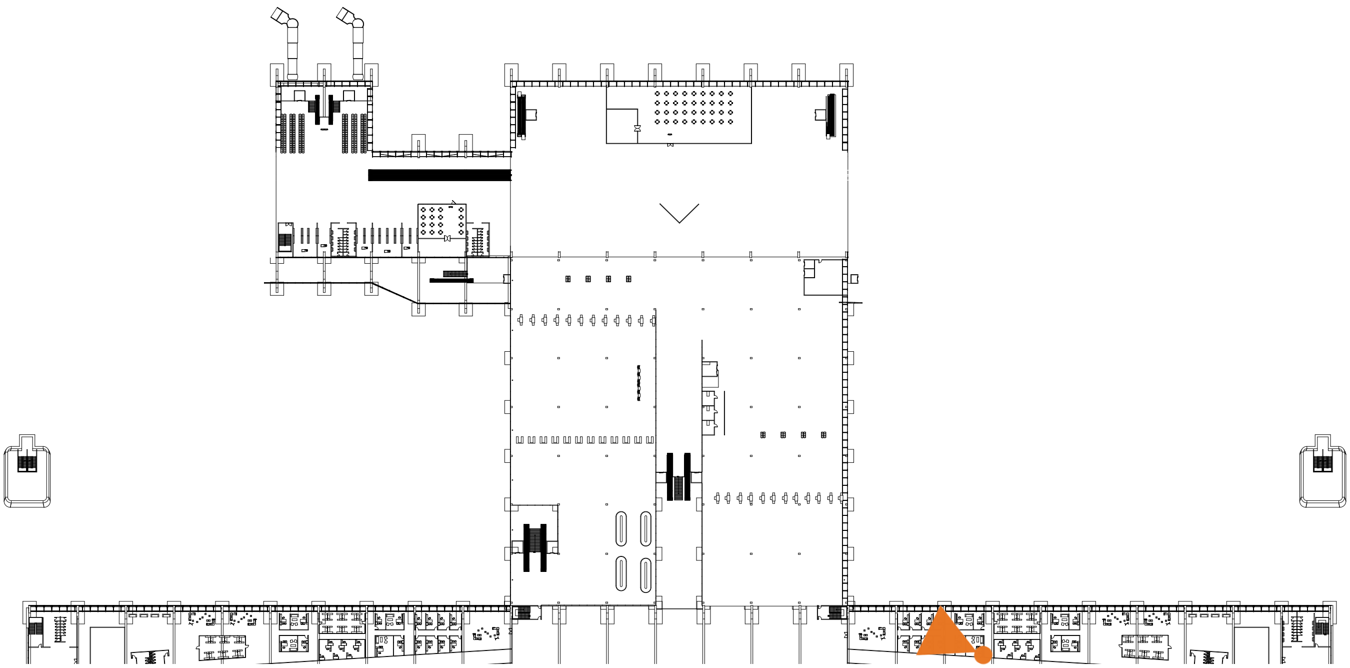


Figure 90 : arriving movement

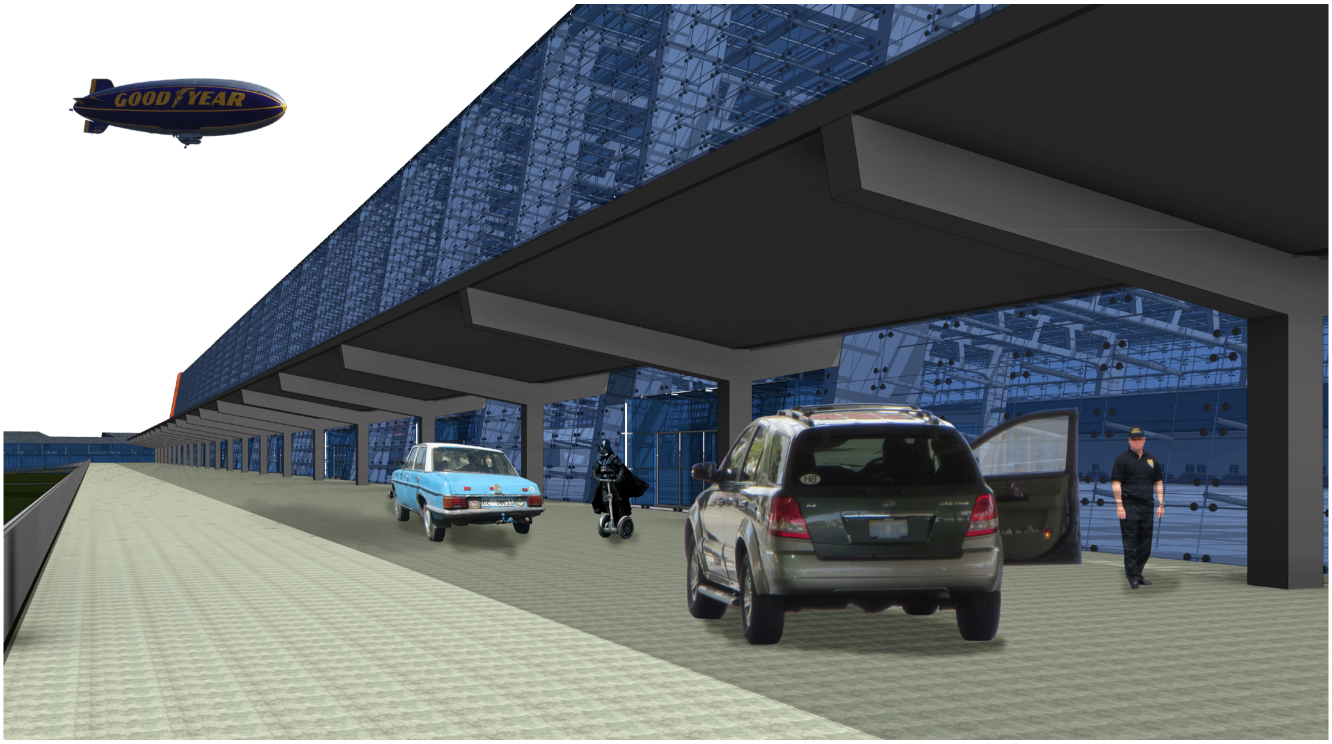


Figure 91 : depatures access rendeing

level 2 departures access

LEVEL 2

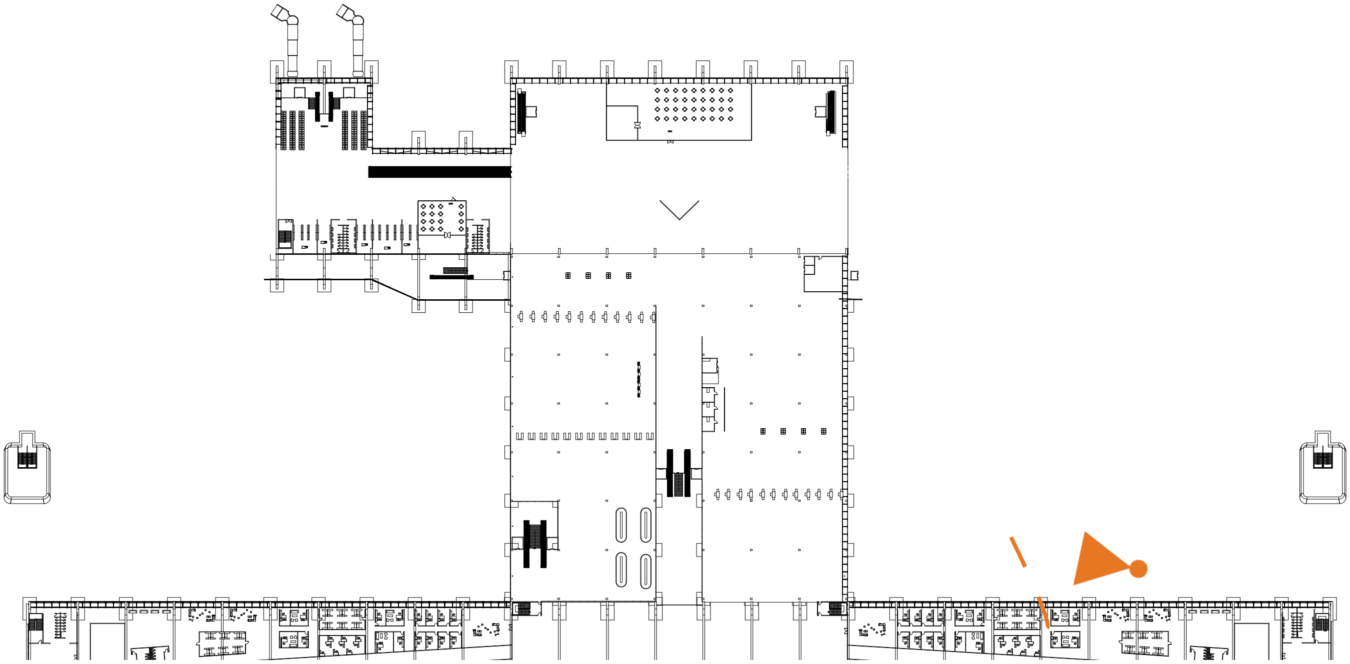


Figure 92 : level 2 movement

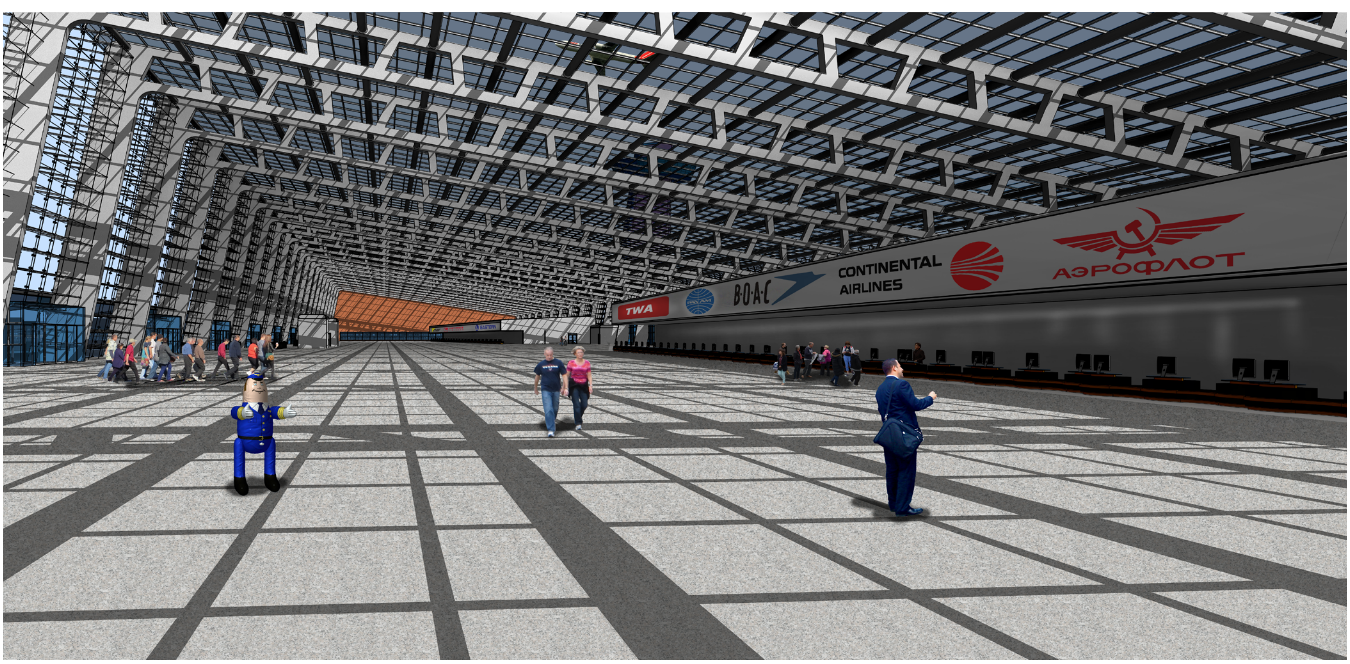


Figure 93 : terminal interior rendering

airport terminal interior 2nd floor

LEVEL 2

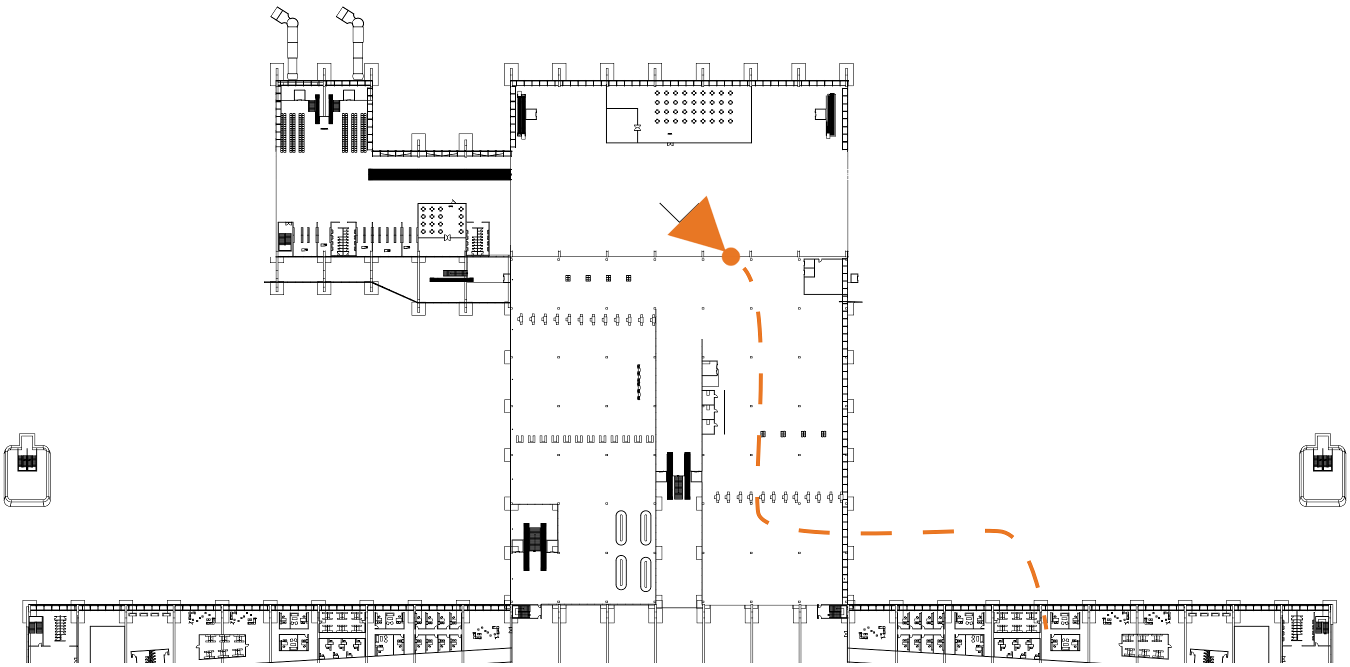


Figure 94 : level 2 movement

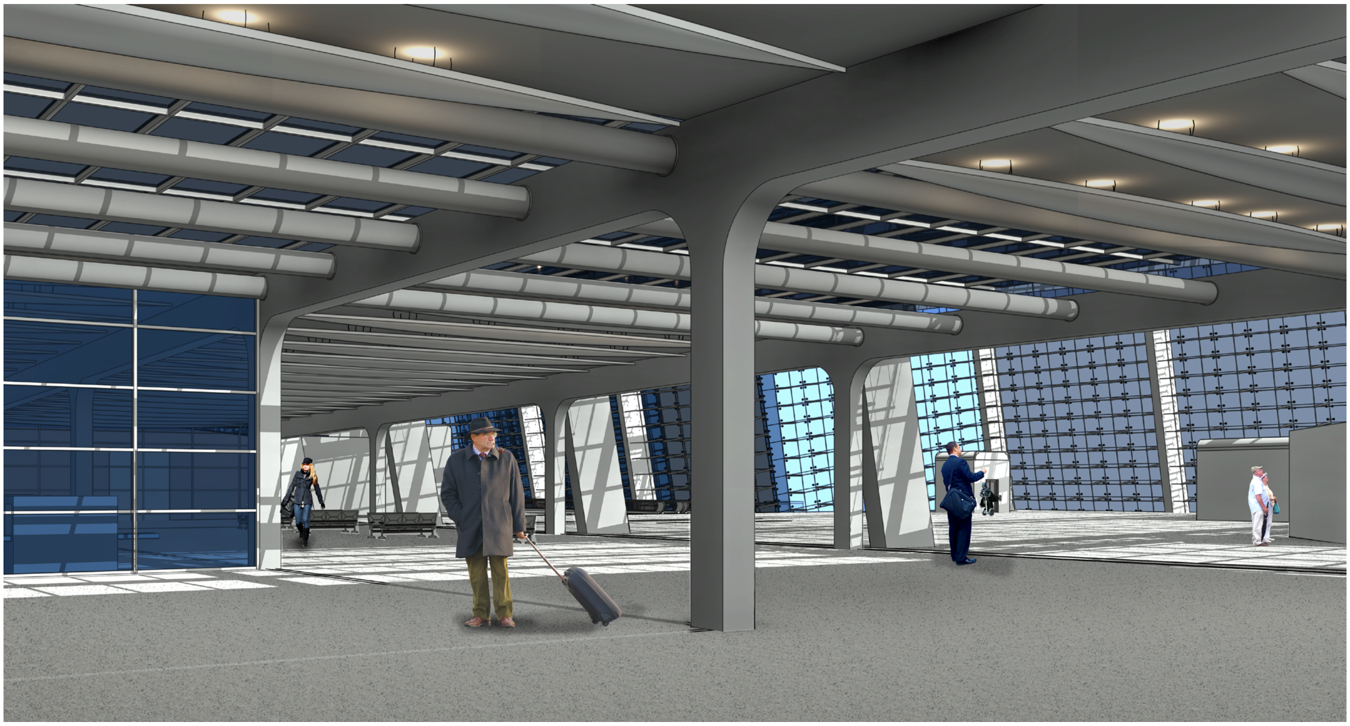


Figure 95 : transition rendering

view to concourse from security

LEVEL 2

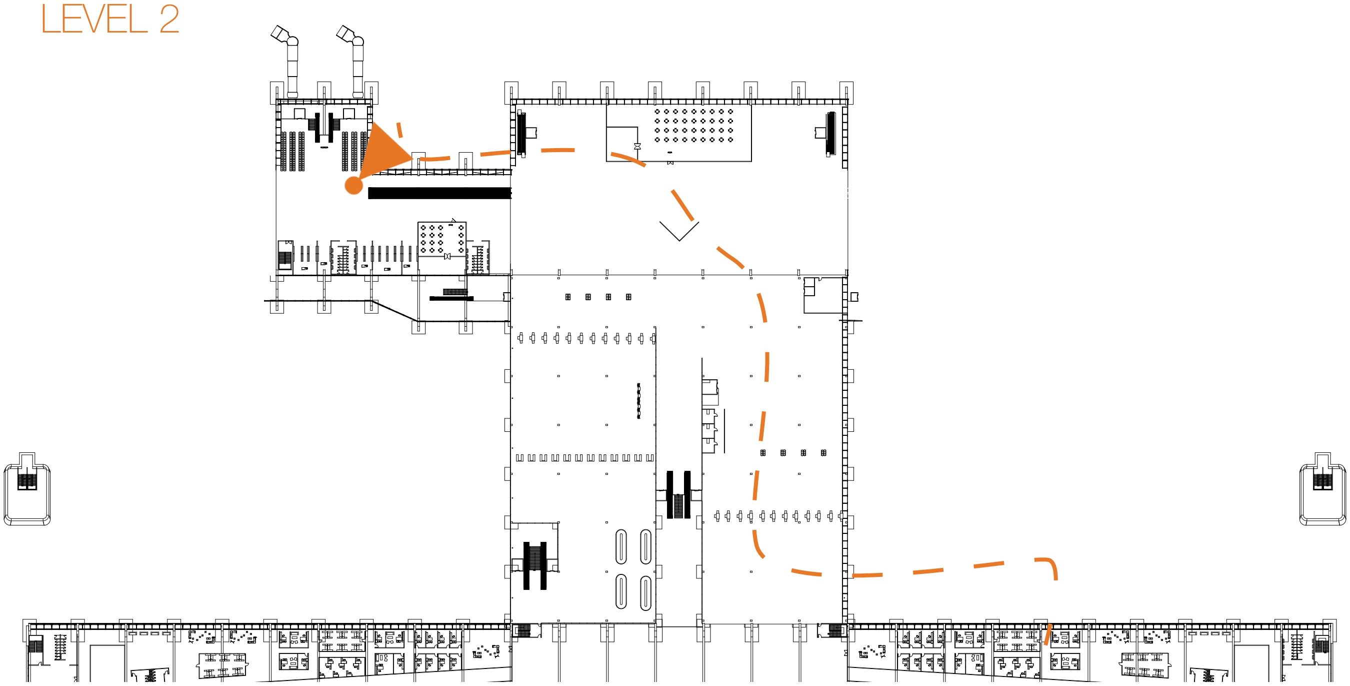


Figure 96 : gate movement

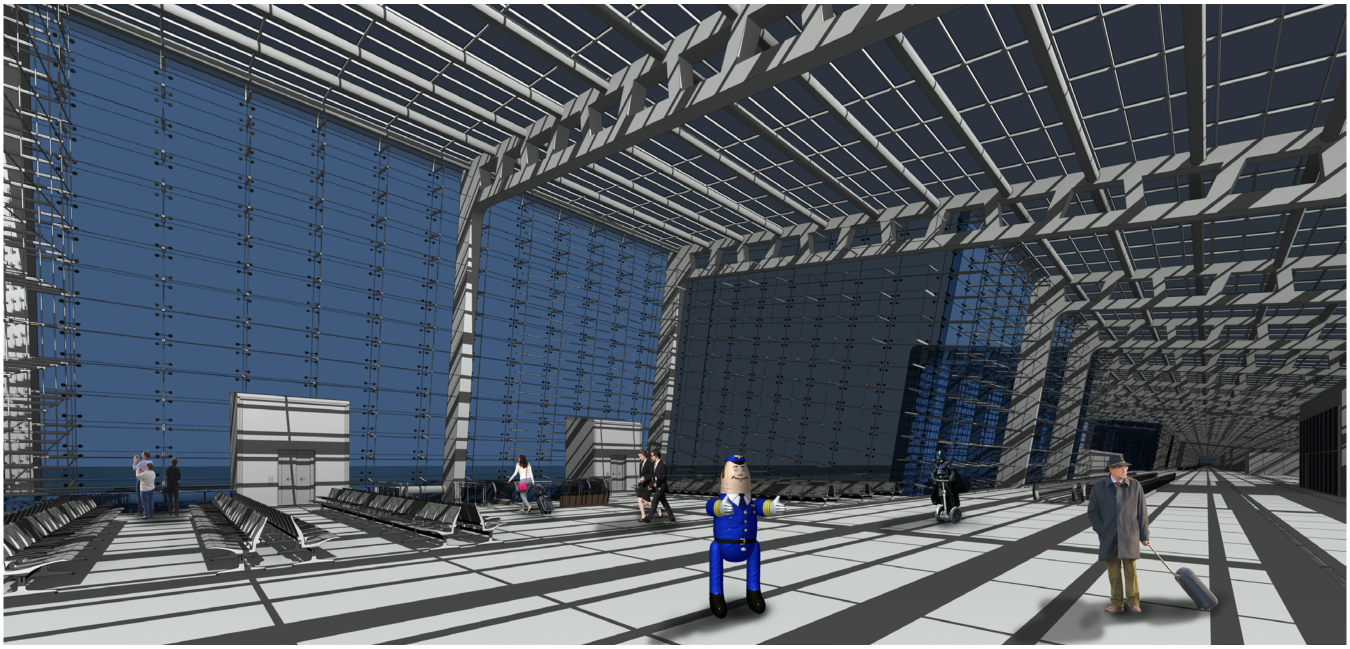


Figure 97 : gate rendering

view to gate from concourse

concourse movement

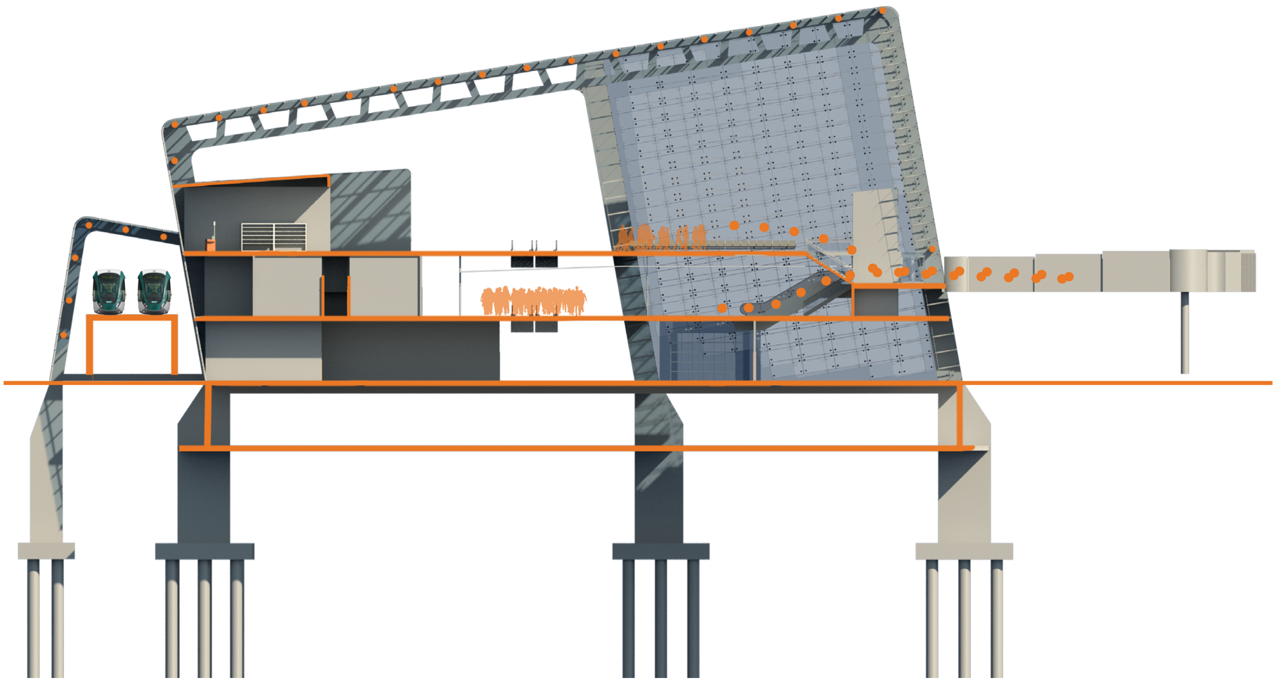


Figure 98 : movement sec. perspective

People that have gone through security would be on the top floor, free to move about as they please. They would descend down to a median level to access the aircraft. If the flight that was disembarking was an international flight, they'd descend a level. This would take them to the customs corridor where they'd move up to the 2nd level for customs, which would screen them and they could leave or get on their next flight.

LEVEL 1

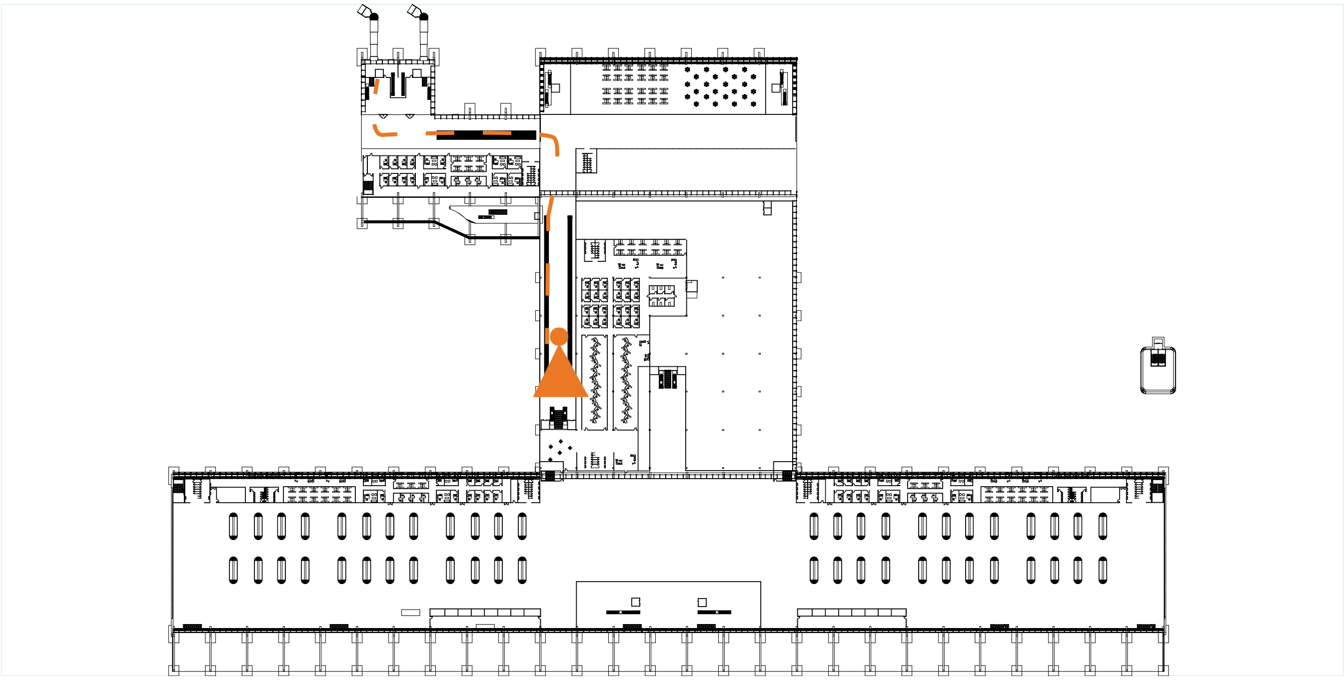


Figure 99 : customs movement

Figure 100 : customs level transition

customs level

LEVEL 2

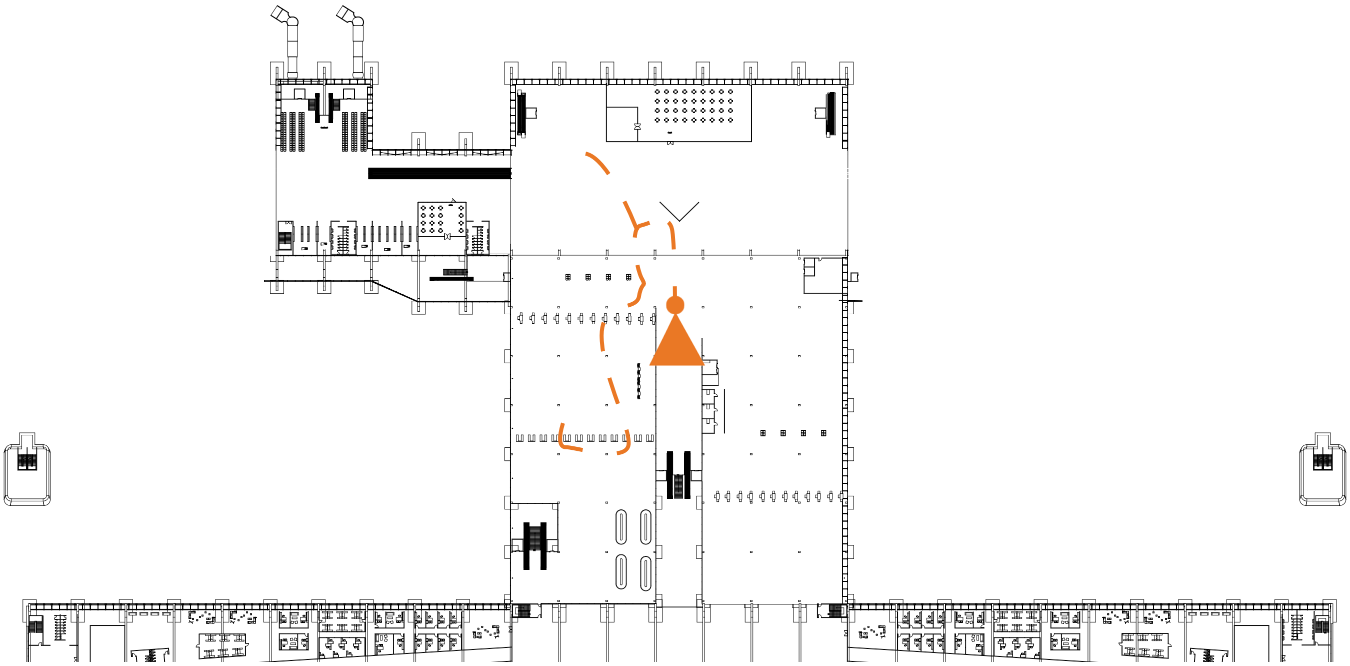


Figure 101 : egress movement

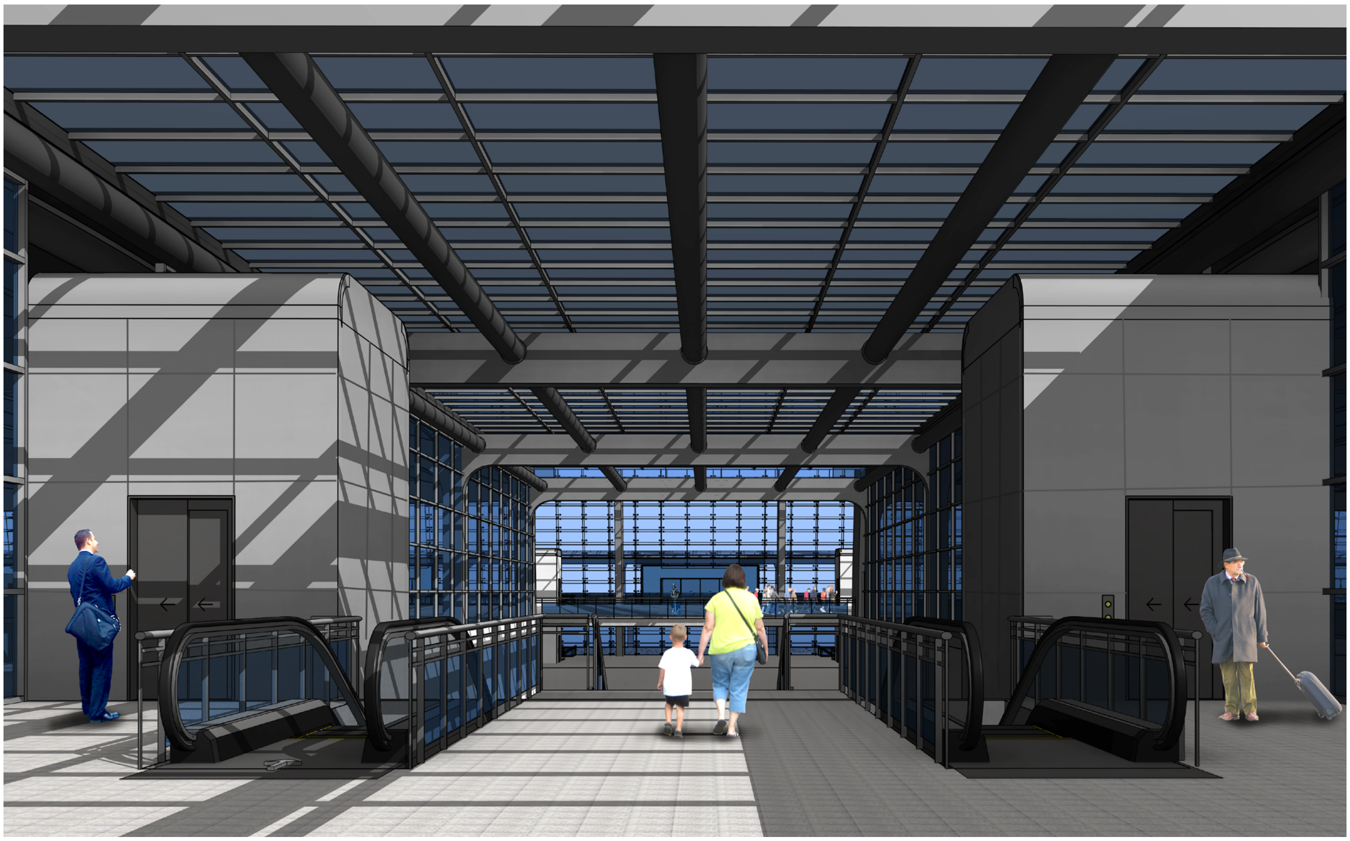


Figure 102 : egress level transition

exit transition from level 2 to level 1

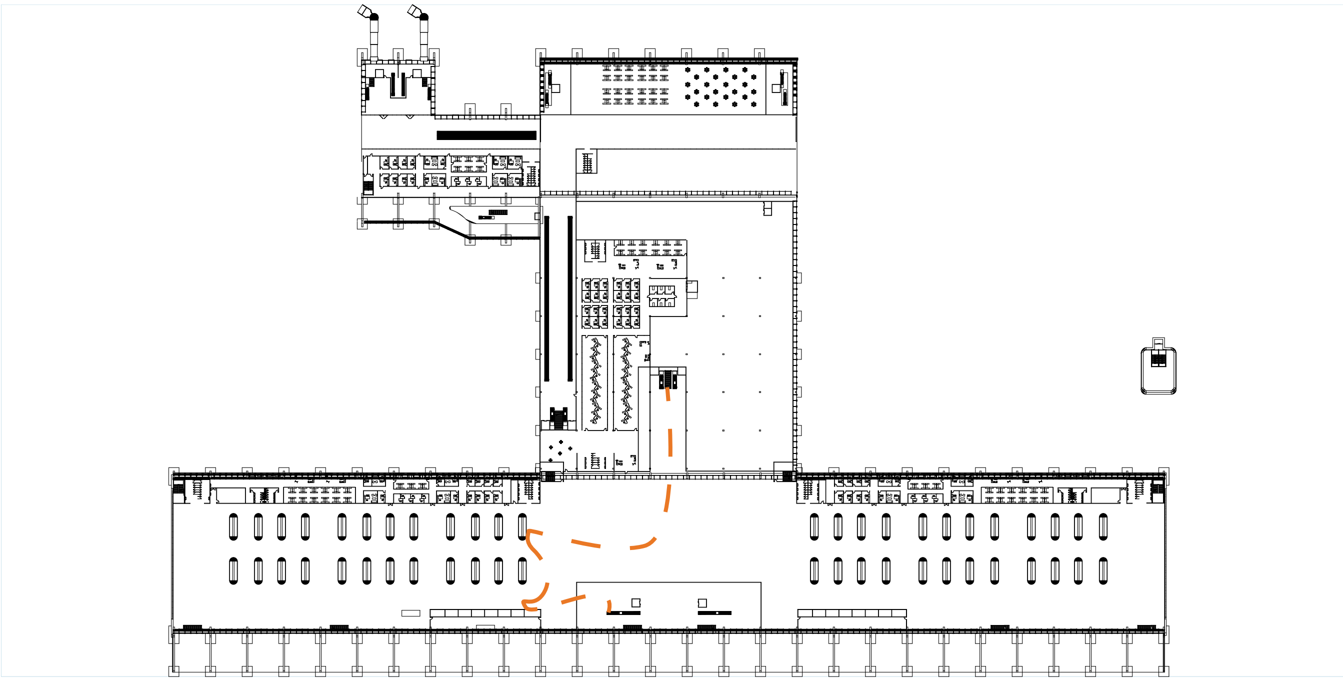


Figure 103 : egress movement

Once a passenger has deplaned from an international flight, movement would go through the customs corridor, up to the customs screen area. This is detailed in fig 98 and 99. Once cleared through customs and screened, a passenger can go to their next flight, or leave as seen in figs 100, 101, and 102.

Renderings

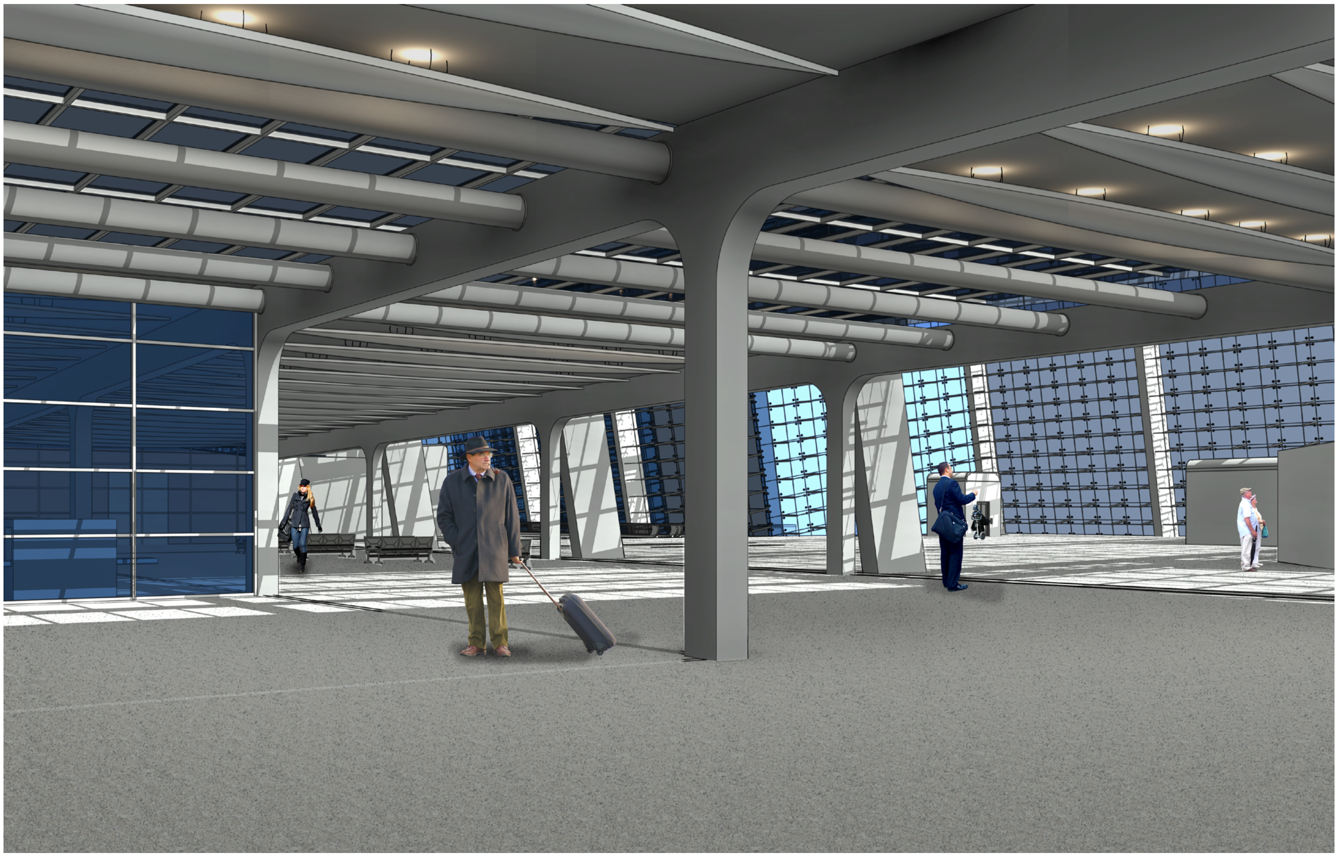


Figure 104 : security transition rendering

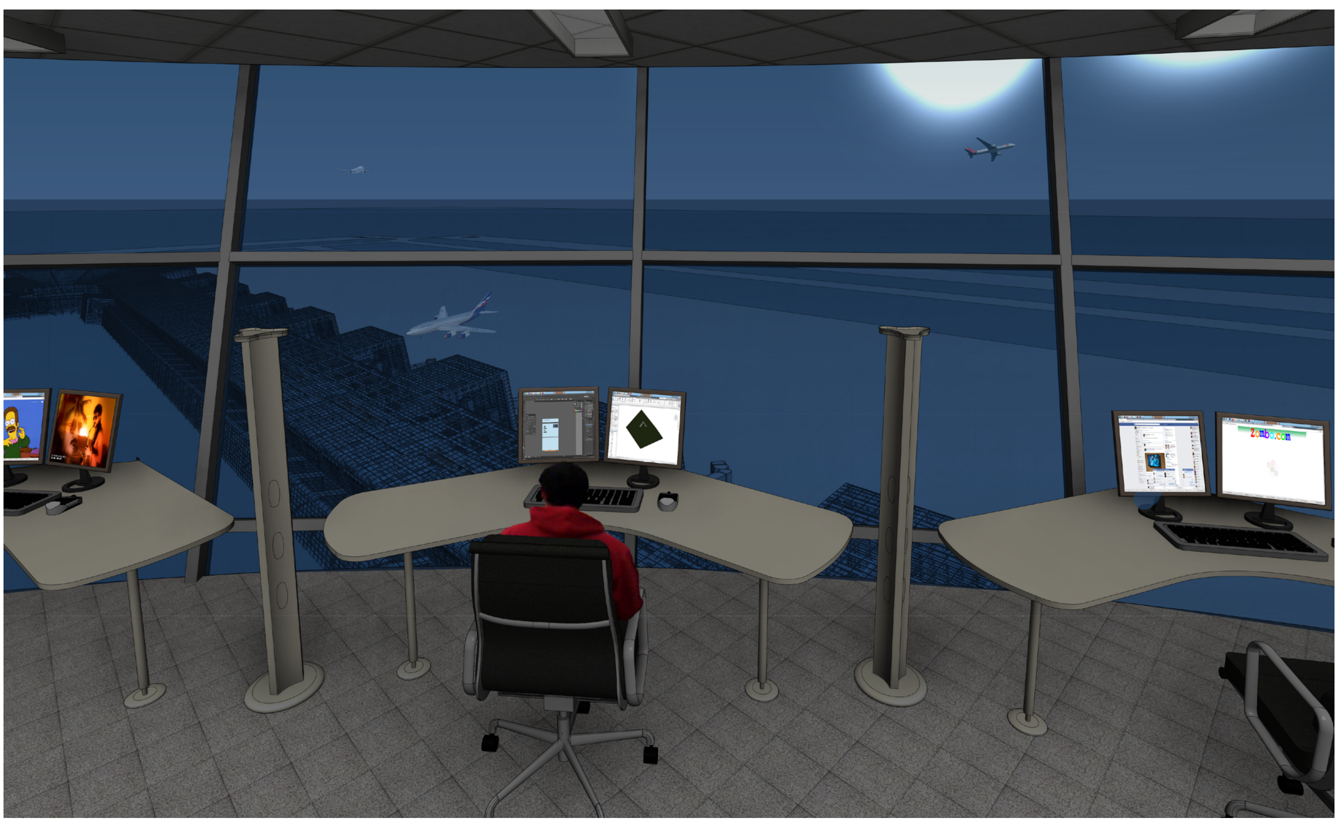


Figure 105 : ATC tower rendering

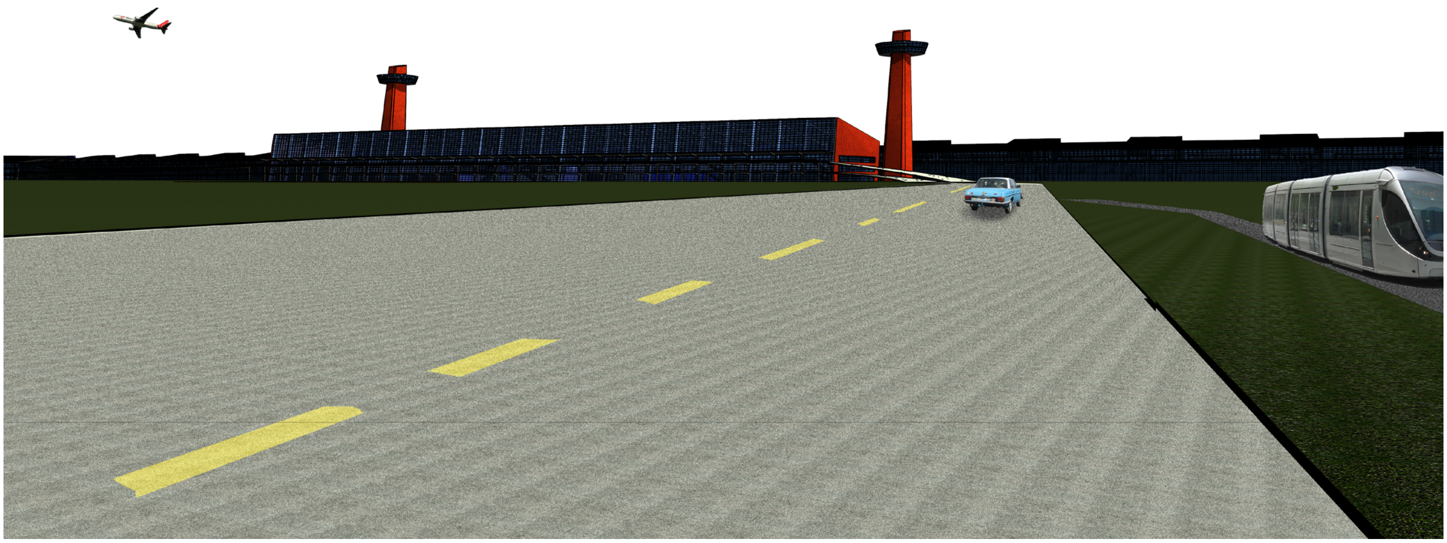


Figure 106 : exterior approach rendering

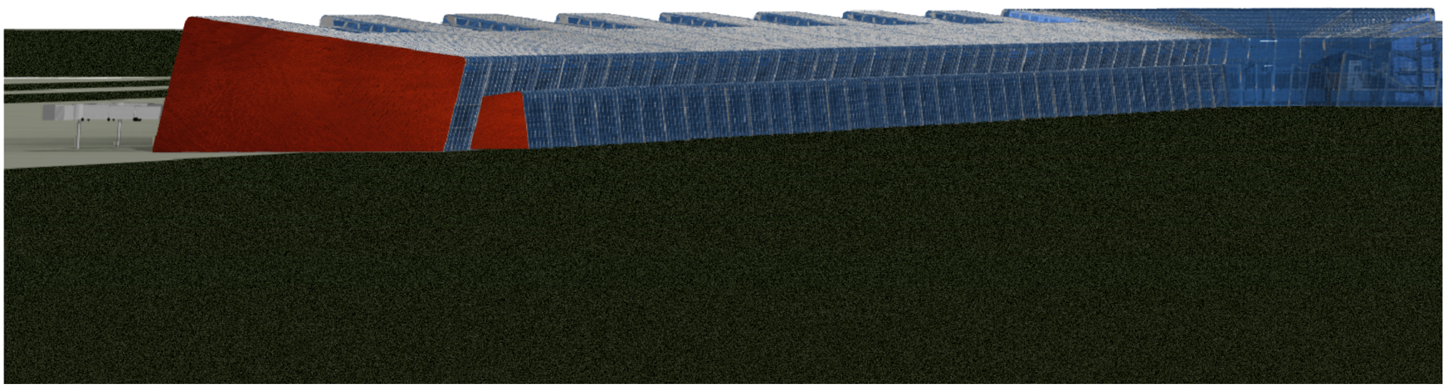


Figure 107 : perspective rendering

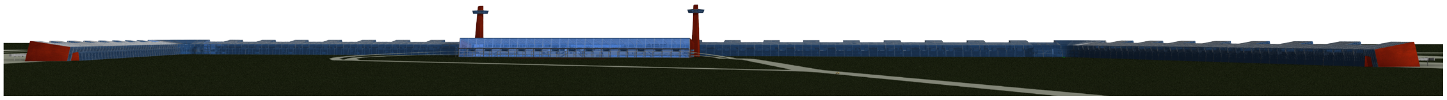


Figure 108 : perspective rendering

Figure 109 : customs level transition rendering

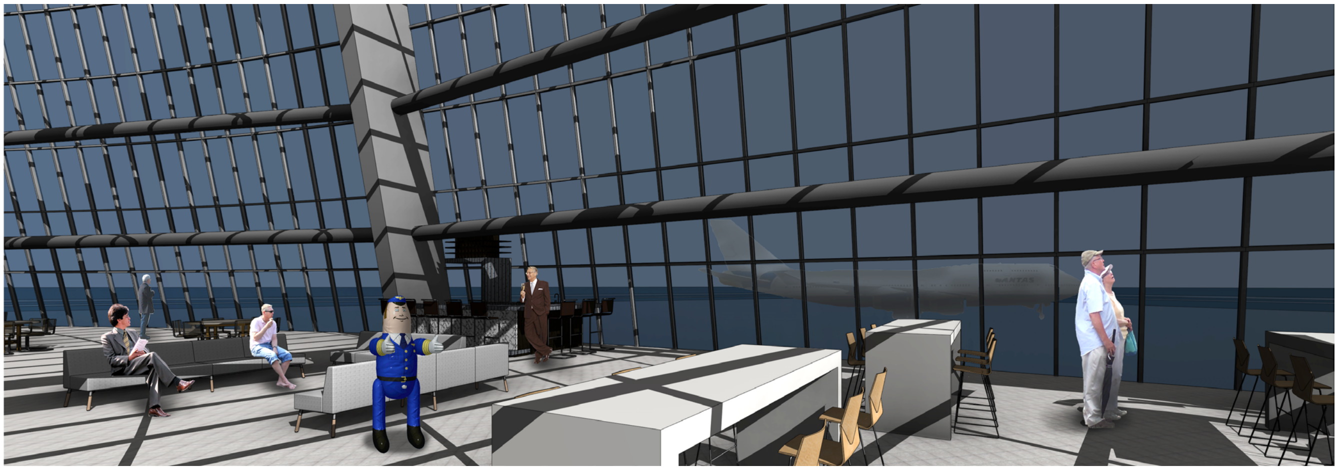


Figure 110 : Delta SkyClub rendering

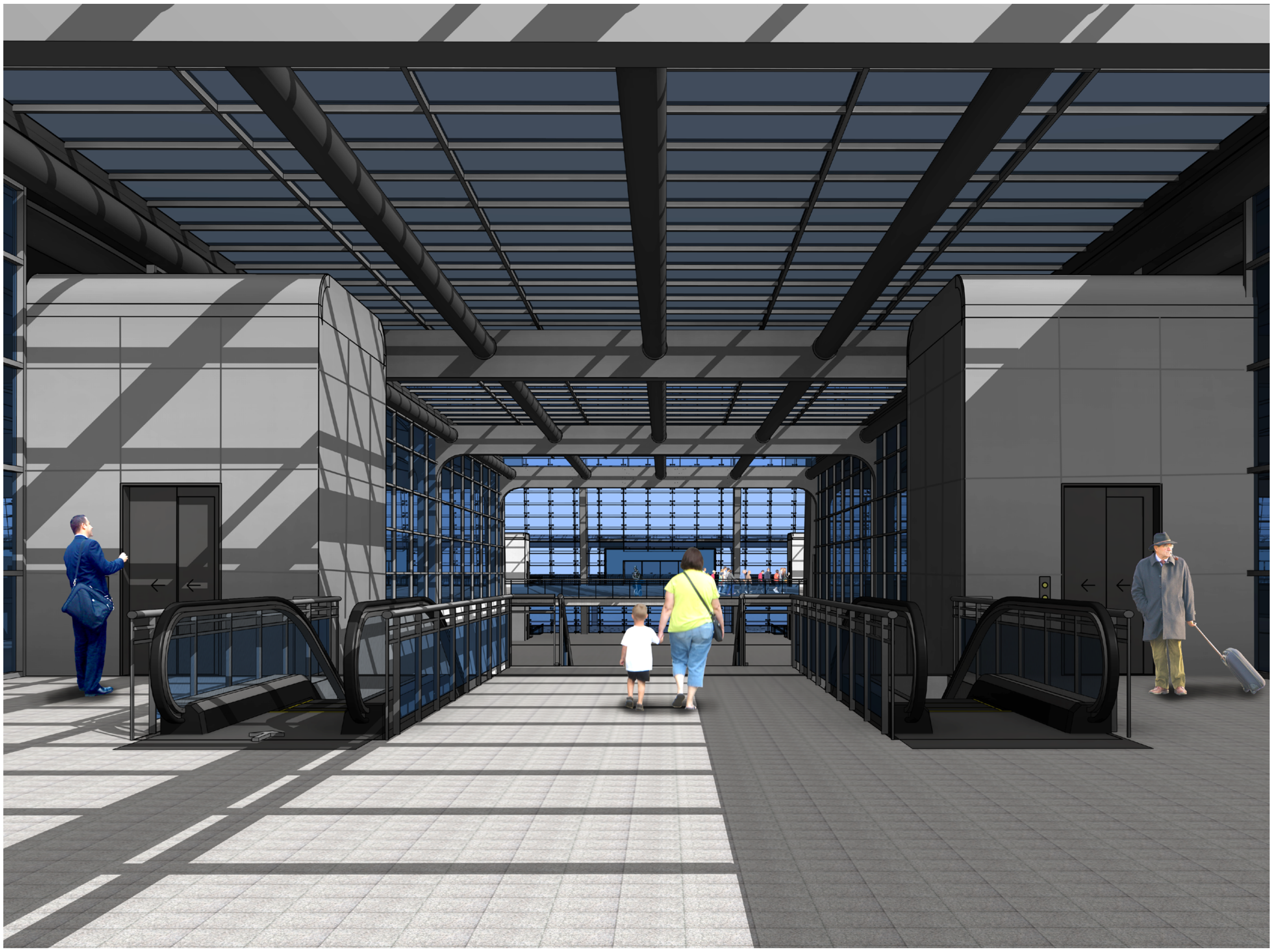


Figure 111 : egress level transition rendering

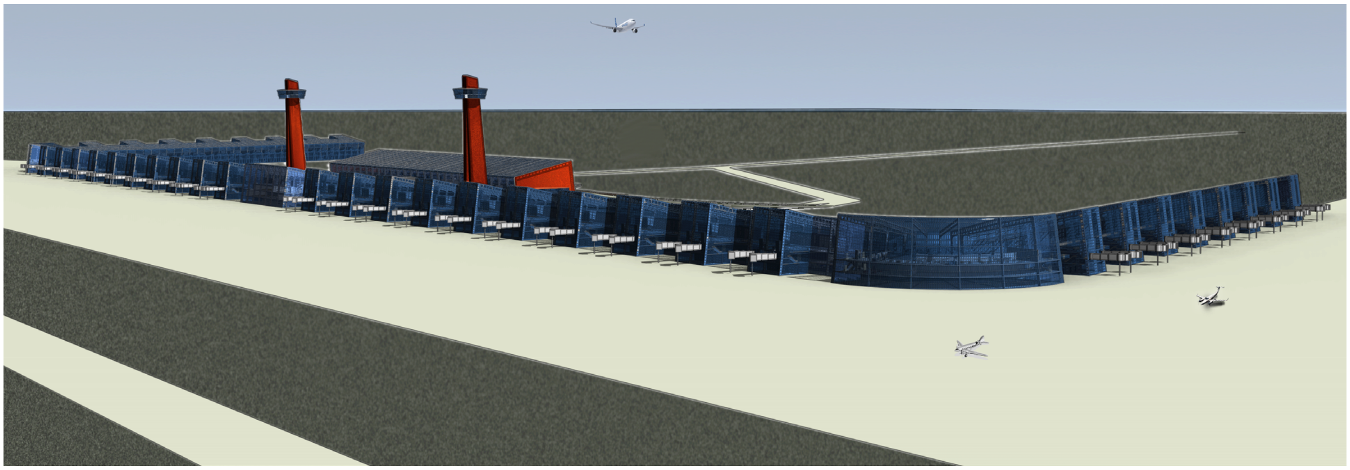


Figure 112 : exterior rendering

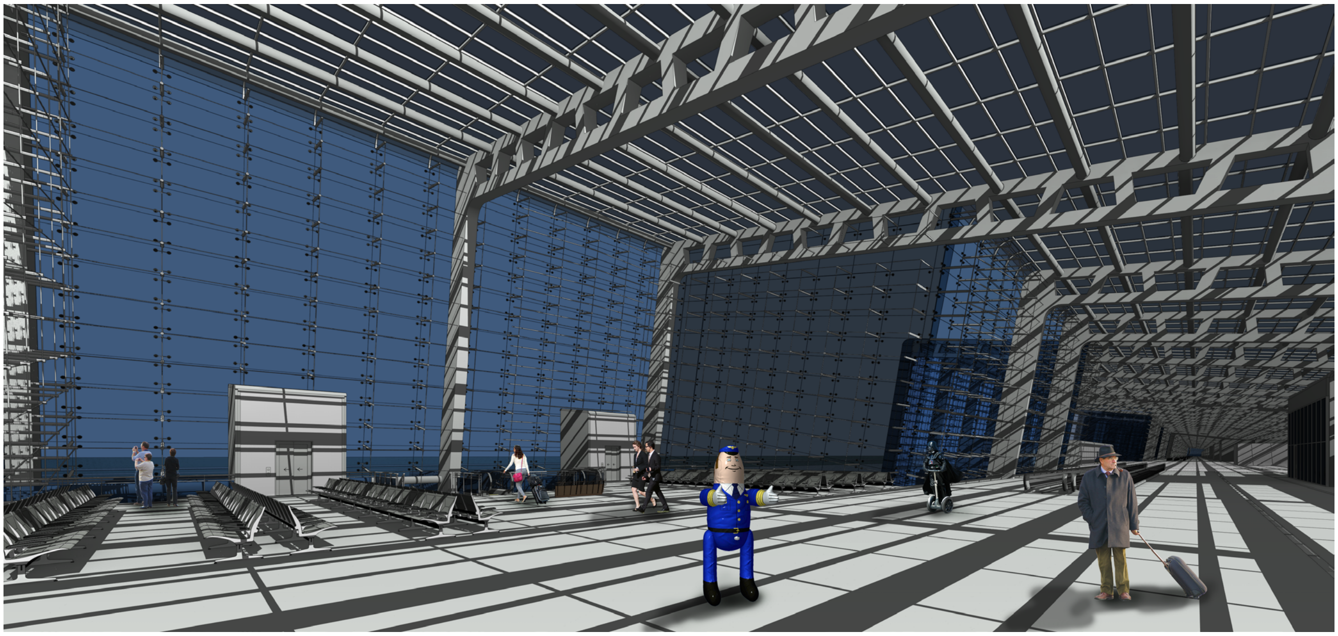


Figure 113 : gate rendering

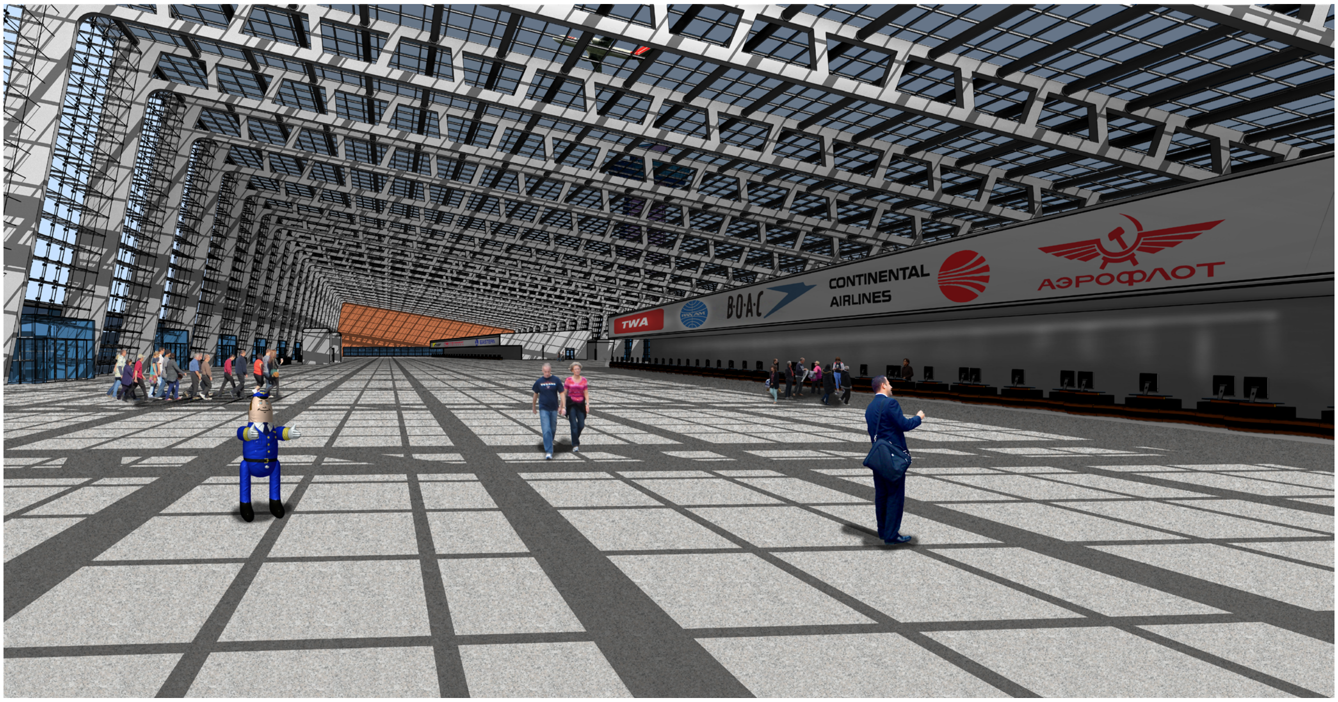


Figure 114 : terminal rendering

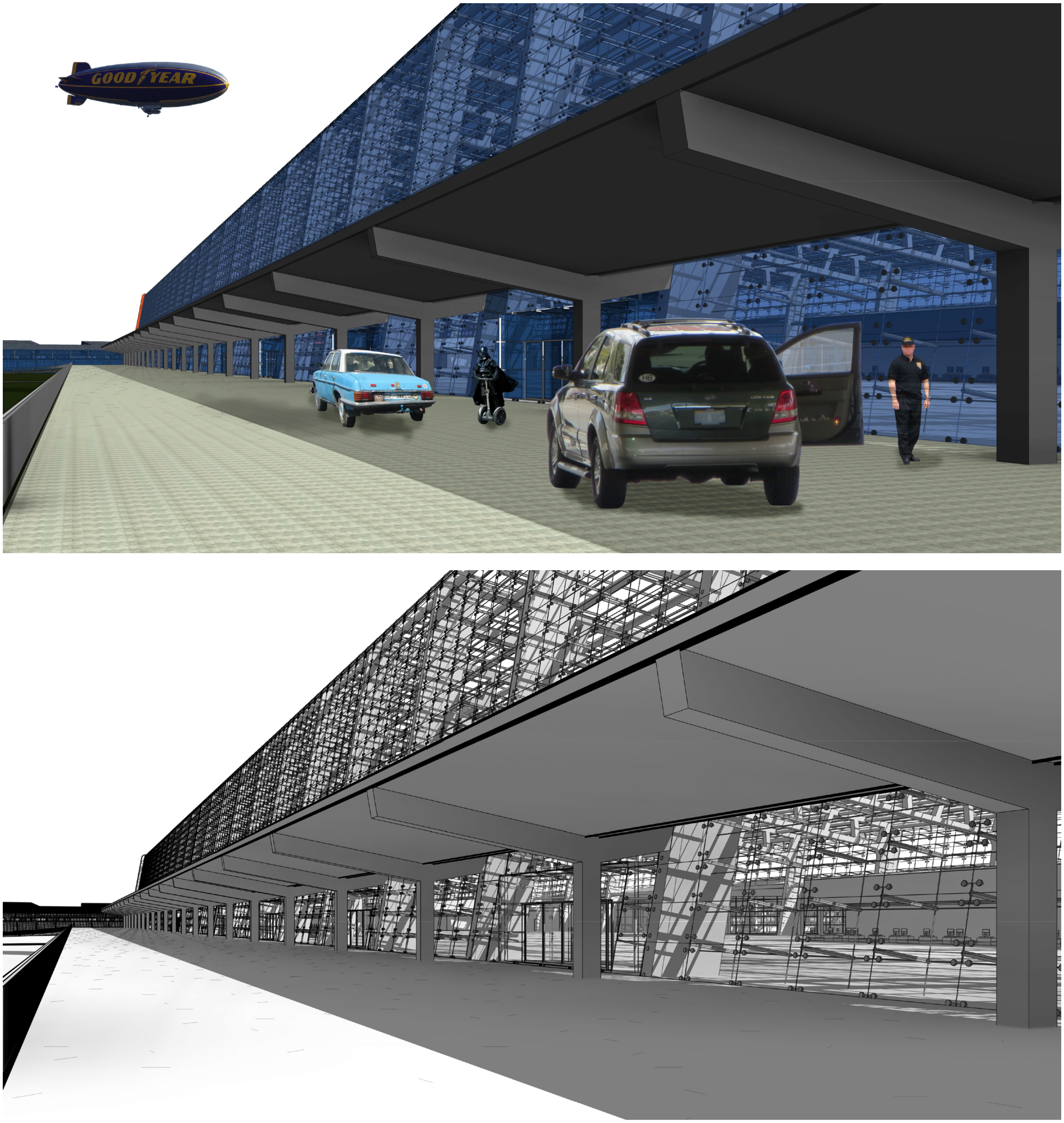
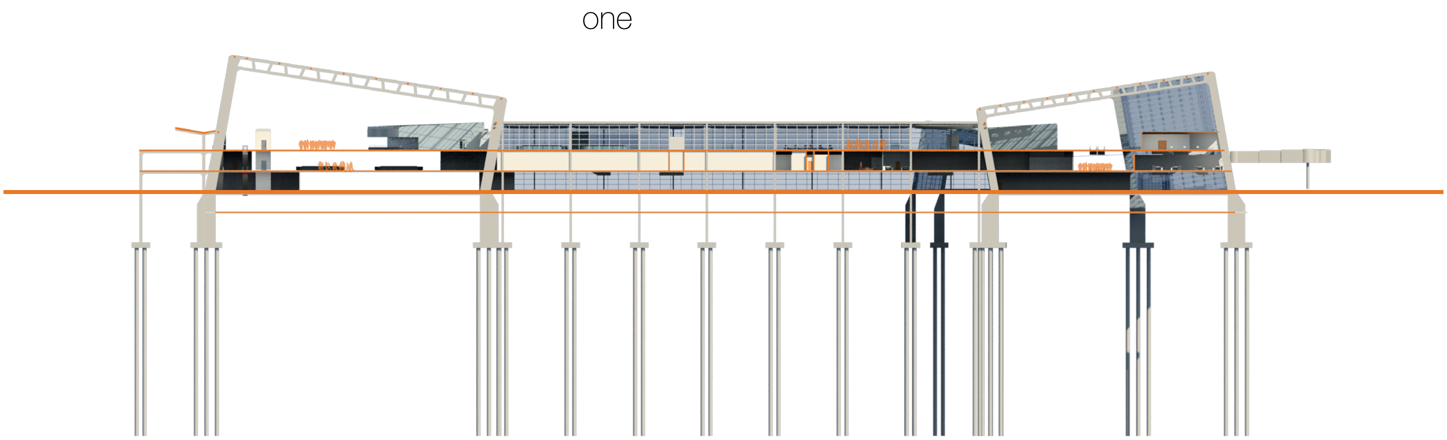
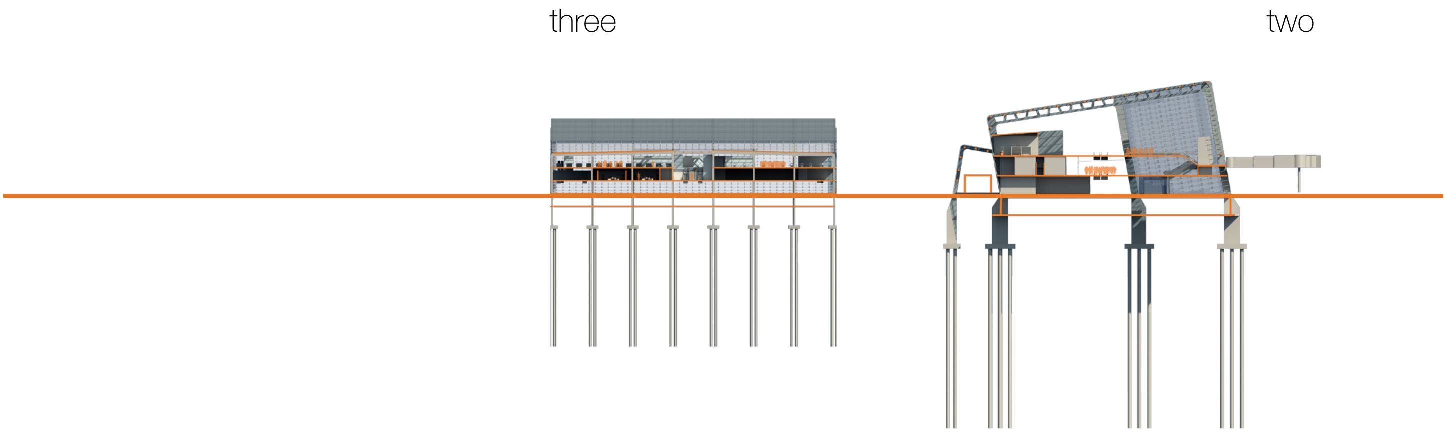


Figure 115 : exterior departures level rendering wth overlay

Plans and details





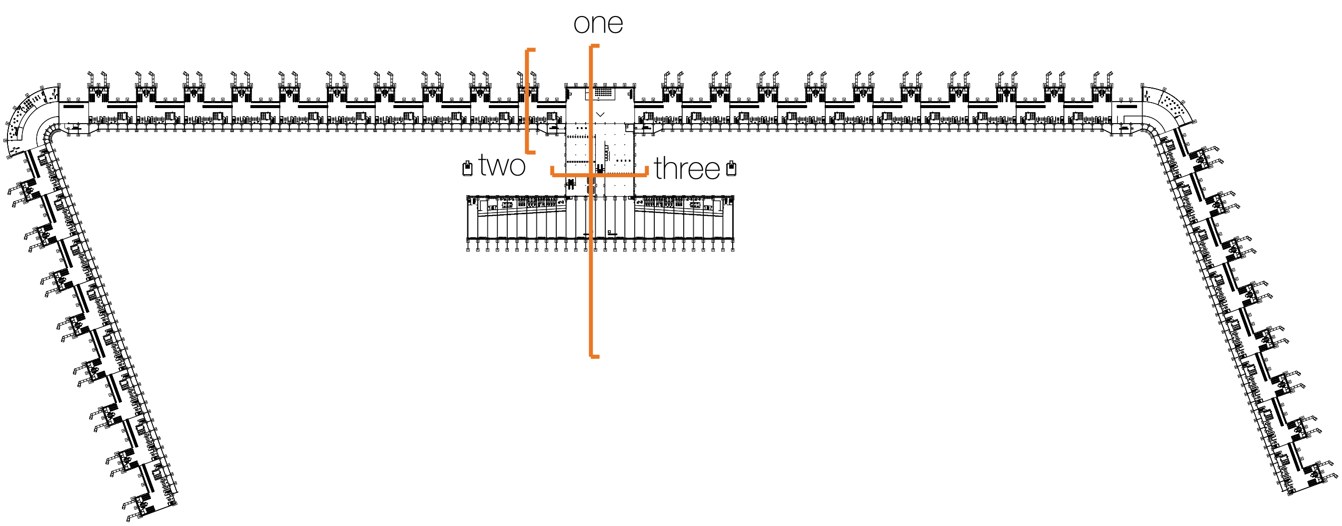


Figure 116 : section perspectives

section perspective one

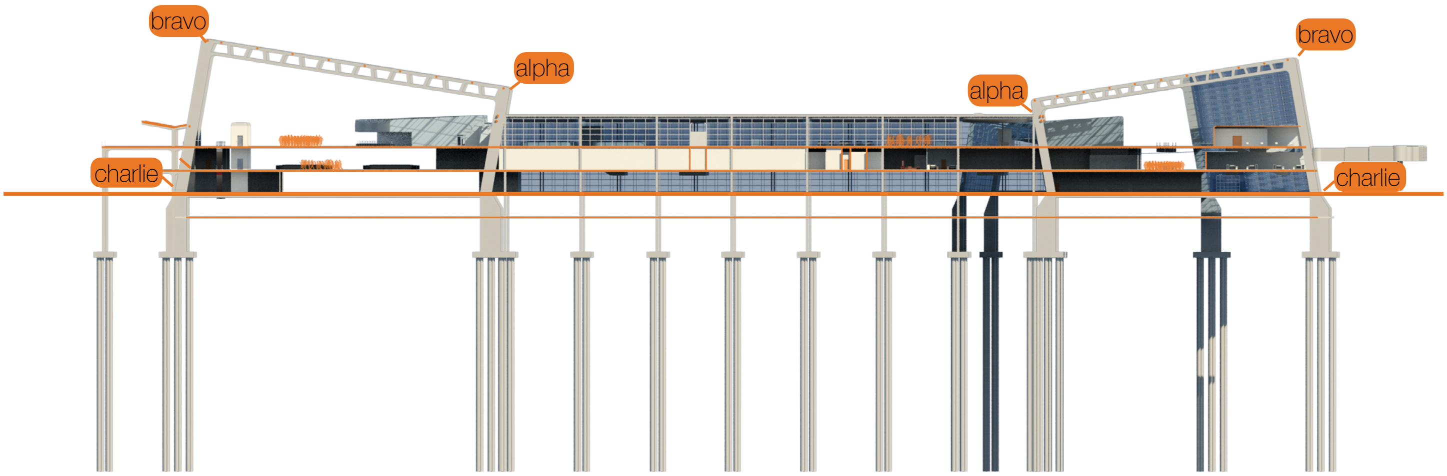


Figure 117 : Section perspective one

detail alpha

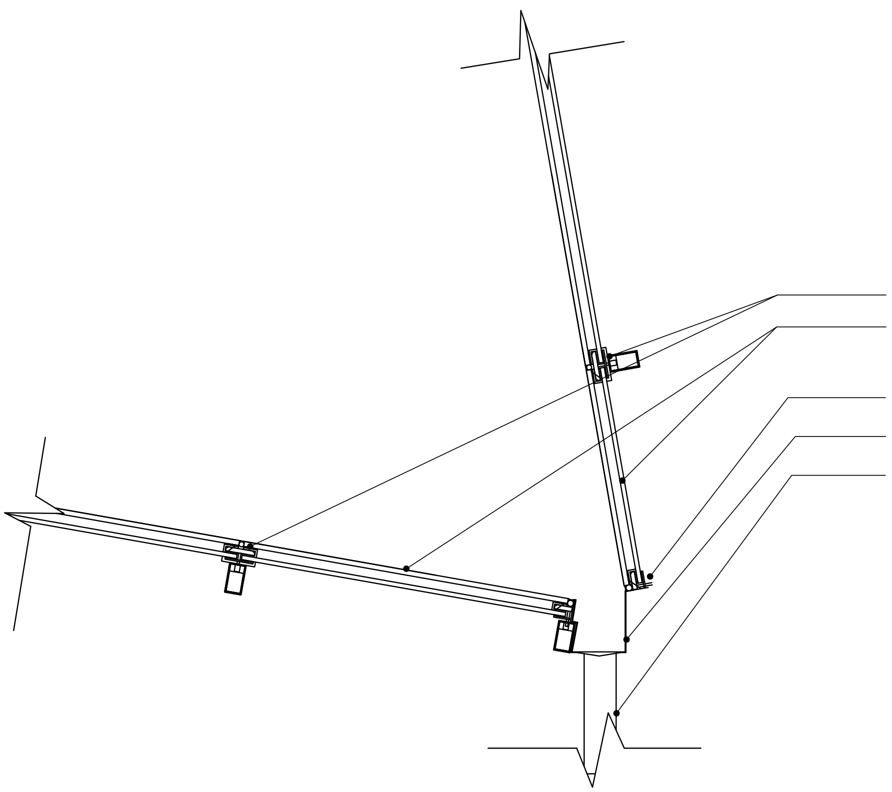


Figure 118 : detail alpha

detail bravo

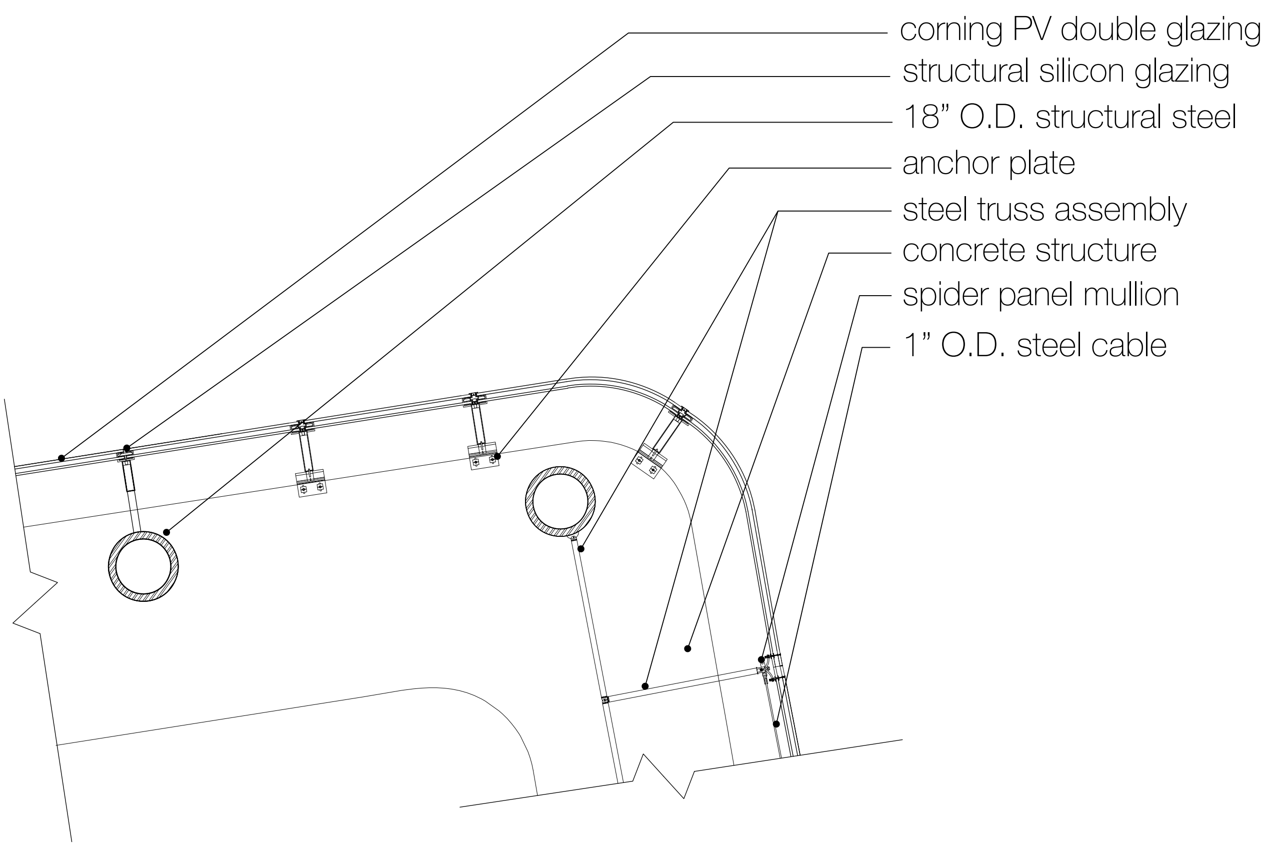


Figure 119 : detail bravo

detail charlie

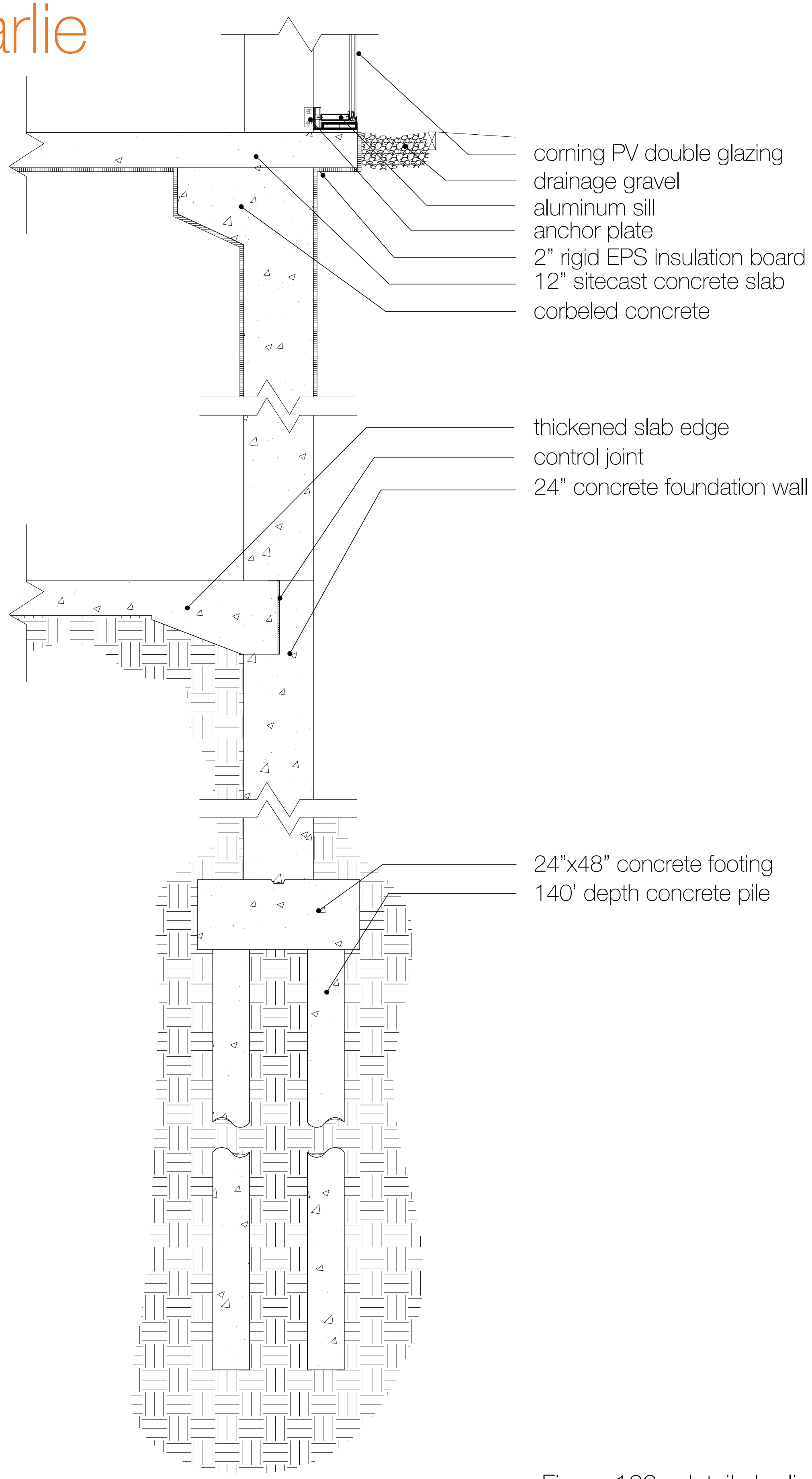


Figure 120 : detail charlie

section perspective two

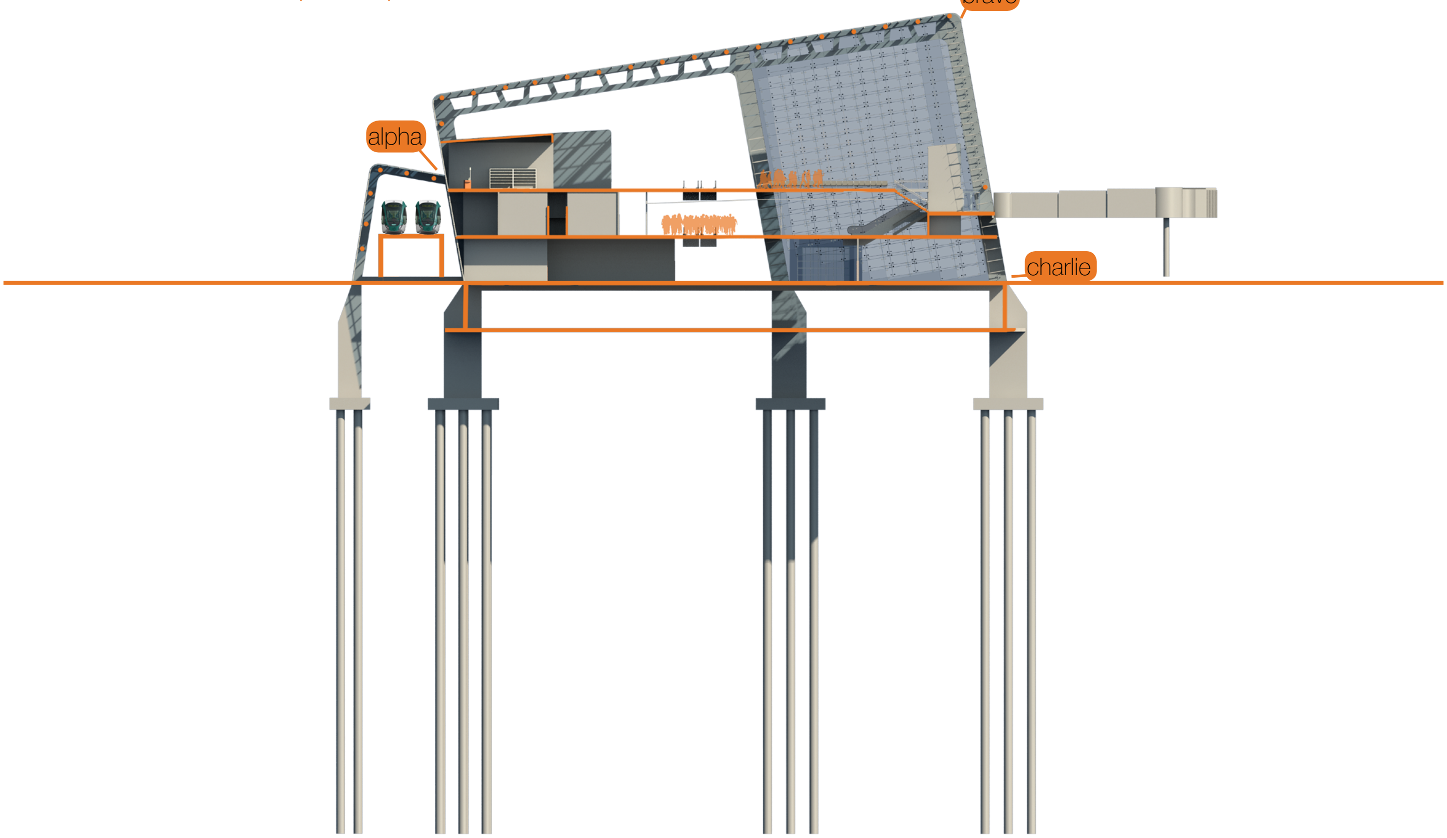


Figure 121 : section perspective two

detail alpha

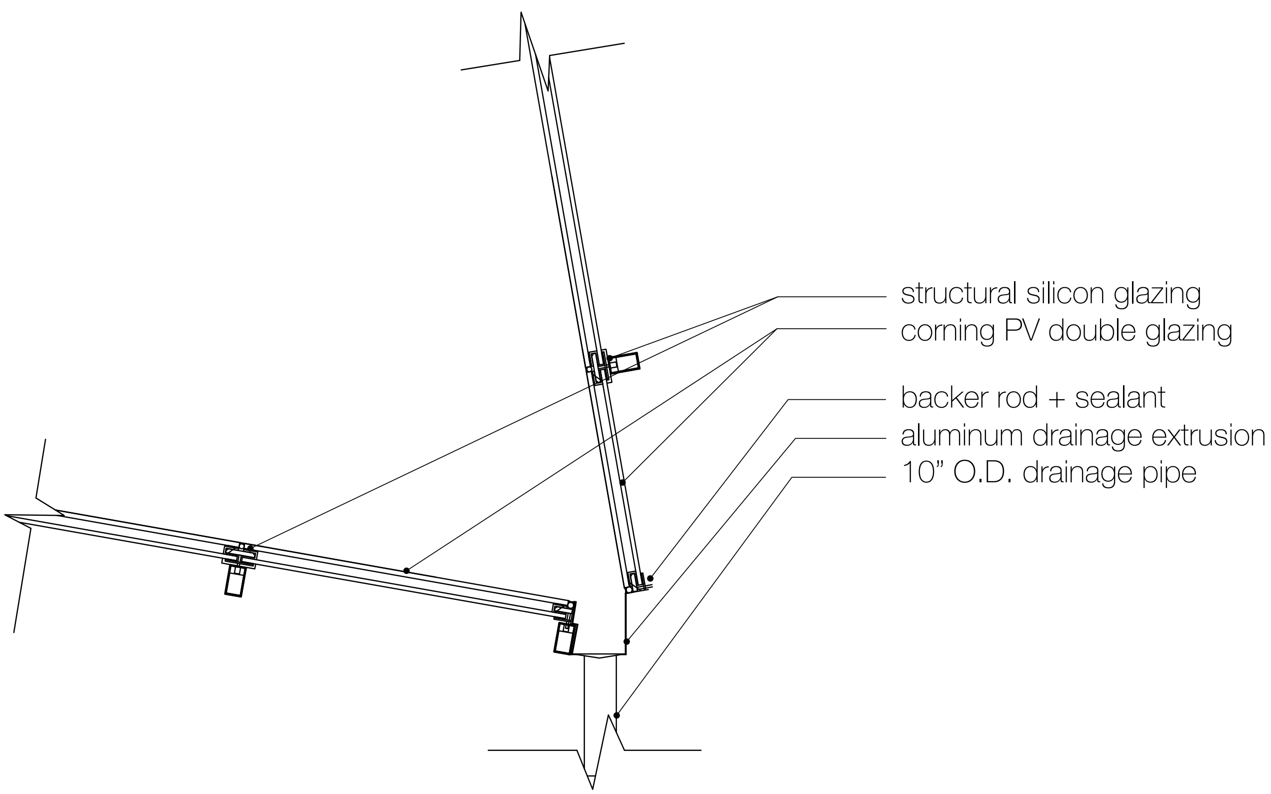


Figure 122 : detail alpha

detail bravo

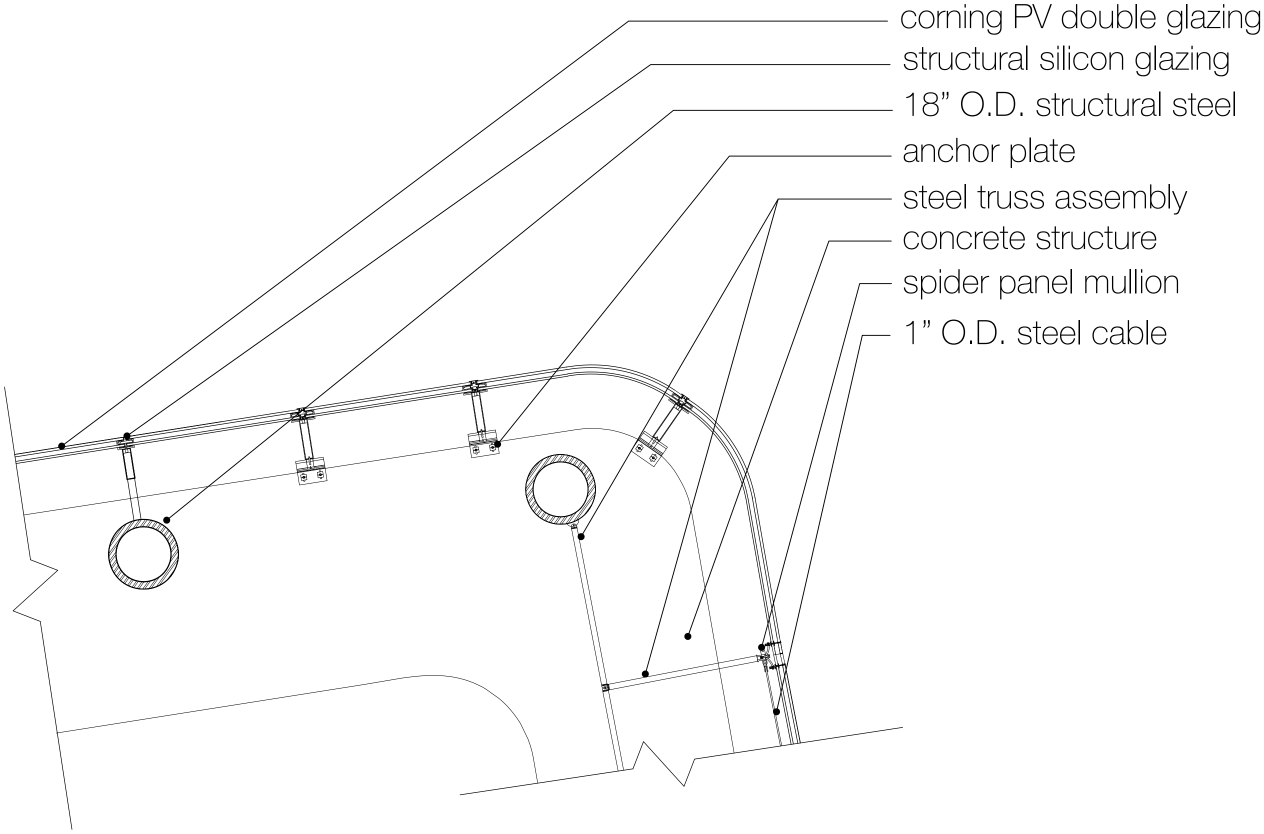


Figure 123 : detail bravo

detail charlie

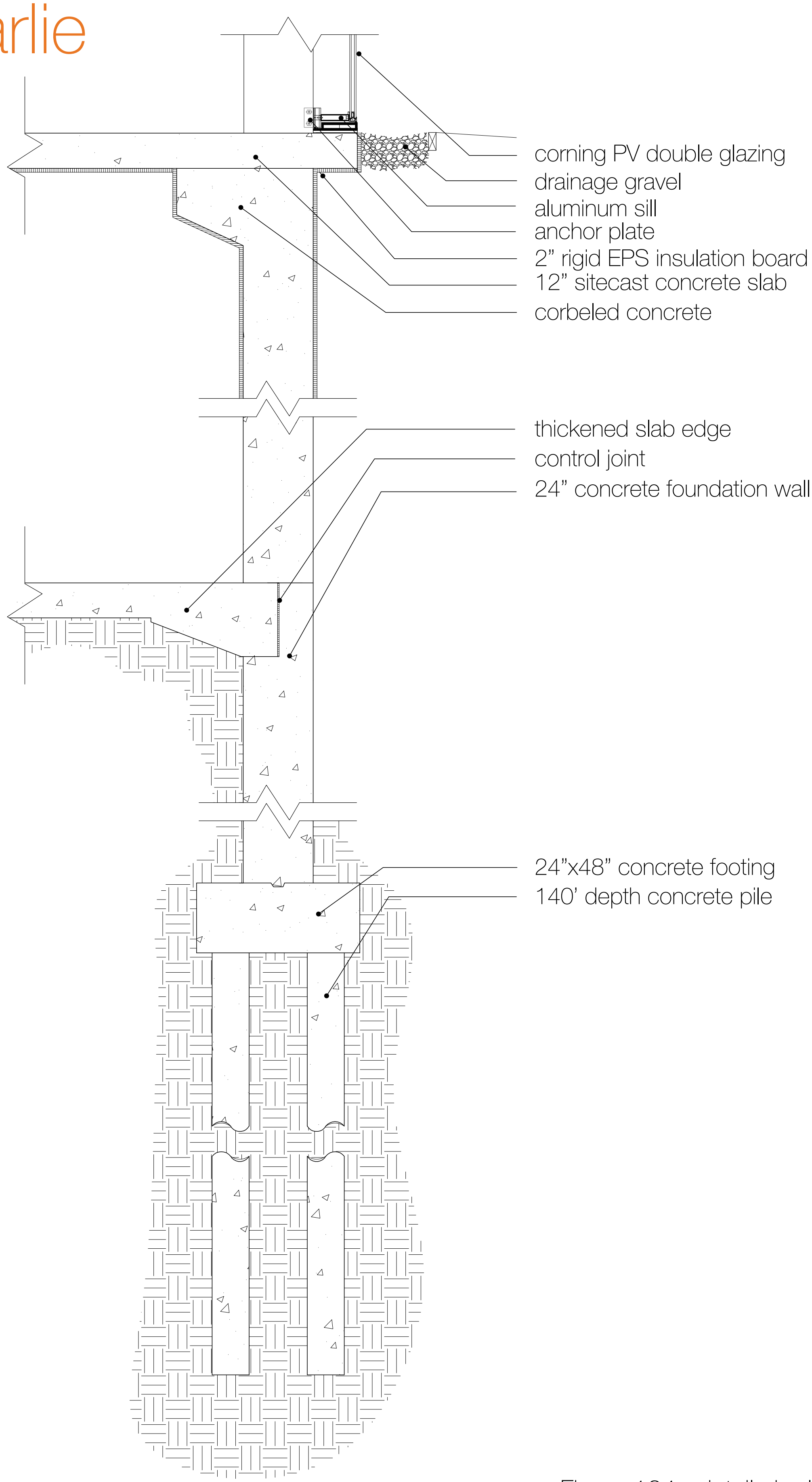


Figure 124 : detail charlie

section perspective three

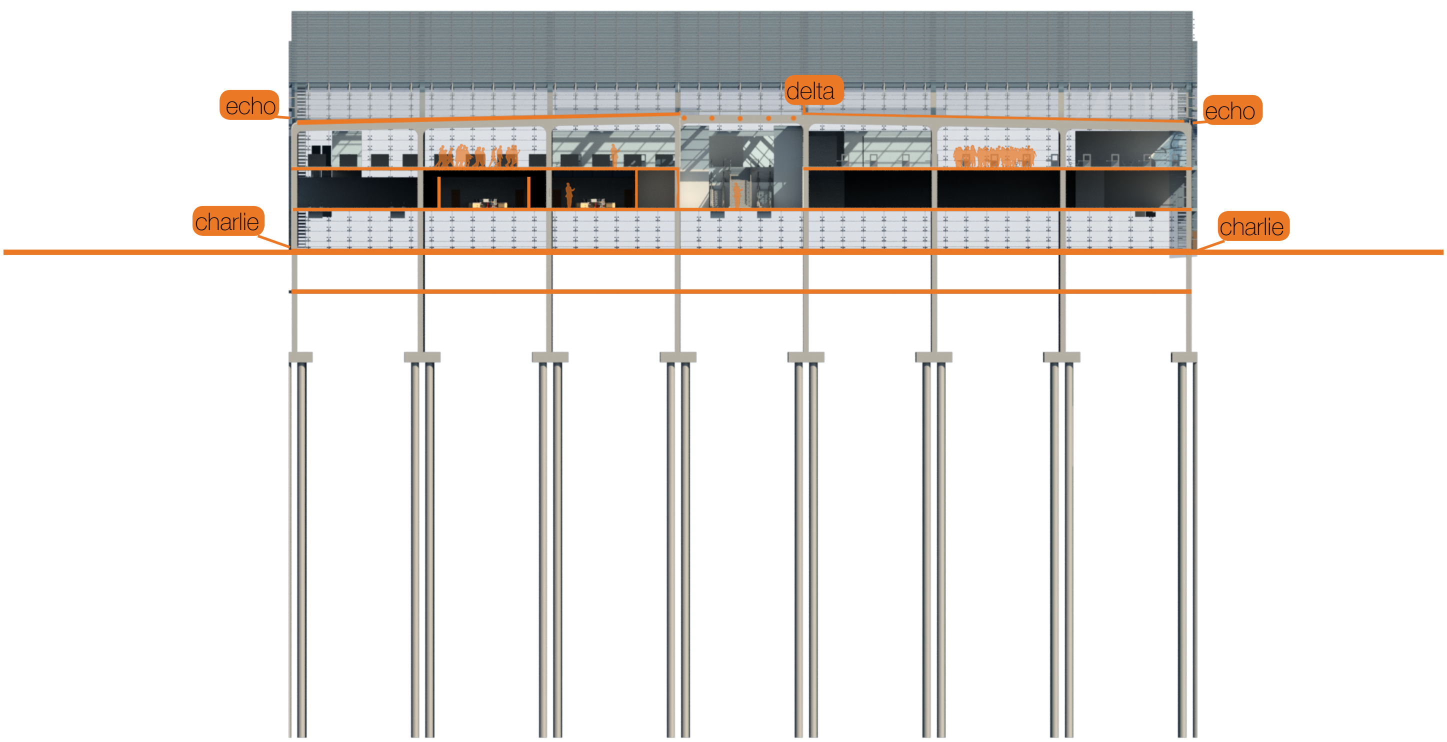


Figure 125 : section perspective three

detail delta

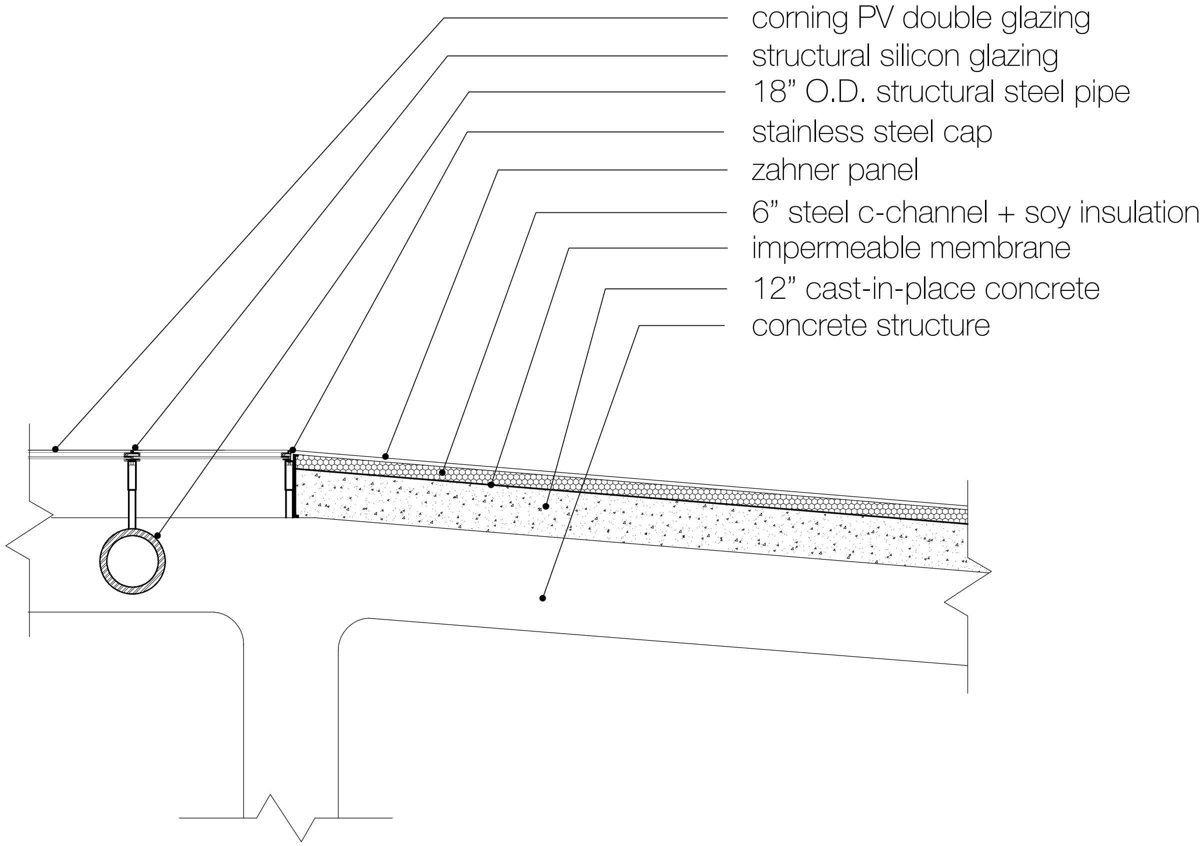


Figure 126 : detail delta

detail echo

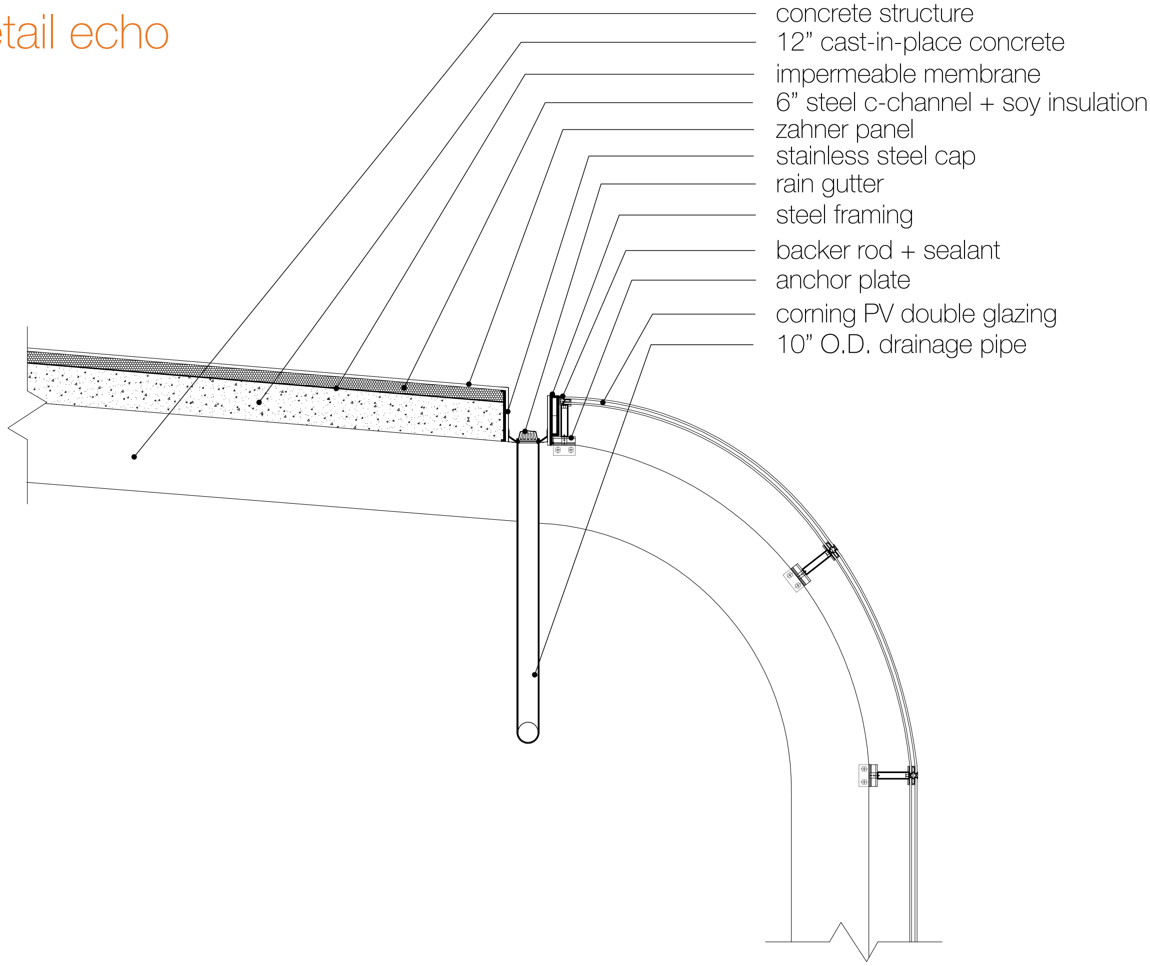


Figure 127 : detail echo

detail charlie

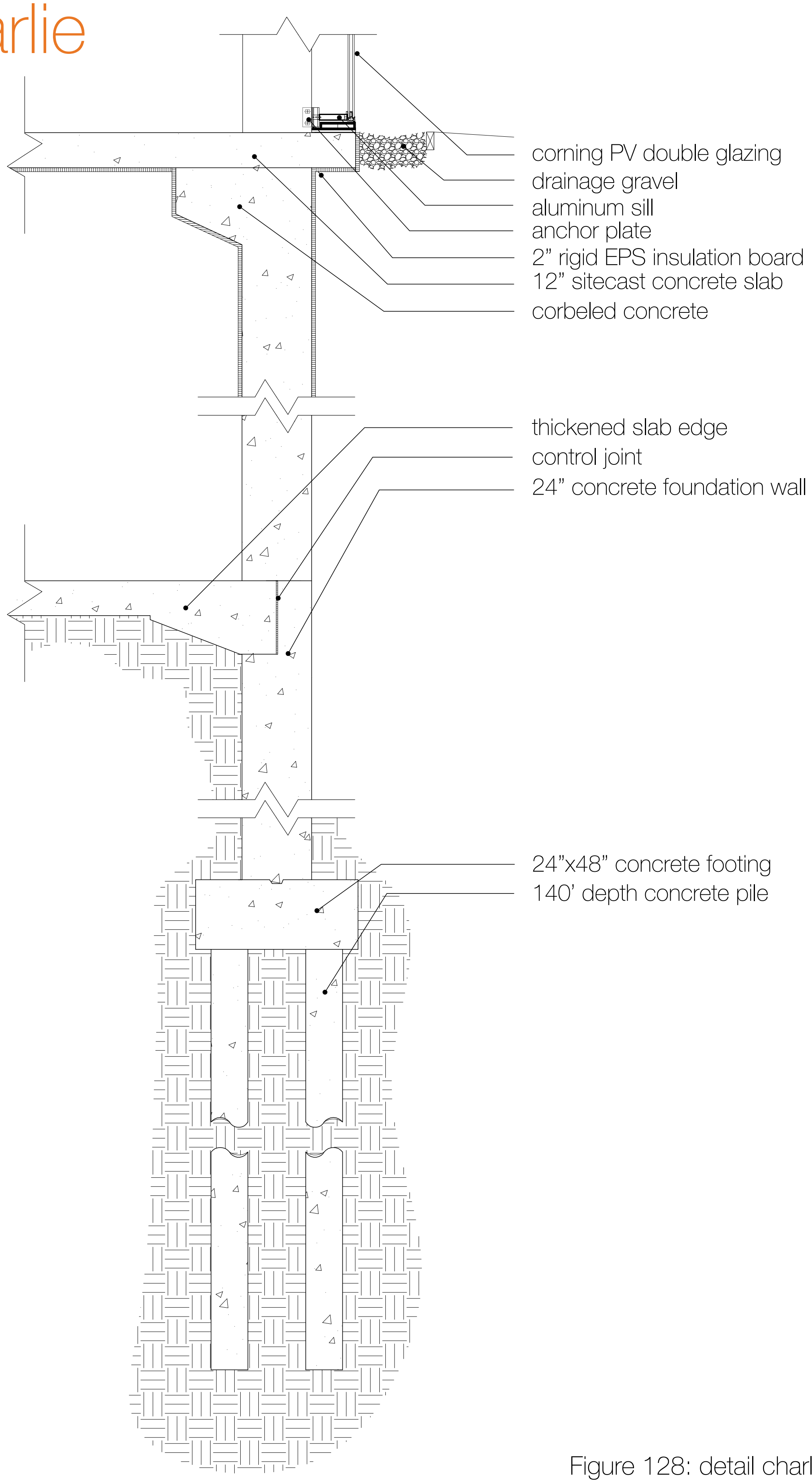
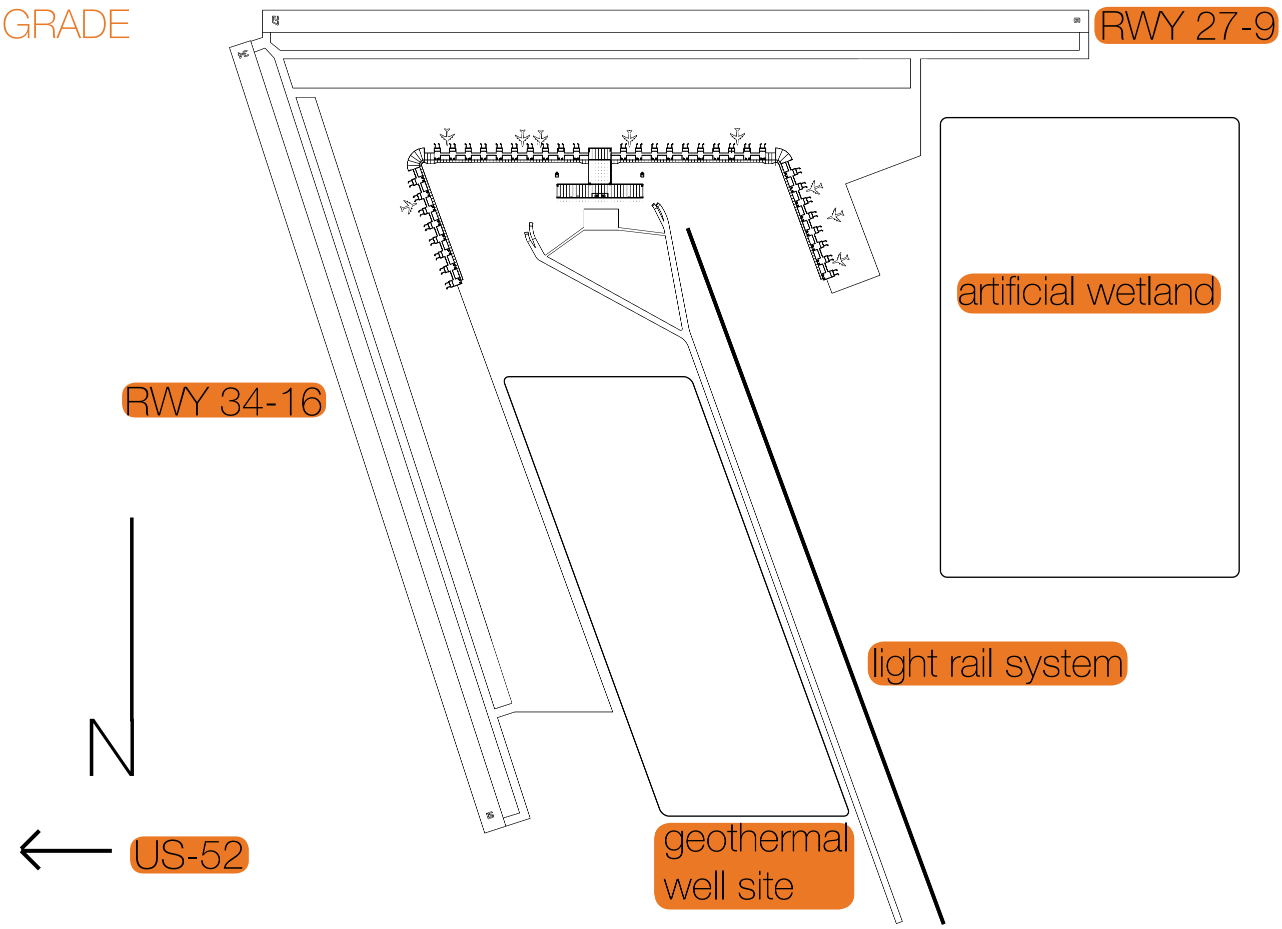


Figure 128: detail charlie

GRADE



GRADE

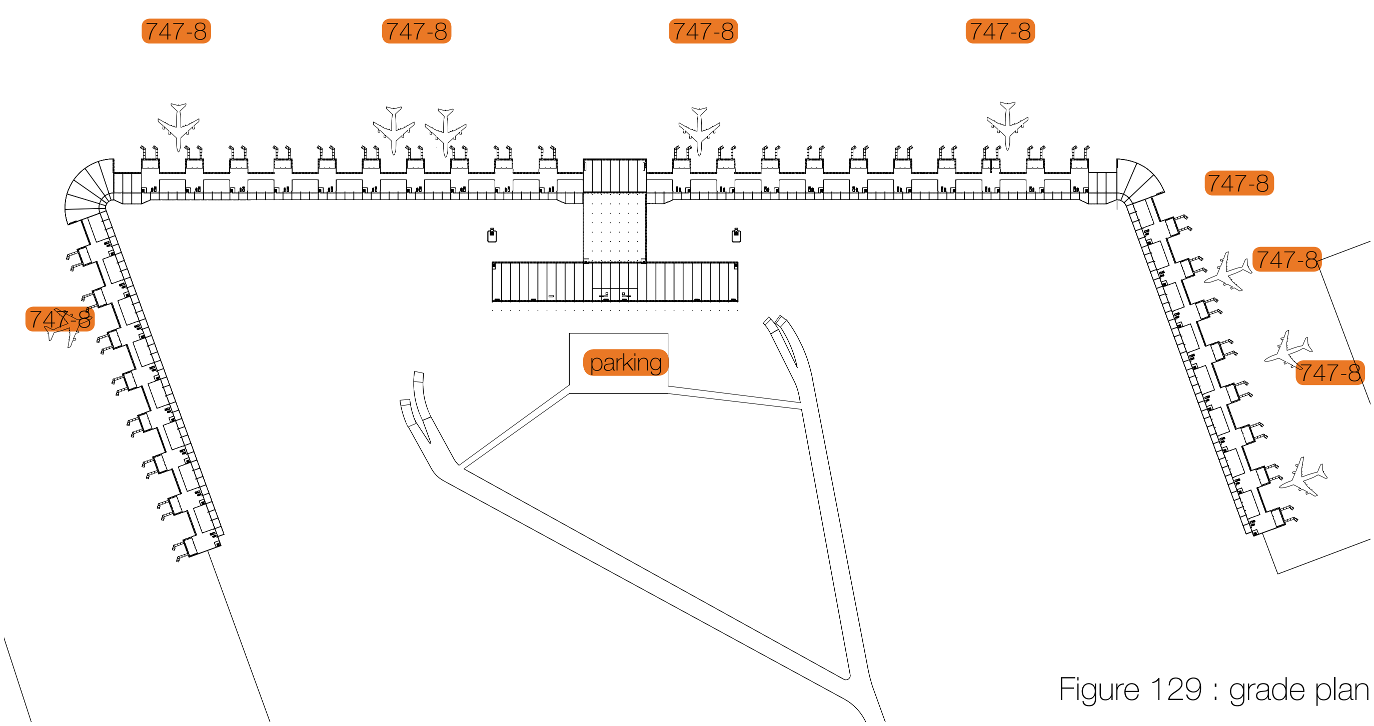


Figure 129 : grade plan

GRADE

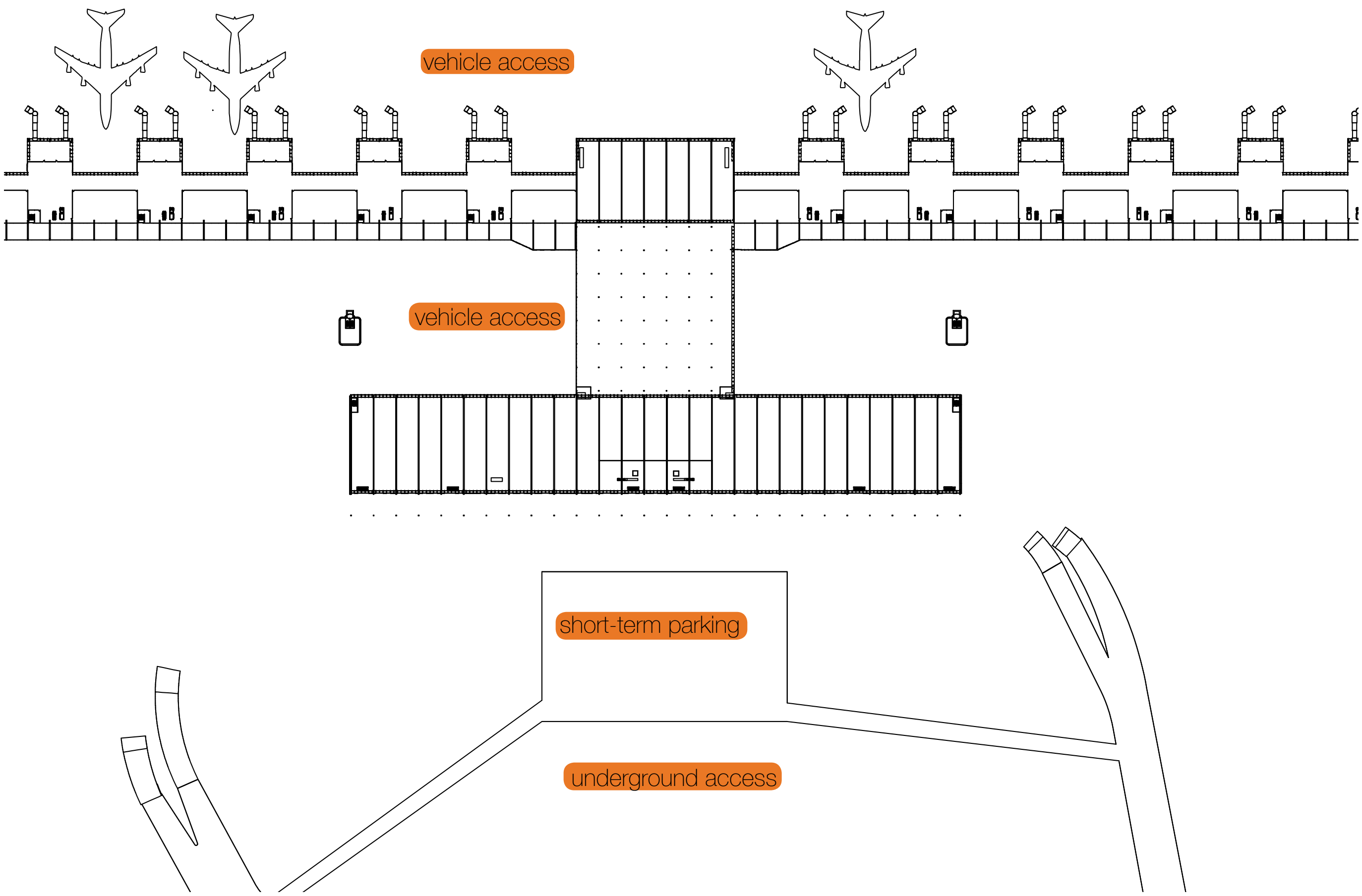
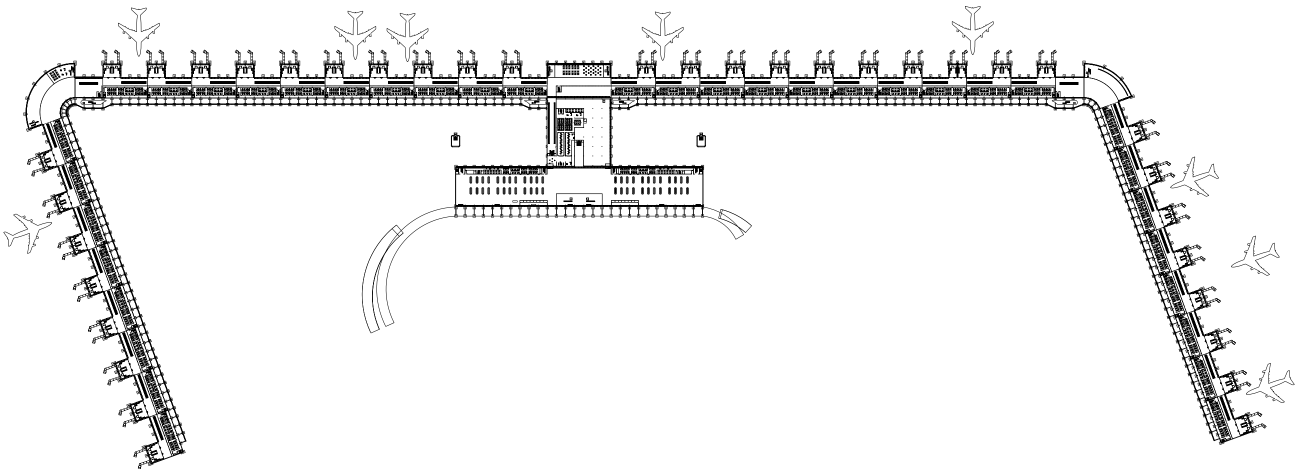


Figure 130 : grade plan



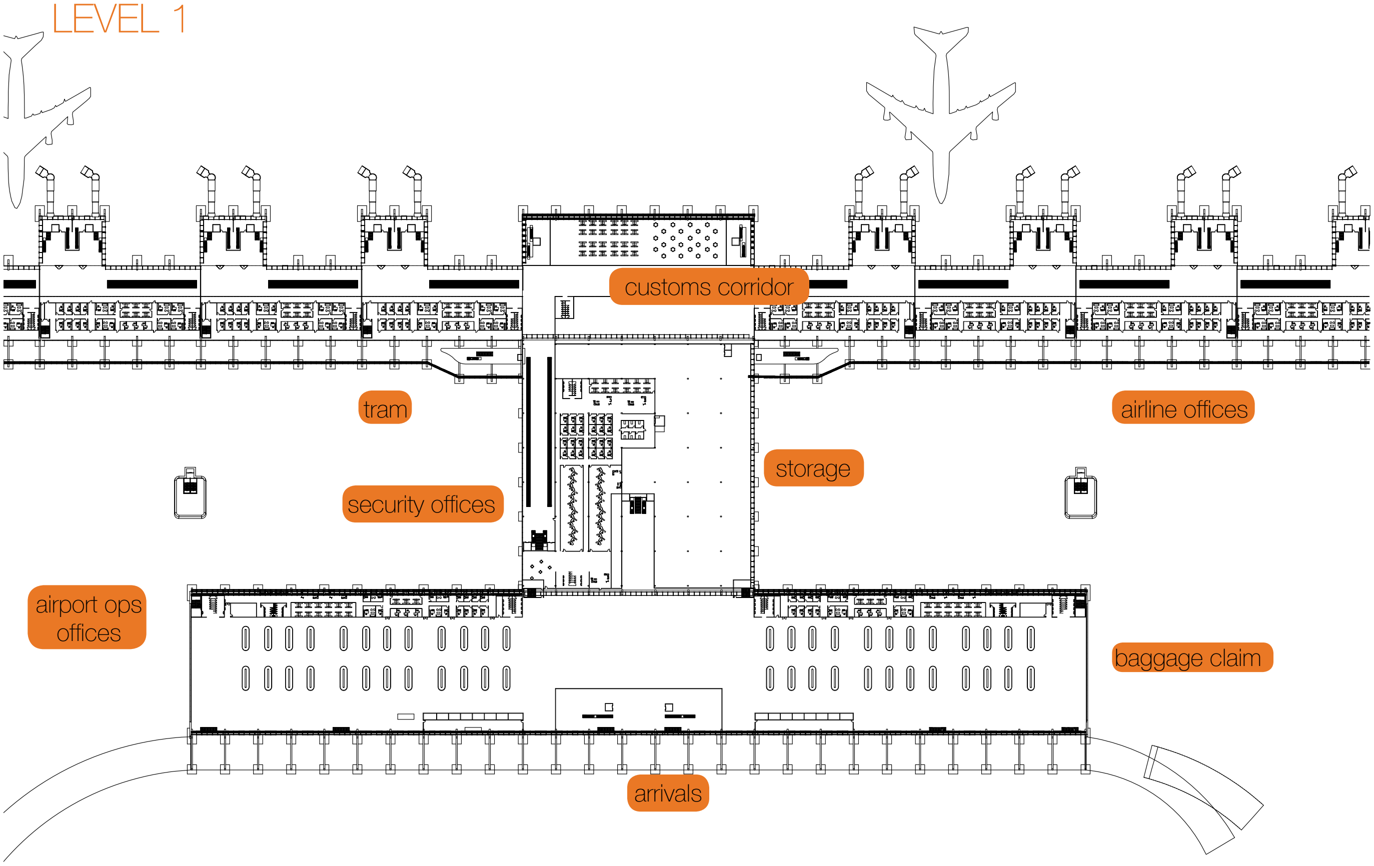


Figure 131 : level one floor plan

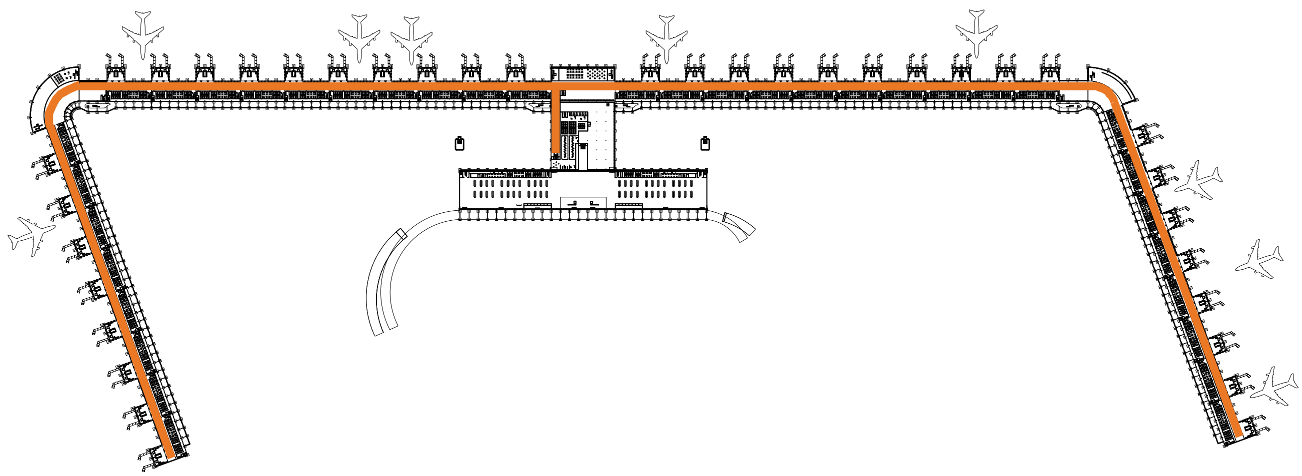
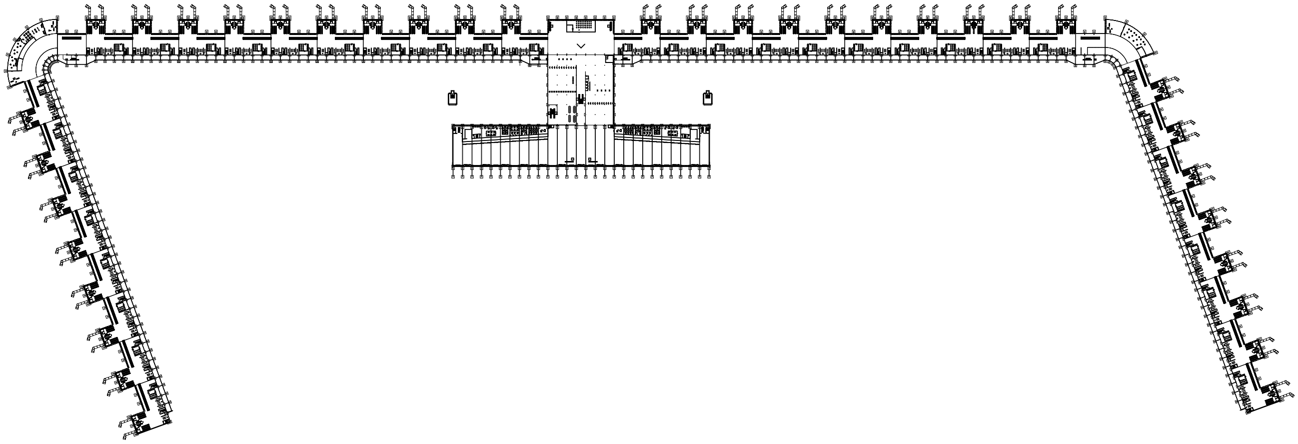


Figure 132 : customs corridor

The customs area is in orange, all gates are connected to it and able to handle international passengers. Passengers are moved along via moving walkways. The movement through this area is defined earlier in the book.

LEVEL 2



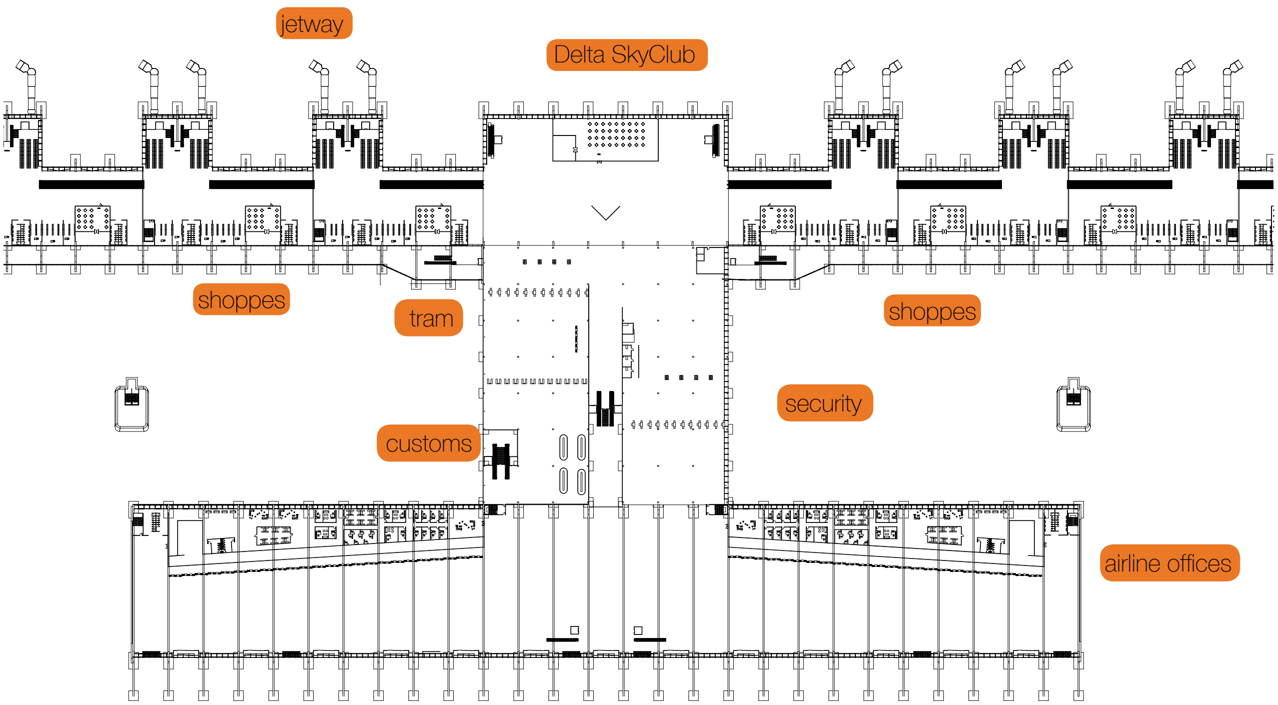
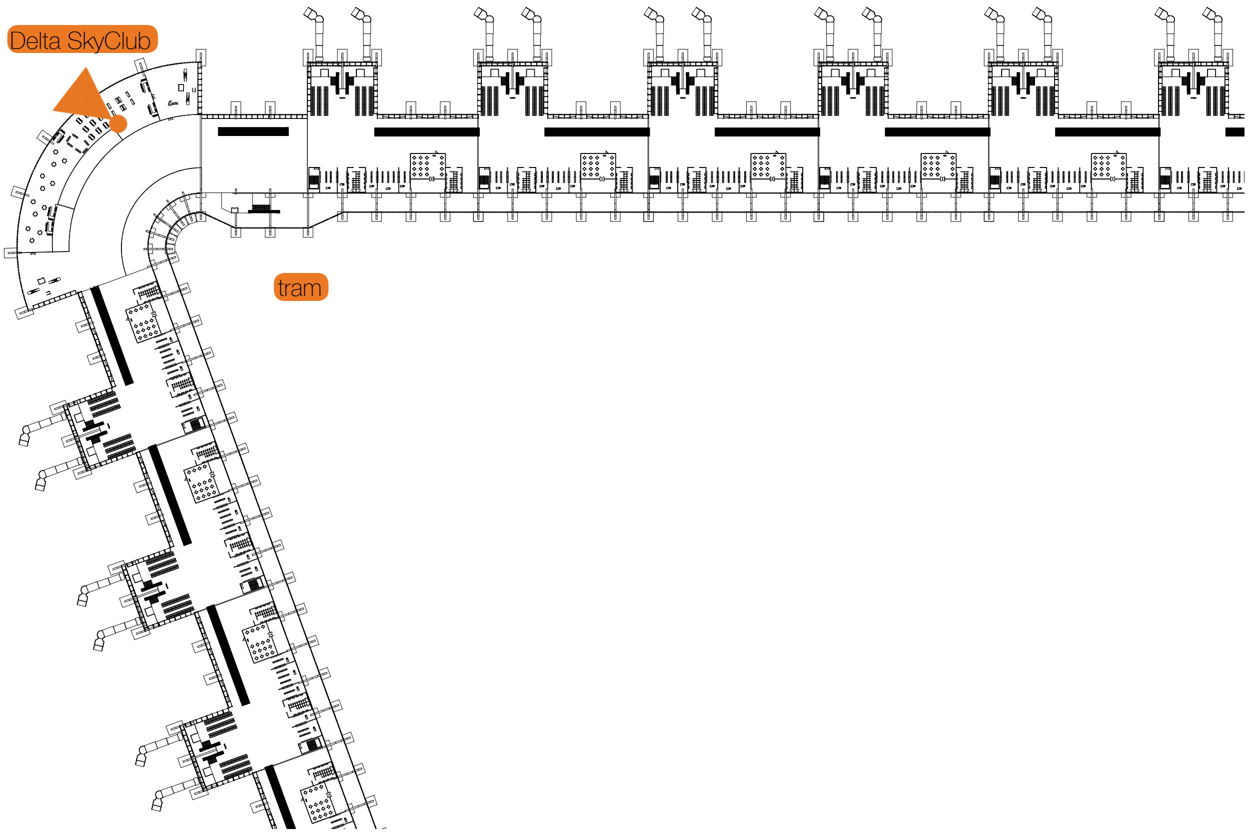


Figure 133 : level two floor plan

WEST



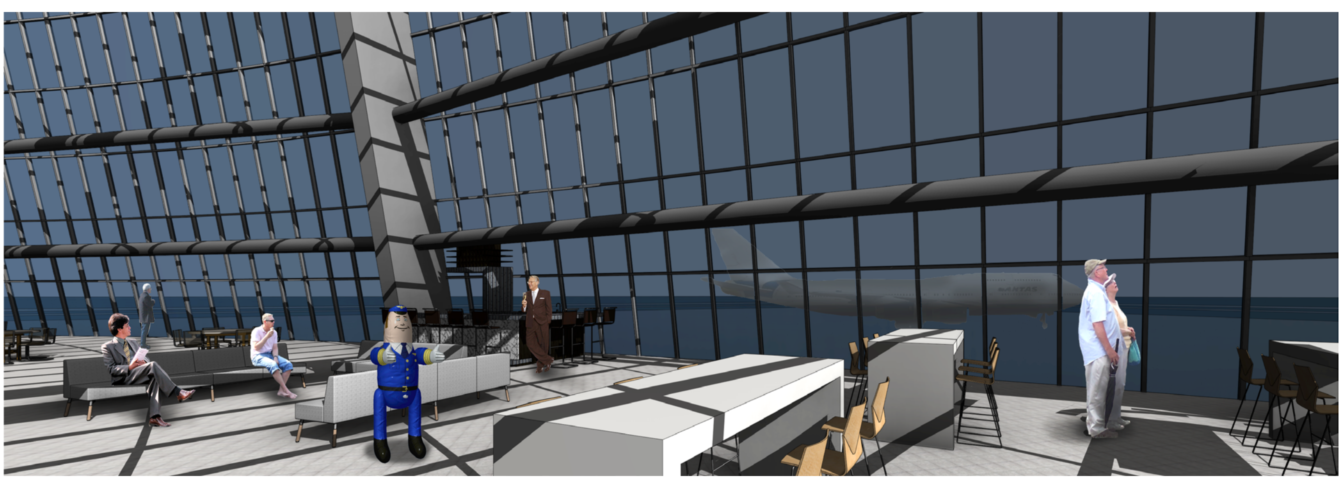


Figure 134 : corner floor plan and rendering

EAST

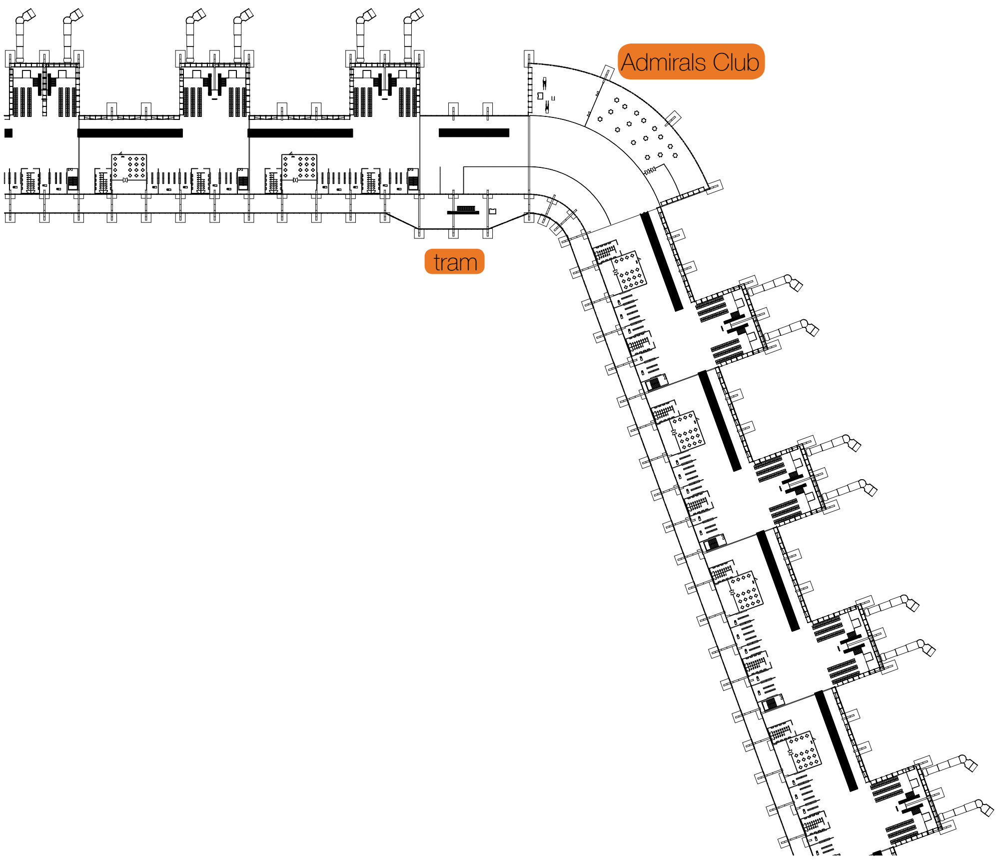
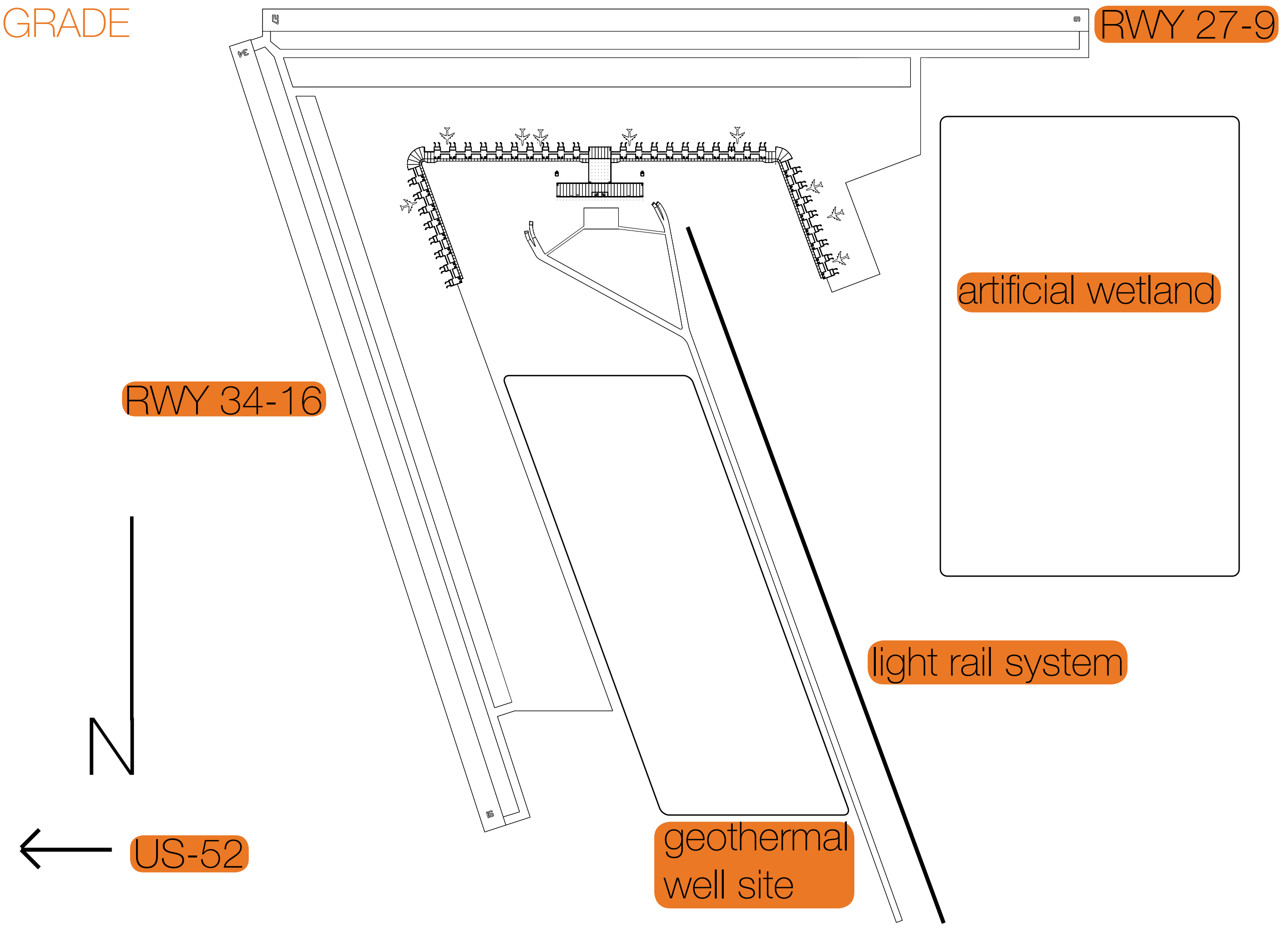


Figure 135 : corner floor plan

GRADE



detail foxtrot
wetland drain detail

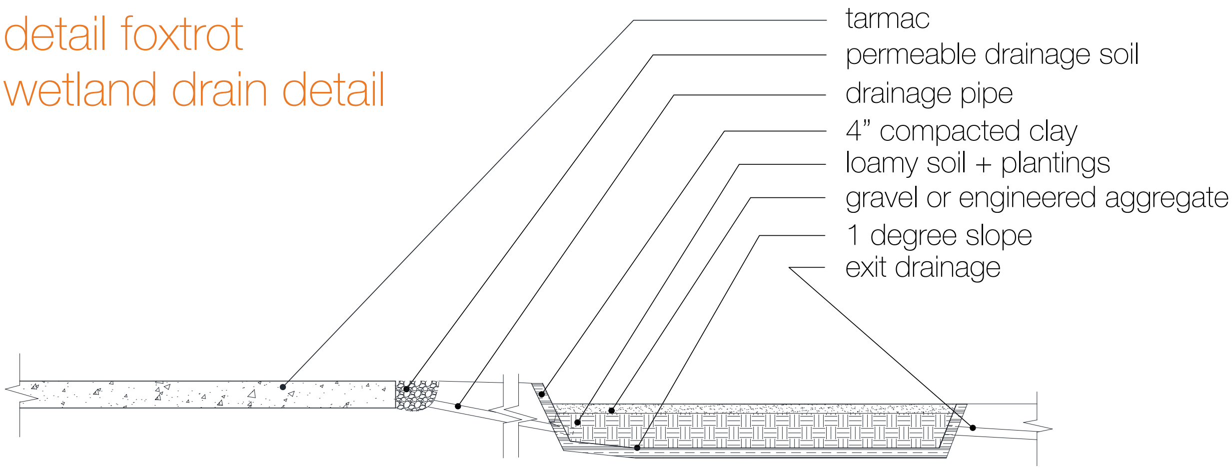


Figure 136 : site plan and wetland detail

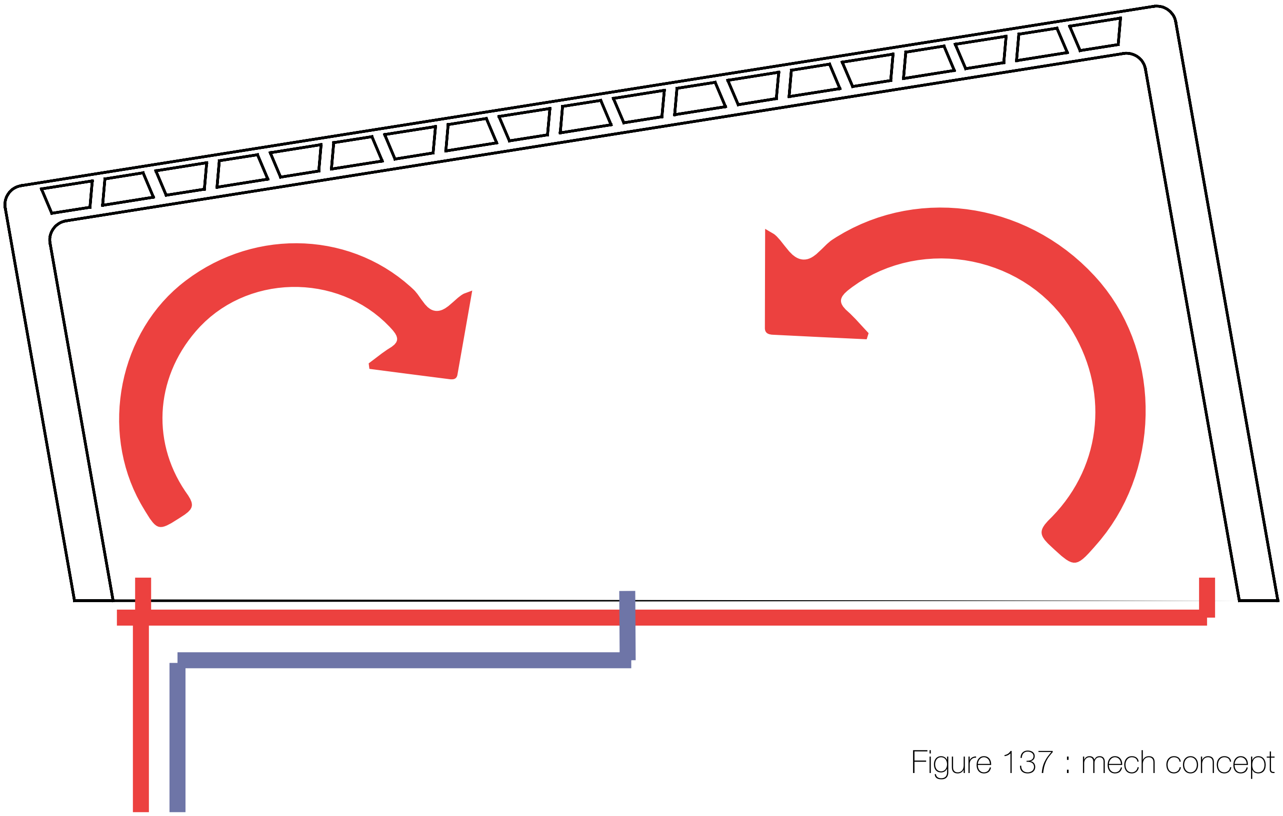
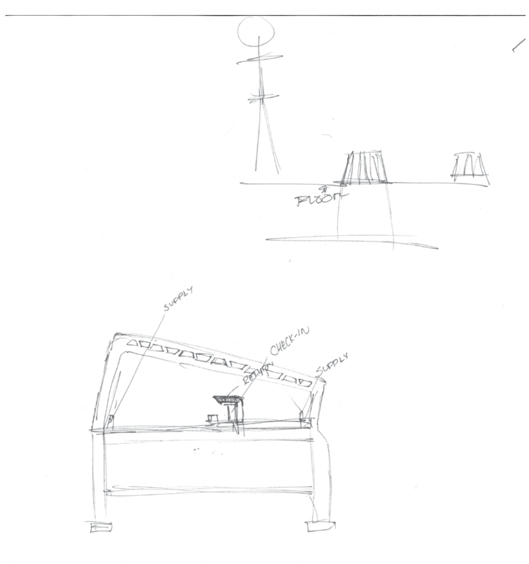


Figure 137 : mech concept



The mechanical system would be fed from the sides, and have return in the middle. supply ducts would come from the floor-level, and be stylised to resemble an engine nacelle. return ducts would be hidden into walls within the area.

Figure 138 : mechanical sketch

images courtesy of siemens.com

Figure 139 : baggage movement

Siemens has developed an autonomous system that moves baggage around via a cart system. each bag is placed on an individual cart and tagged in the system, so all bags are in a specific location, and can be readily accessed when needed to be. bags are stored in a storage facility until such time. This system would be underground.

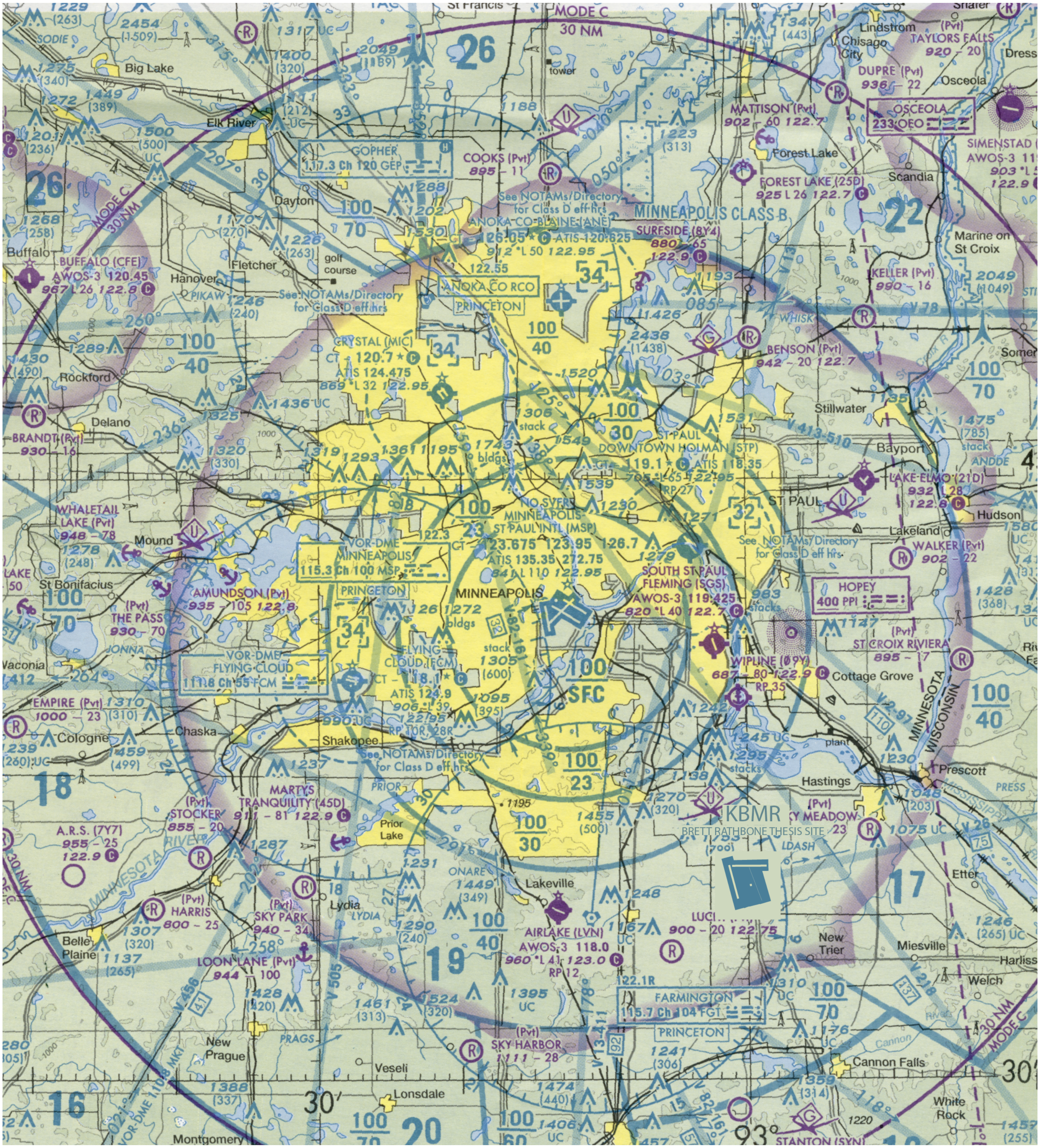
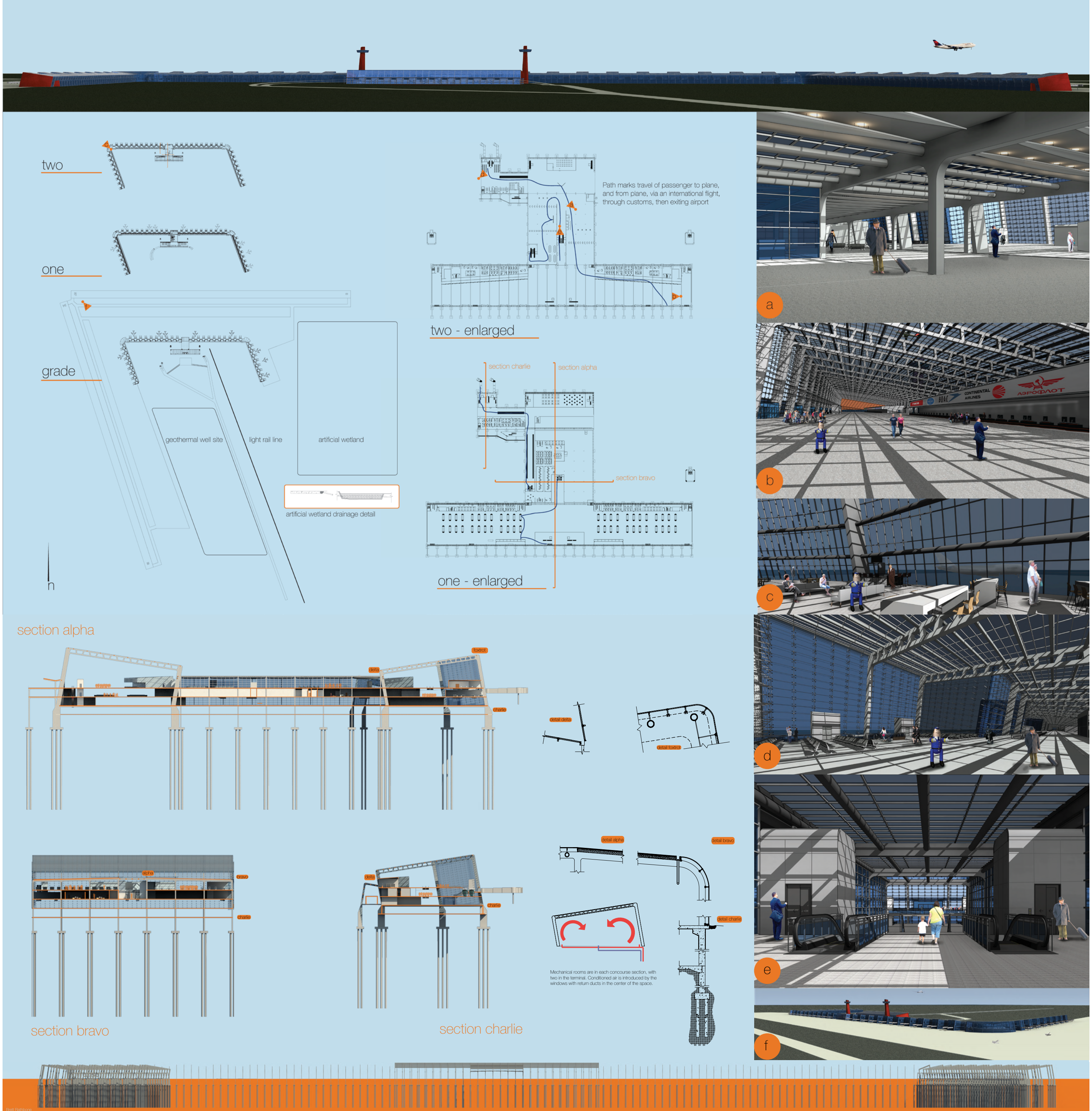


Figure 140 : sectional airport map

Figure 141: model

Figure 142: model bokeh

aeronautical destinations

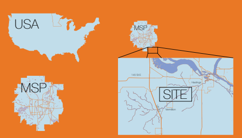


Brett Rathbone
ARCH 772 M. Barnhouse, Revit 2015, Illustrator CS6, Photoshop CS6

This building uses Zahner metal panels with a GB60 finish, Pilkington spider glass assemblies with curved glass bent by US Precision Glass. The glass panels are a Corning design and include a subtle PV panel and are self-shading. Changing the quality of light inside and providing a variable exterior. The structure is cast-in-place concrete. Concrete floors with a granite from Coldspring Granite help give this building a durable, yet desirable finish. Trams are built by Bombardier, an aircraft manufacturer. Elevators are Otis Gen2 traction elevators, the escalators and moving walkways are Otis products as well.

The design is 3.5 million square feet, features 64 gates, and two runways. Each concourse node is designed to be able to accomodate an Airbus A380 or Boeing 747-8. The secondary gate allows for two smaller aircraft to berth at the same time, such as a Boeing 737, or an Airbus A320.

Minneapolis can no longer efficiently expand their current airport. They will need a new airport. This uses a site that is relatively clear of existing infrastructure and removed from the city. This would help attenuate noise, but is still within a 30 minute commute of the downtown metropolitan area. The Air port also has provisions for a light rail connection.



Can an airport serve not only as a means of travel, but as a destination itself?

Figure 143: boards

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Figure 144: photo of the

Photograph courtesy of Nicholas “Beard” Anderson

“I have a degree from there.”
-Brett Rathbone on NDSU