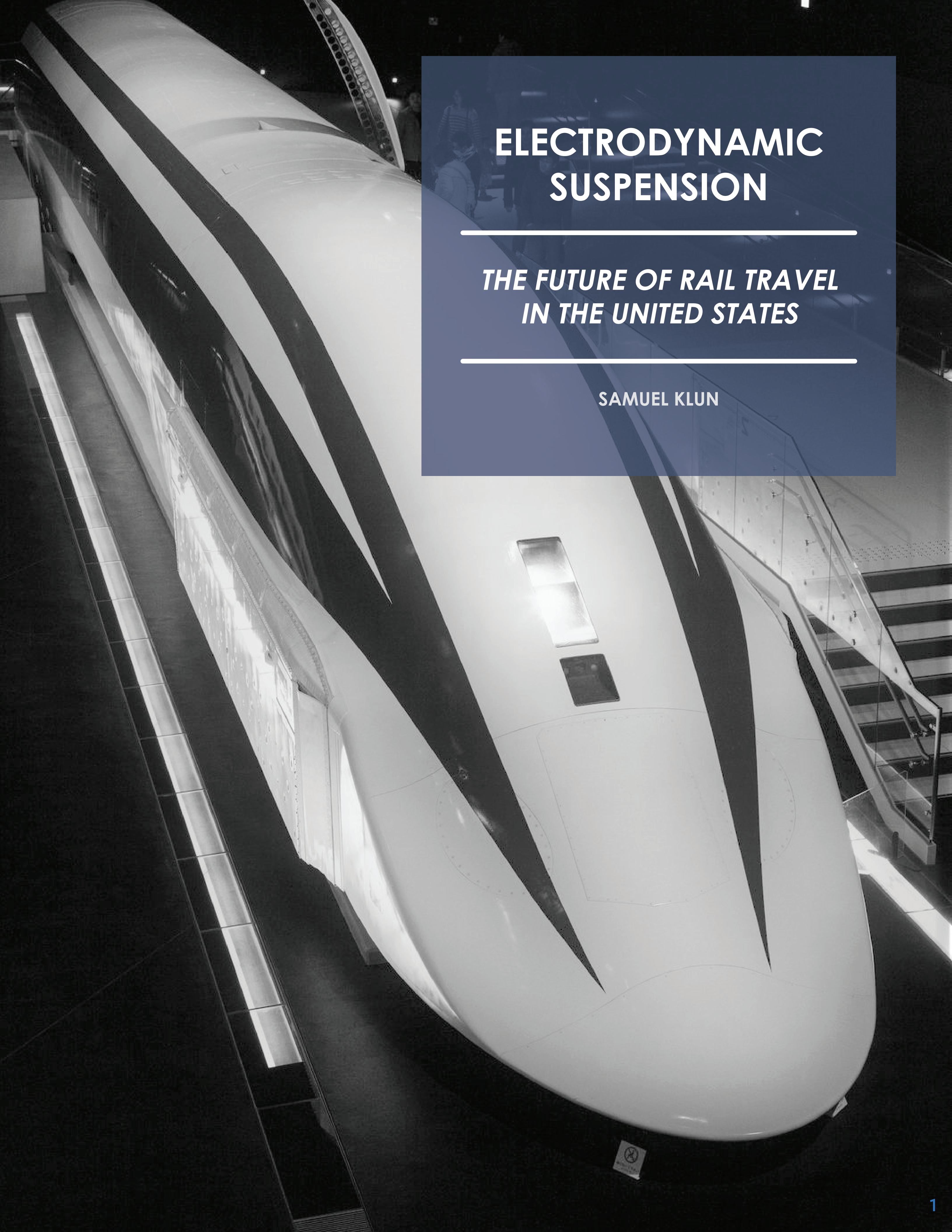

ELECTRODYNAMIC SUSPENSION

THE FUTURE OF RAIL TRAVEL IN THE UNITED STATES

SAMUEL KLUN

ELECTRODYNAMIC SUSPENSION

*THE FUTURE OF RAIL TRAVEL
IN THE UNITED STATES*

A Design Thesis Submitted to the Department of Architecture and Landscape Architecture of North Dakota State University

By: Samuel Klun

In Partial Fulfillment of the Requirements for the Degree of
Masters of Architecture

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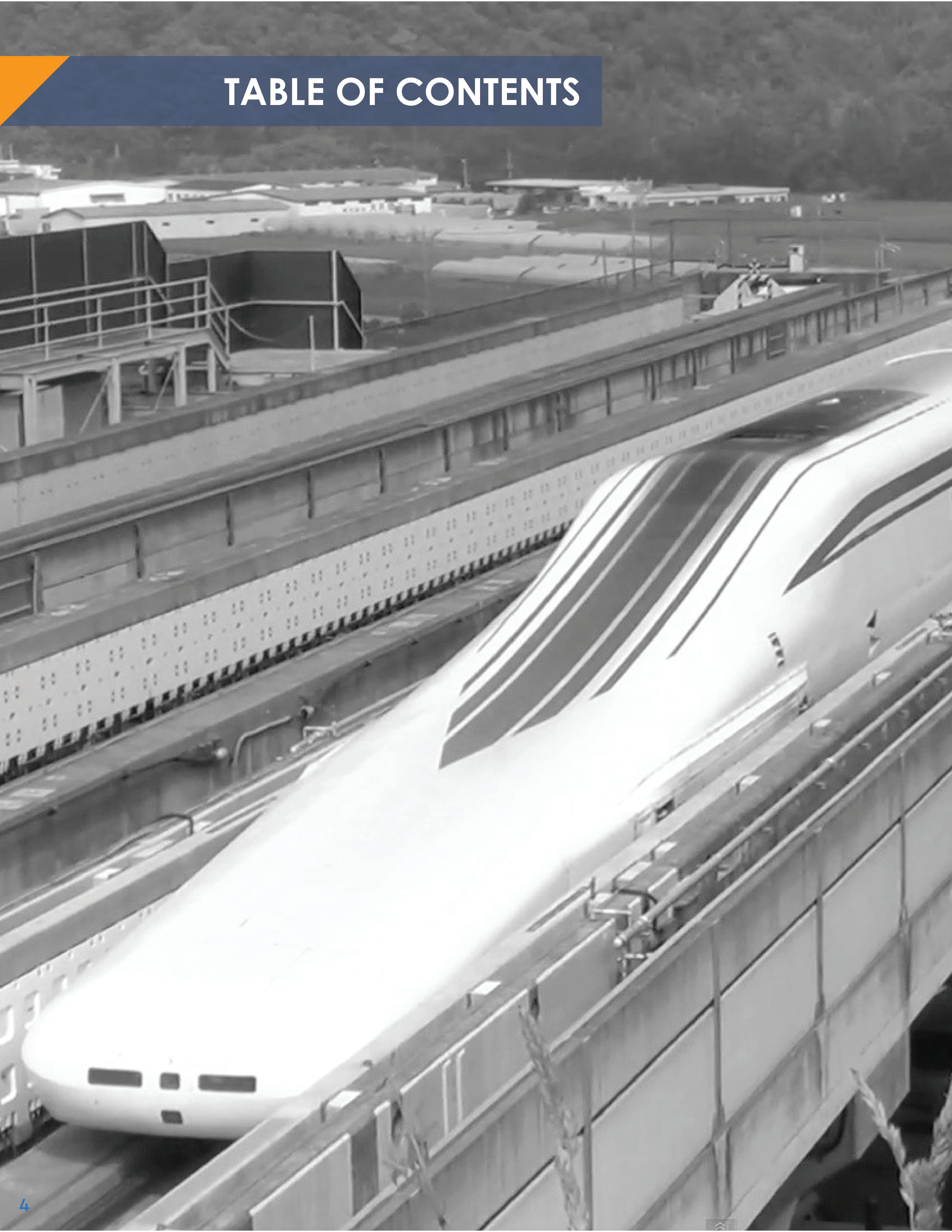


TABLES & FIGURES

THESIS ABSTRACT

With the steady increase in population throughout the United States, the issue of transportation is becoming more of a problem. With how prevalent personal car ownership is American culture, the number of vehicles on the road are drastically increasing, contributing to a rise in pollution. Aircraft flying overhead also have a large impact on the environment with the sheer amount of people that need to travel long distance for either work or pleasure.

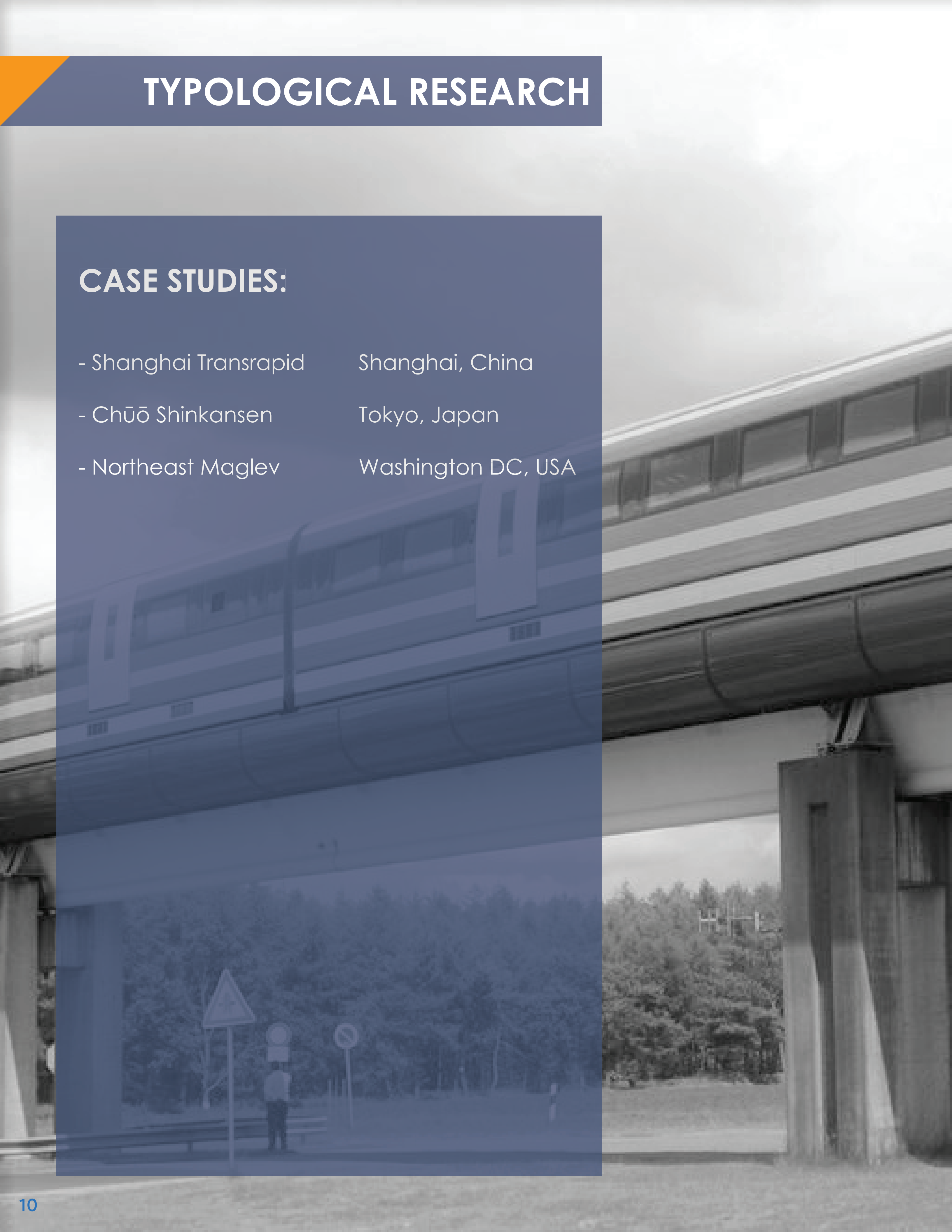
The incorporation of electrodynamic suspension rail systems spanning across the United States will allow a substitute for both automotive and airplane travel by reintroducing a third option for moving people/cargo. This third option for travel will help to reduce pollution caused by car and plane travel by relying primarily on green energy. This thesis research will outline where this new system will be located in order to achieve maximum effectiveness. The research will examine the towns and cities that are the most traveled to in the United States as well as which locations would be conducive to a new high speed rail system.

THESIS NARRATIVE

In the mid 1800's the introduction of the first transcontinental railroad revolutionized the way people travel in the United States. This new railroad line offered an easy and relatively safe way of traveling from coast to coast in the US, beating out steamboats and carriages. The introduction of this rail line had a drastic change in the American industrial complex, allowing for the easy flow of goods and people across the Unites states.

Today, the United States rail system is significantly larger and more connected than it was in the 1800's, but with the creation of the first passenger airline service in 1914 and the US highway system in 1939, the relevance of the rail system for anything other than cargo too heavy and expensive for airplanes has become very apparent. In this new age of innovation, where everything is turning towards renewable and green energy, it is time to look at our aging rail network and consider alternatives such as trains capable of electrodynamic suspension to make it more popular than the two forms of transportation that beat it out in the mid 1900's.

TYPOLOGICAL RESEARCH



CASE STUDIES:

- Shanghai Transrapid — Shanghai, China
- Chūō Shinkansen — Tokyo, Japan
- Northeast Maglev — Washington DC, USA


STOP

SHANGHAI TRANSRAPID

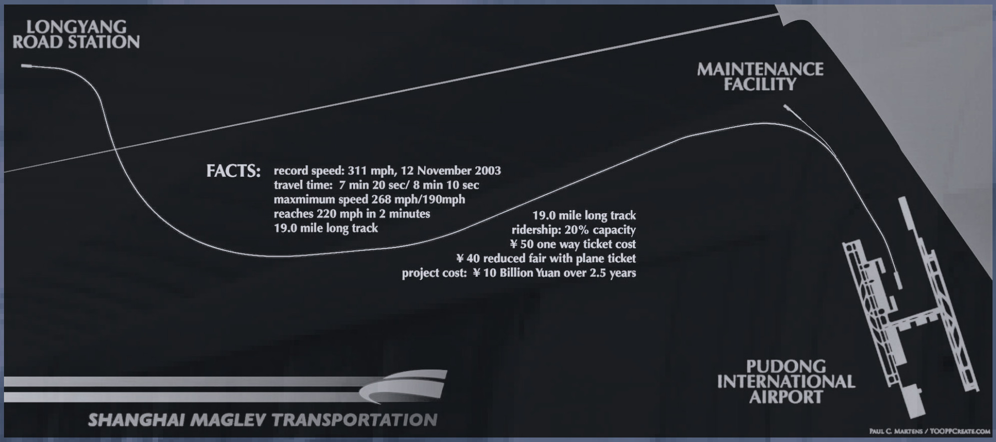
TYPOLOGY: Magnetic Levitation Train Line
LOCATION: Shanghai, China
OPERATOR: Shanghai Maglev Transportation Development Co., Ltd.
DESIGNER: Siemens
STATUS: Completed 2003
LINE LENGTH: 19 Miles

SITE CONTEXT:
Shanghai is a city located in the People's Republic of China and is one of the four cities that is a direct-administered municipality in the country. Originally a small fishing village, due to its location, the town has since turned into a hub for international trade. The city is said to have the 3rd most competitive financial sector in the world and also has one of largest stock markets in the world. In addition to the city's focus on trade and finance, Shanghai also boasts the largest metro network of any city in the world at 462 miles. The closest any other nation that is not China gets is Moscow, Russia at 256 miles.


SMT

SHANGHAI TRANSRAPID

SUMMARY:
Opened to the public in 2003, the Shanghai Maglev Train, otherwise known as Shanghai Transrapid, is the oldest commercial maglev train system still in operation. The rail line runs from Longyang Road Station to Pudong International Airport. Shanghai Transrapid runs on a dual-track guide-way for a total of 19 miles at speeds of up to 268 mph. The rail system runs in 15 minute intervals for 15 hours per day, seven days a week. It takes approximately 8 minutes for it to travel from the start of the rail line to the end.



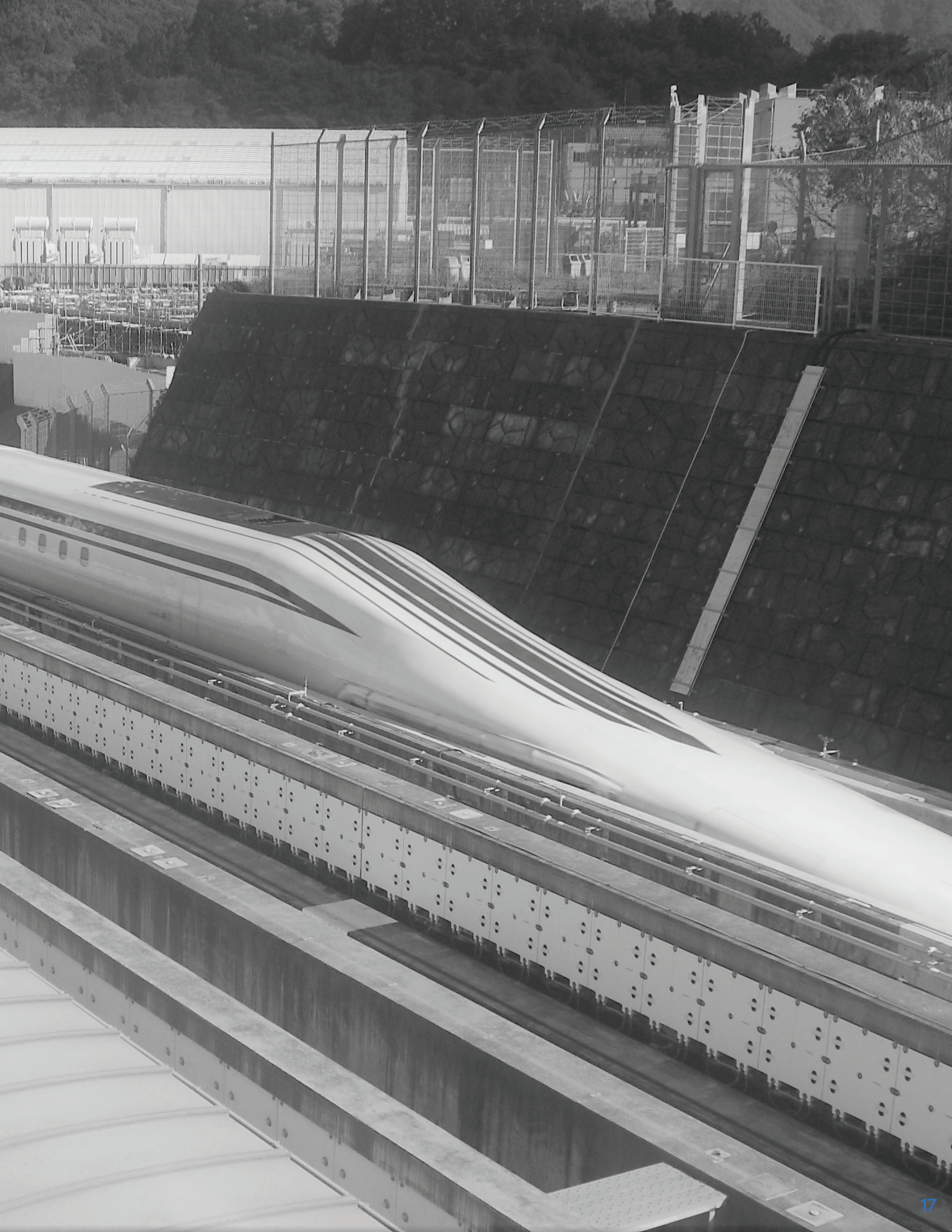
CONTRIBUTIONS/TAKEAWAYS:
The rail line is the oldest running maglev system in the world. With how many people take the system on a weekly basis, Shanghai Transrapid is an excellent example of this system in a highly dense urban environment. Elements of this system have helped to inspire future maglev systems across the globe.


anghai Transrapid

CHŪŌ SHINKANSEN

TYPOLOGY: Magnetic Levitation Train Line
LOCATION: Tokyo, Japan
OPERATOR: JR Central
DESIGNER: Siemens
STATUS: Under Construction, Planned 2037
LINE LENGTH: 177 Miles (Currently 27 Miles)

SITE CONTEXT:
Tokyo is one of the biggest cities in Japan with a population of 14 million not counting the surrounding areas. Like Shanghai, Tokyo also started out as a fishing village, but came to prominence when the government moved there during the 1600's. Post World War II, Tokyo underwent a large reconstruction process that has since turned it into the largest urban economy in the world. The city is also served by a large amount of rail facilities such as light rail, subway and now maglev. Additionally, the city is known as a hub for research and development. In the case of this thesis, they designed the L0 maglev train which currently hold records as the fastest commercial train in the world at 375mph.



CHŪŌ SHINKANSEN

SUMMARY:
Chūō Shinkansen started off as a test track in the Miyazaki Prefecture in Japan at a length of 12 miles in 1990. Over 20 years later, the track was extended by 16 miles and was opened to the public via a lottery system in 2014. The track is currently being extended after a proposal in 2007 to link Tokyo and Nagoya with the rail line extending it to a length of 178 miles. The extension is expected to be finished in 2037.

CONTRIBUTIONS/TAKEAWAYS:
Chūō Shinkansen is currently on the cutting edge of maglev research, having a train that runs off of electrodynamic suspension (EDS) allowing the train to get up to speeds well north of 350mph. Their use of EDS in the L0 train that was created by JR Central has helped to inspire other nations such as America to use the system to replace their aging rail infrastructure.

NORTHEAST MAGLEV

TYPOLOGY: Proposed Magnetic Levitation Train Line
LOCATION: Washington DC, United States of America
OPERATOR: Northeast Maglev, LLC
DESIGNER: Siemens
STATUS: Planned 2028
LINE LENGTH: 206 Miles

SITE CONTEXT:
"The Northeast Corridor is home to 17% of the US population and 20% of US jobs—all on a land area that represents just 2% of the United States. Travel between the major cities of the Northeast Corridor is predicted to increase by 115% by 2040" - Northeast Maglev.

The Northeast Corridor was originally constructed between the 1830's and 1920's by several railroads. Currently it is home to a vast quantity of electrified Amtrak trains and various other commuter rail services. The Northeast Corridor carries an average of 2,200 trains every day.

NORTHEAST MAGLEV

SUMMARY:
Given that maglev technology is a fairly new technology, many of the rail lines in existence are either proposals or concepts. Northeast Maglev's proposal is slightly further than both of those and is actually currently in development with Phase I of their rail line set to be constructed by 2028. The maglev system is extremely similar to that of Chūō Shinkansen's with both using L0 Series maglev trains, but in this case is meant to be operated overseas in North America. The rail line is expected to run up the Northeast Corridor from Washington D.C. to New York City.

CONTRIBUTIONS/TAKEAWAYS:
With this rail line being the largest rail line of the three case studies and in North America, this proposed rail line is an extremely good example for building new rail systems in the United States and the difficulties that arise from it. Additionally, the points that Northeast Maglev address resonate with this thesis projects own goals in that they are both trying to reduce pollution and update the United States aging rail infrastructure.

TYPOLOGICAL RESEARCH TAKEAWAYS

The creation of a new rail system will always have some issues that might come up during construction. These three case studies were chosen due to their significance in the transportation industry. In breaking down the case studies, several key points can be presented for future designs. These key points are:

FOCUS ON USER EXPERIENCE:
Many people tend to be wary of new inventions especially in the transportation sector. When designing the rail system, strategies for bringing people into the building and making sure they have a pleasant experience should be heavily considered. This is especially true if this system is meant to compete with cars and planes for travel.

BEWARE OF COSTS:
When designing with a system as new as maglev, cost is a massive factor in the design. In order to drive costs down, multiple strategies will have to be considered in order to prevent large amounts of money from being spent when they do not have to. An example of this would be avoiding tunnels if possible.

PLAN IN PHASES:
With a project as large as this one certain areas will have to have existing infrastructure removed or replaced. Construction often creates a lot of headaches for your average person due to circulation being disrupted and creating traffic. It is imperative that each phase happens quickly not only to get the system running as quickly as possible, but to prevent intrusion onto everyone’s daily life.

BE MINDFUL OF FUTURE ADVANCES IN TECHNOLOGY:
With maglev being a newer technology, it is very likely that certain systems will be outdated by the time the project is finished. In order to mitigate this, the project should be planned with this in mind so that any new technologies can seamlessly integrate into the existing system.

PROJECT JUSTIFICATION

At the start of my educational career, back in grade school, I developed an interest in trains during a science fair project I did on the TR08 maglev system. Now, after interning at an architecture firm for the last few years, I have acquired a greater interest in the transportation sector through architecture. These two experiences have led me to my thesis subject on Electrodynamic Suspension as a way to wrap up my education.

The rail system in the United States has been around for over 150 years at this point and has rose and fell numerous times based on technological innovations at the time. Currently, national rail travel is considered inferior to both car and plane travel. Part of this has to do with cultural movements since then, but it also has to do with the experience provided compared to the other two methods. Electrodynamic Suspension offers a way to put rail travel back at the top in terms of traveling across the country.

This project is designed to be a proposal of how a national electrodynamic suspension rail system could work in the United States as well as what it may look like. This project is meant to be designed without economic consideration due to the exorbitant costs of this system using our current technology. It is instead supposed to offer an insight into what could be. This project should be able to offer an alternative to existing transportation options and should be able to satisfy the needs of as many users as possible.

Despite the absurdly high costs of a system such as maglev compared to traditional rail, I believe the United States is a perfect testing ground for a project such as this one. There is a vast amount of space that is needed to be covered and an even greater user group for such a concept. The addition of a system such as this one using current technology will be enable passengers to travel at speeds greatly exceeding that of automotive transportation and rivaling that of commercial air travel in terms of time.

MAJOR PROJECT ELEMENTS

ELECTRODYNAMIC SUSPENSION:
The main selling point of the project. Electrodynamic Suspension (EDS) utilizes magnets to propel specialized train cars at speeds approaching that of a commercial airliner. This system will be utilized for its ability to ferry people cross country quickly and its ability to be future-proofed for green systems with the train and tracks using only electricity to operate.

THE US RAIL SYSTEM:
In order to integrate this new rail system into the United States existing infrastructure, the project is going to have to work closely with the United States Department of Transportation and the Federal Railroad Administration. With the project being a public transportation system, it will need to follow these rules and regulations set by these two government entities.

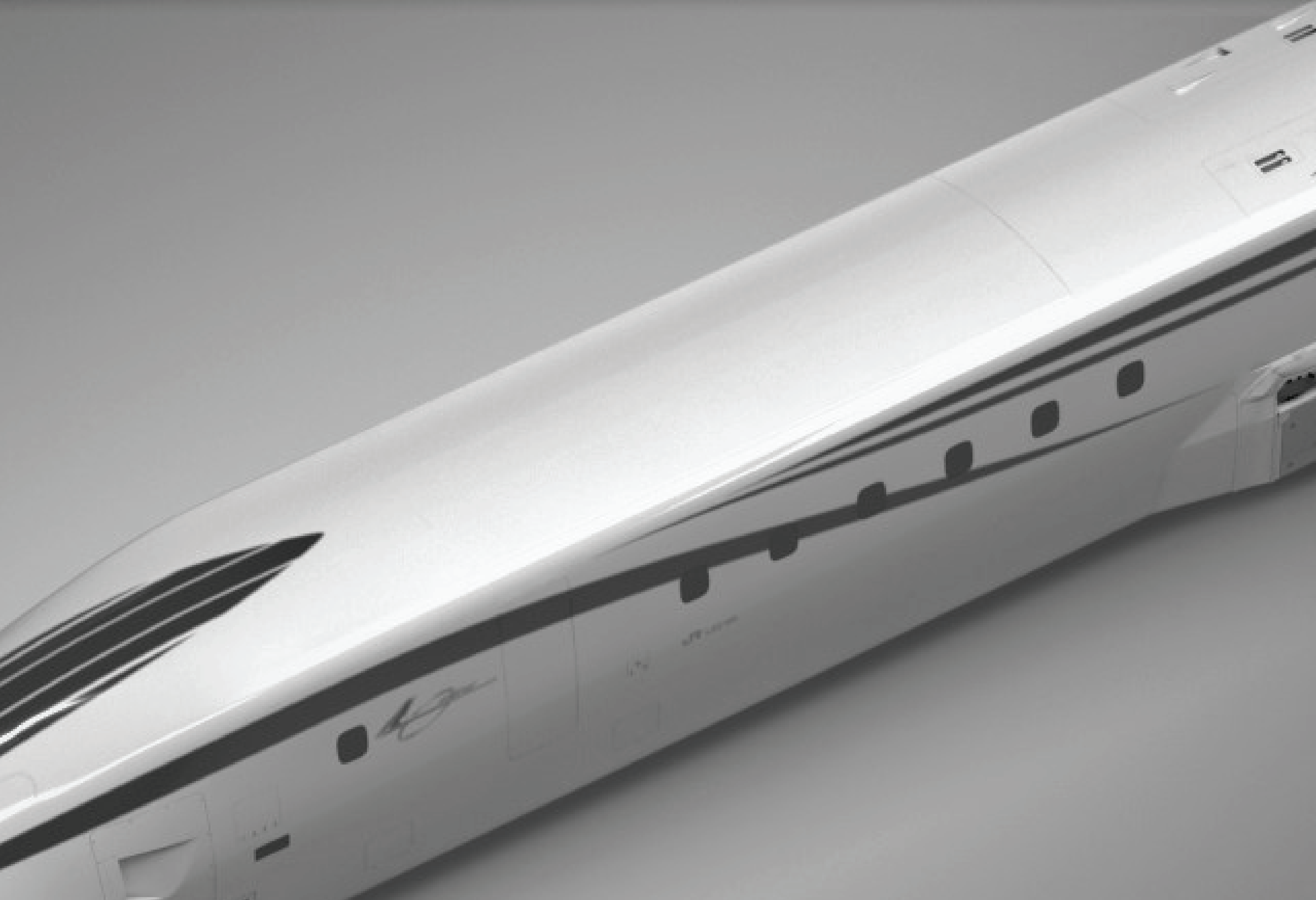
NEW ROUTES:
With this project being a new transportation service, several new routes need to be charted out. Locations will have to be considered in order to help bring in people, but also be in an area that is not cost prohibitive to get to.

NEW INFRASTRUCTURE:
EDS systems operate differently from a normal rail system. Because of this, new track needs to be laid along the route this project chooses. Additionally, methods will have to be considered to help power the track in order to keep the train running at maximum efficiency.

THE CLIENT

The client for my thesis would be the United States Department of Transportation because of this project being on a national scale. With the client being the Federal Government, there are some benefits and downsides. The upside is that if it can be proven to be effective, some funding is guaranteed. Additionally, there is a lot of public input and feedback on how the project is doing. The downsides to this is that the project is at the whims of the government. Sections of the rail line could be delayed due to new rules and regulations, or funding could be cut or heavily reduced at anytime potentially stopping the project.

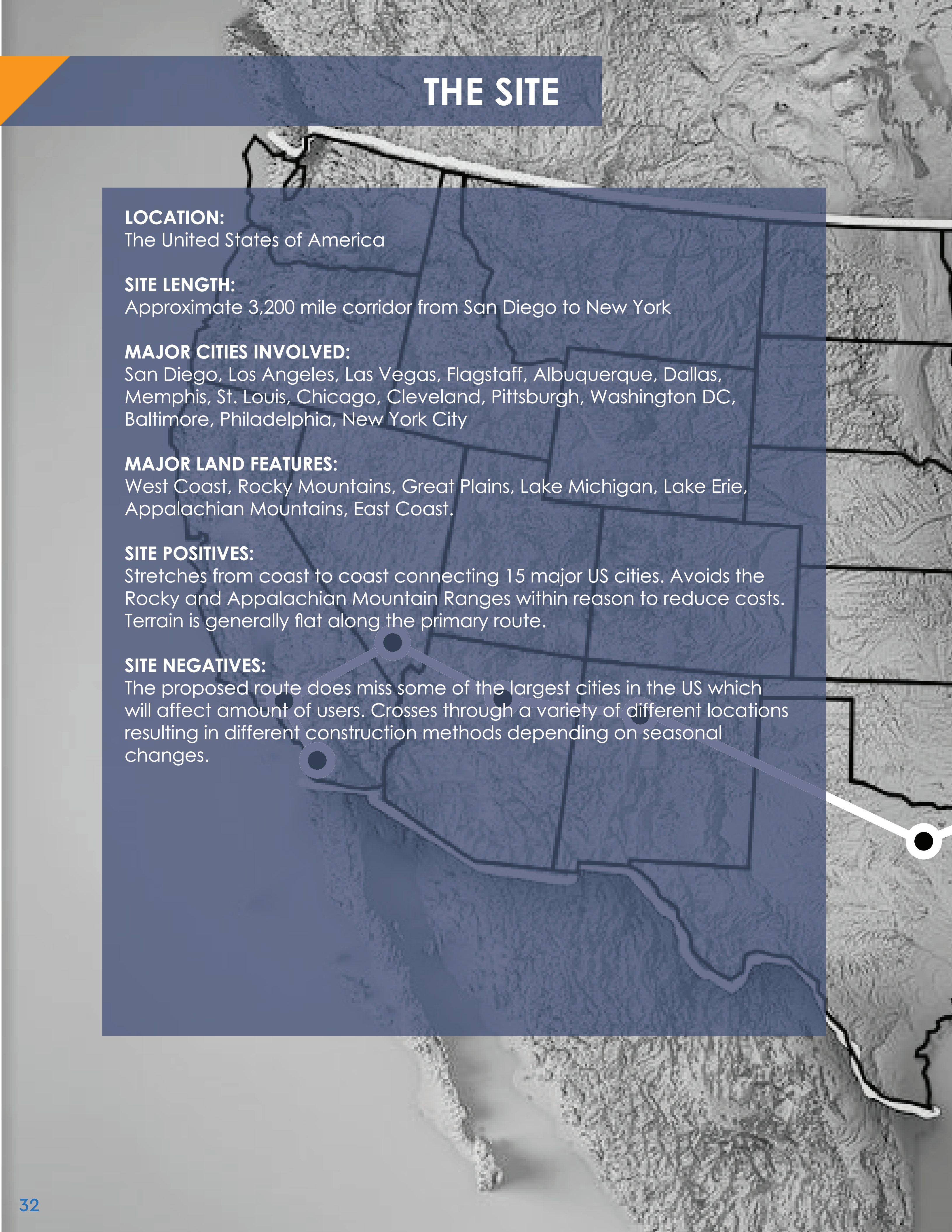
The secondary client would be the Federal Railroad Administration (FRA). The project will have to work closely with this agency to make sure it adheres to all of the rules and regulations of the FRA



THE USER

The users of this new rail system would be the general public. It is expected that the primary users would be separated into two categories: tourists and white/blue collar workers. With the system rivaling air travel, tourism would be a large part of the user group. Whether it be for people traveling to the coastline or just for the experience of traveling on a floating train, tourism will play a large part in the user group. The other primary user group would be the working class. Despite it taking a little more time than an airplane to get to places, it would be a much cheaper option for travel. Businessmen and workers that frequently have to travel across the country for meetings or to get to their job-site will be the largest section of the user group.

THE SITE



LOCATION:
The United States of America

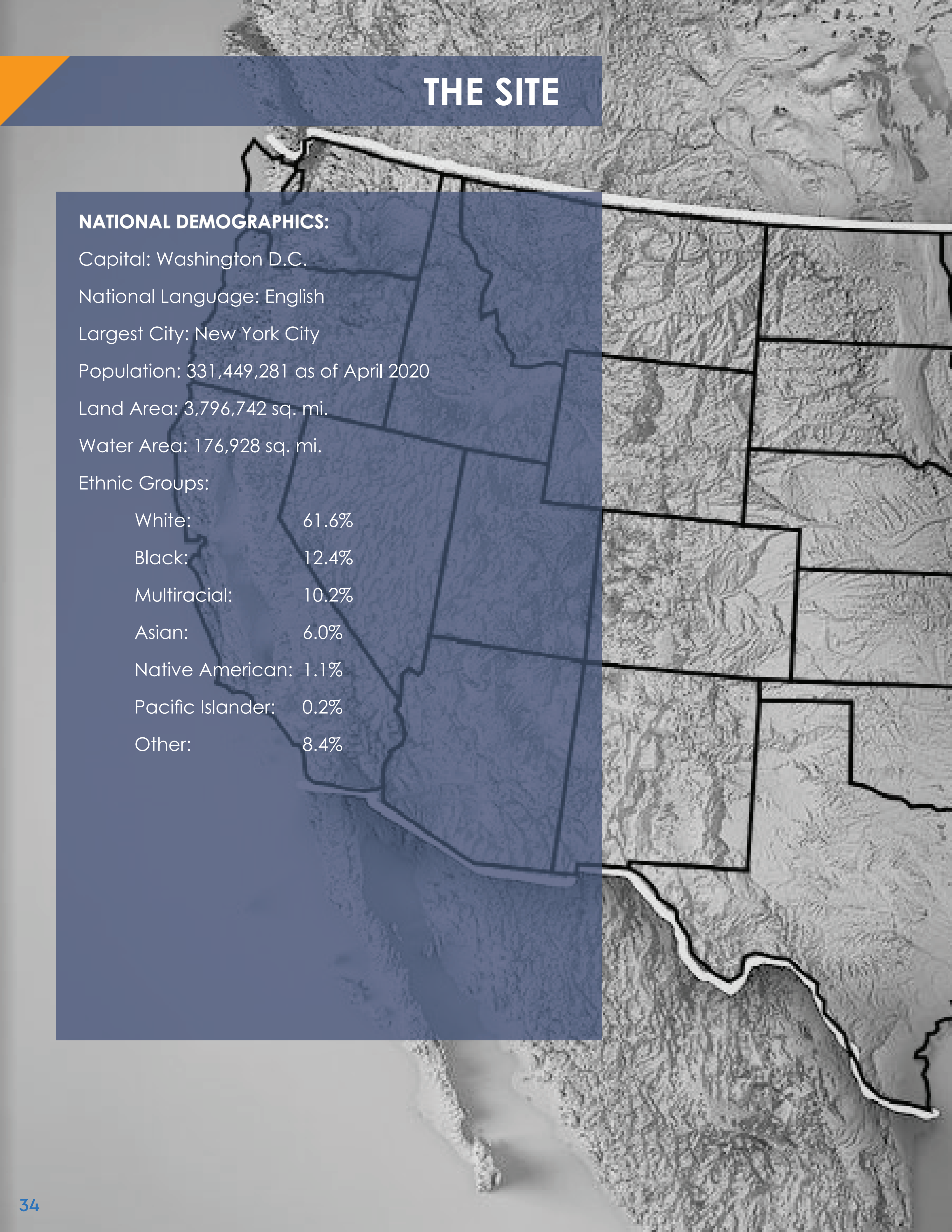
SITE LENGTH:
Approximate 3,200 mile corridor from San Diego to New York

MAJOR CITIES INVOLVED:
San Diego, Los Angeles, Las Vegas, Flagstaff, Albuquerque, Dallas, Memphis, St. Louis, Chicago, Cleveland, Pittsburgh, Washington DC, Baltimore, Philadelphia, New York City

MAJOR LAND FEATURES:
West Coast, Rocky Mountains, Great Plains, Lake Michigan, Lake Erie, Appalachian Mountains, East Coast.

SITE POSITIVES:
Stretches from coast to coast connecting 15 major US cities. Avoids the Rocky and Appalachian Mountain Ranges within reason to reduce costs. Terrain is generally flat along the primary route.

SITE NEGATIVES:
The proposed route does miss some of the largest cities in the US which will affect amount of users. Crosses through a variety of different locations resulting in different construction methods depending on seasonal changes.



THE SITE

NATIONAL DEMOGRAPHICS:

Capital: Washington D.C.

National Language: English

Largest City: New York City

Population: 331,449,281 as of April 2020

Land Area: 3,796,742 sq. mi.

Water Area: 176,928 sq. mi.

Ethnic Groups:

White:	61.6%
Black:	12.4%
Multiracial:	10.2%
Asian:	6.0%
Native American:	1.1%
Pacific Islander:	0.2%
Other:	8.4%

THE SITE

HISTORY:

The United States of America started out as the 13 colonies under British rule. They later declared their independence on July 4th, 1776. Several years afterwards, the nation began moving westward across the continent, either through purchase agreements, trades or conflict. In 1861, the south seceded from the north sparking the American Civil War. Four years later the war ended.

In the 19th century, the US had a period of rapid industrialization with inventions such as riverboats and the transcontinental railroad being highlights of the time. In 1917, the United States entered World War I. The war would later end a year after the US declared war. During this time, the Roaring 20's was going on. Some notable events from this period were prohibition, the creation of jazz and eventually the Great Depression. What brought America out of the Great Depression was World War II. This war went on until 1945 when the US dropped two atomic bombs on Japan forcing their surrender.

From the 1950's onwards, events such as the Cold War and the Civil Rights Movement were prevalent. In 1991, the Soviet Union collapsed, causing an end to the Cold War.

In the 21st century, the War on Terror was started after the events of 9/11. This brought the United States into an invasion of Iraq. Also during this time, the Great Recession began in 2008. This led to several crises making it the worst financial situation since the Great Depression. The recession ended a year later in 2009.

PERFORMANCE CRITERIA

Arguably the most difficult part about the performance criteria of a coast to coast rail system using new technology such as this one is the sheer scale of the project. However, how this scale is dealt with will play an instrumental part in how successful this project is on a local, regional and national level. The initial design is supposed to incorporate fourteen large cities across the continental United States with a train station on the west coast serving as a template for future locations. The station is meant to be divided up into three parts: the commercial area, the boarding platform and the maintenance facility. The most significant parts of the performance criteria will be the environmental impact, the psychological impact and the code compliance. By focusing on these three sections, the project will be extremely successful.

ENERGY CONSUMPTION:
With Electrodynamic Suspension rail systems relying on super-conductive magnets to work properly, a substantial amount of electricity is needed to keep both the trains and track powered. In order to address this issue, I plan on considering energy efficient options in and around the stations the trains stop at. Additionally, I plan on considering having several renewable energy solutions to help reduce the strain that the new rail system will have on the power grid. Most of the power consumption in the stations will go to the following areas:

- Site Lighting
- Interior Lighting
- Display Systems
- Climate Control
- Powered Maintenance Equipment
- The Commercial Area
- The Electrodynamic Rail Lines

ENVIRONMENTAL PERFORMANCE:
With the amount of energy that the station and rail system will consume, sustainable materials will become a huge part in reducing the impact this project will have on the surrounding landscape. I plan on utilizing sustainable materials to strive towards a LEED silver or higher building. When plotting out the route of the EDS rail line, I plan on looking into the areas that the track cuts through to make sure it has as little of an effect on the surrounding ecosystem as possible during construction and daily operation.

ENVIRONMENTAL IMPACT:
The performance criteria of this section correlated directly with energy consumption and environmental performance. The criteria will be set through the research done on these two sections and a response will be formed based on the results. This will allow for a reduced impact on the surrounding landscapes and ecosystems that the rail line travels through. Additionally, existing locations of traditional rail will be located in order to add the new rail line to the old system. This will allow the possibility to save space in certain areas since much of maglev systems are elevated far above the ground. I plan on consulting Amtrak high speed passenger routes for areas where rail can be added onto and the National Environmental Policy Act (NEPA) for areas where new routes have to be created.

PSYCHOLOGICAL IMPACT:
The psychological impact will be directly influenced by the design of the stations where you board the rail line. Additional information will be acquired by studying existing successful rail facilities in order to bring in riders and give a good impression on this relatively new technology that maglev is based on. Design strategies will have to be considered to make people want to use a technology that seems like it has been pulled straight out of the future.

PERFORMANCE CRITERIA

CODES:
I plan on utilizing the respective codes of each city that the electrodynamic rail line passes through in order to set the performance criteria for the design. Existing rail depots and stations will be considered for reference as needed to ensure a safe and accessible experience for any and all passengers who choose to take the rail line.

COST:
This is the simultaneously the most and least important section of the performance criteria categories. Considering modern maglev technologies are over five times the cost of traditional rail systems, the idea of a coast to coast EDS rail system is almost imaginary with current technology. However, I plan on utilizing cost effective systems to help earn back the initial cost of such a system. Cost effective materials and design strategies will be considered in the design of the stations.

OVERVIEW:
The creation of a system as complex as a new rail system using cutting edge technology is the most difficult part of this design process. The sheer size of the proposed line dwarfs even the largest of maglev lines ever constructed. Without any references on a line this big, it is difficult to judge how successful a project such as this may be. However how successful the proposal is depends on categories such as the environmental impact, the psychological impact and the code compliance. The environmental impact will help reduce the effect that the system has on the surrounding landscape. The psychological impact will help bring in passengers to use the system. Finally, the code compliance will make sure that the system is grounded in reality and allows anyone to use the rail line in utmost safety. These three categories will be able to tell us if it is worth considering a concept as large as this one.

SPACE ALLOCATION - MICRO

The following sections represent elements that are to be present in the major train stations at the fourteen large cities throughout the main route. Depending on location, some of these categories may not be present due to seasonal weather or cultural influence.

PUBLIC TRANSIT (OUTSIDE OF STATION):
- Boarding/drop off areas
- Parking
- Lighting/signage
- Seating areas
- Vegetation
- Utilities

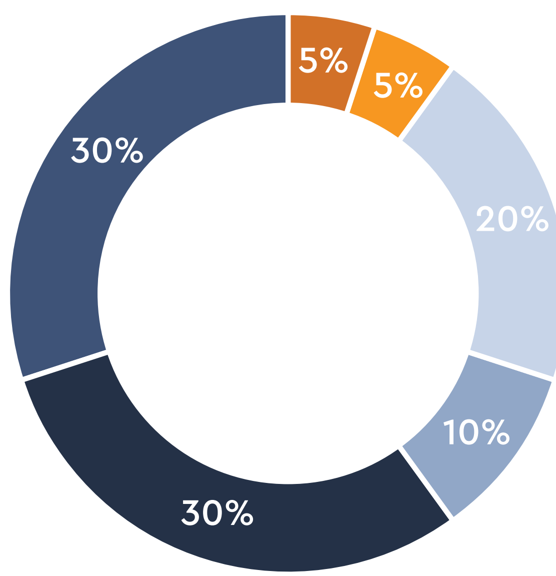
ENTRANCE:
- Lighting/signage
- Seating areas
- Vegetation
- Attractions
- Passive systems
- ADA accessibility
- Utilities

COMMERCIAL AREA:
- Lighting/signage
- Seating areas
- Vegetation
- Vendors
- Passive systems
- Bathrooms
- ADA accessibility
- Utilities

PUBLIC GATHERING SPACE:
- Lighting/signage
- Seating areas
- Water features
- Attractions
- Vegetation
- Event space
- Utilities
- Information center

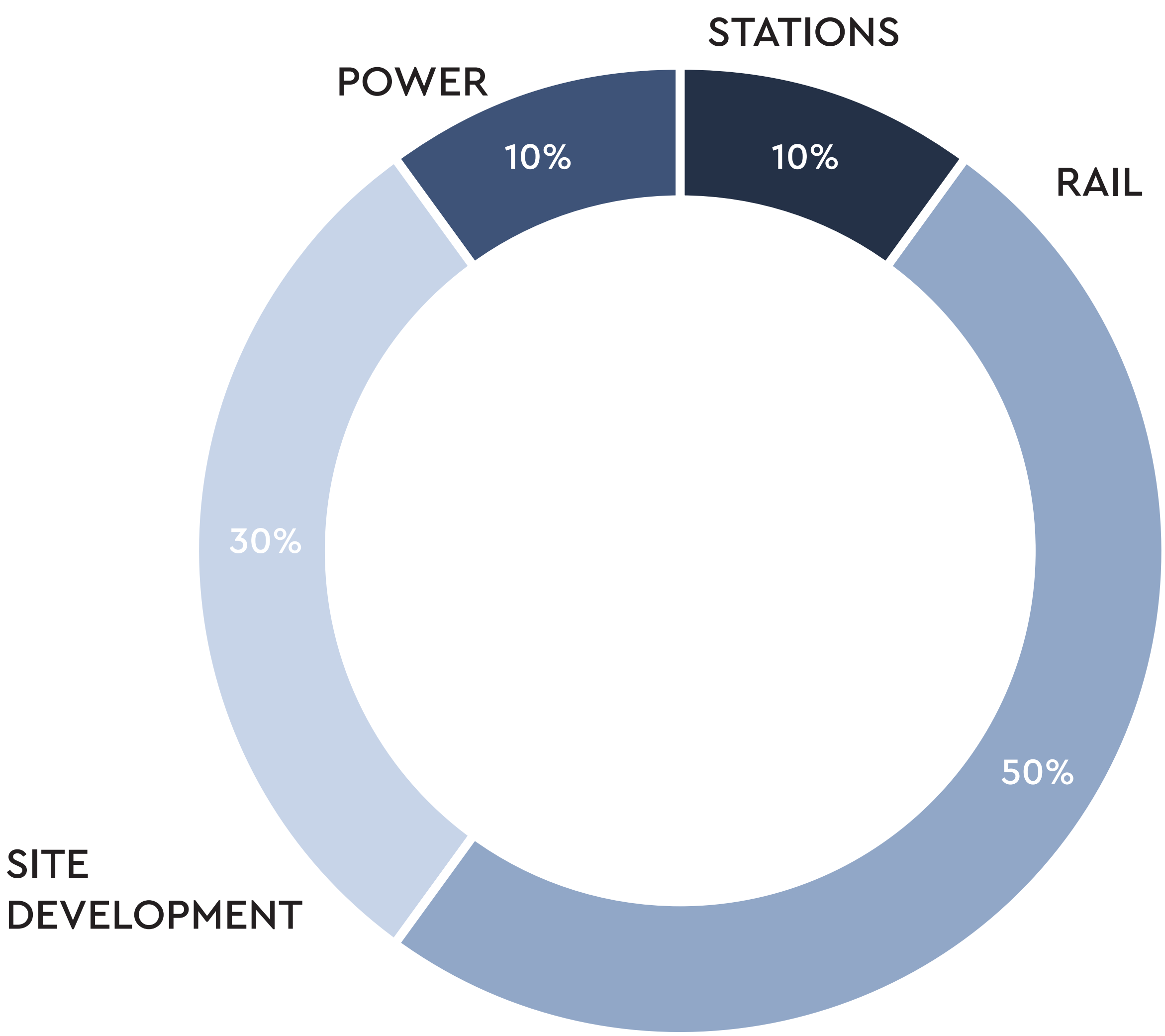
PUBLIC TRANSIT (INSIDE OF STATION):
- Boarding/drop off areas
- Lighting/signage
- Seating areas
- Ticket gates
- Ticket offices
- Security offices
- Vegetation
- Bathrooms
- ADA accessibility
- Utilities

REPAIR DEPOT:
- Lighting/signage
- Tool rooms
- Car storage
- Lifts
- Welding areas
- Parts storage
- General storage
- Work areas
- Loading dock
- Offices
- Bathrooms
- Utilities



SPACE ALLOCATION - MACRO

The following chart represents general elements that are to be present along the 3,200 mile corridor that this thesis is proposing. Depending on location, some of these categories may not be present due to seasonal weather or cultural influence.



LITERATURE REVIEW

Technical Assessment of Maglev Concepts - Final Report by the Government Maglev System Assessment Team

James H. Lever

ABSTRACT

"The Government Maglev System Assessment Team operated from 1991 to 1993 as part of the National Maglev Initiative. They assessed the technical viability of four U.S. maglev system concepts, using the French TGV high-speed train and German TR07 maglev system as assessment baselines. Maglev in general offers advantages that include high speed potential, excellent system control, high capacity, low energy consumption, low maintenance, modest land requirements, low operating costs and ability to meet a variety of transportation missions. Further, the U.S. Maglev concepts could provide superior performance to TR07 for similar cost or similar performance for less cost. They could also achieve both lower trip times and lower energy consumption along typical U.S. routes. These advantages result generally from the use of large-gap magnetic suspensions, more powerful linear synchronous motors, and tilting vehicles. Innovative concepts for motors, guideways, suspension and superconducting magnets all contribute to a potential for superior long-term performance of U.S. maglev systems compared with TGV and TR07".

- James H. Lever, Editor

This document goes into the technical details of the maglev system and its general feasibility in the continental United States. Outside of the introduction which covers history and overview, it is divided up into three main chapters: Characteristics of specific HSGT (High Speed Ground Transportation) concepts, Application of evaluation process, and Overall technical viability of concepts.

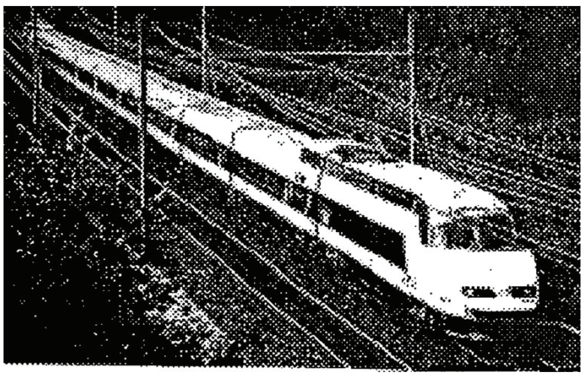
1. CHARACTERISTICS OF SPECIFIC HSGT CONCEPTS:
As a baseline for research, six HSGT concepts were chosen to base the documents findings off of. These six concepts are High-Speed Rail—TGV, Transrapid 07 (TR07), Bechtel, Foster-Miller, Grumman, and Magneplane. Each of the six concepts are further broken down into four sections: Concept, Vehicles, Guideway, and Status. Of these six concepts, TGV and TR07 were used as assessment baselines when comparing traditional to maglev systems.

2. APPLICATION OF EVALUATION PROCESS:
Breaking down the information, the Government Maglev System Assessment Team developed a four step process to evaluate issues such as: the advantages of U.S. maglev vs. foreign alternatives, the suitability to the transportation mission, and the technical approach feasibility. The four step process that was created to address these issues were: Applying the maglev system, Verifying subsystem performance, Verifying system performance, and Applying other criteria.

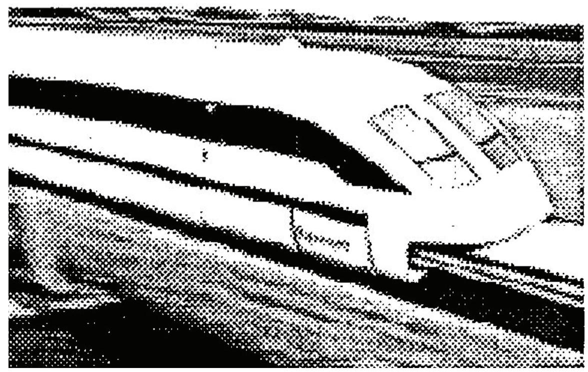
3. OVERALL TECHNICAL VIABILITY OF CONCEPTS:
Relying on information from the previous two chapters, this section compiles the technical research into a summary of the technical viability of the six concepts brought up in Characteristics of specific HSGT concepts. Multitudes of advantages and disadvantages are brought up and discussed. Other subjects such as risks, benefits, technical issues, and performance are brought up and considered.

Technical Assessment of Maglev Concepts - Final Report by the Government Maglev System Assessment Team

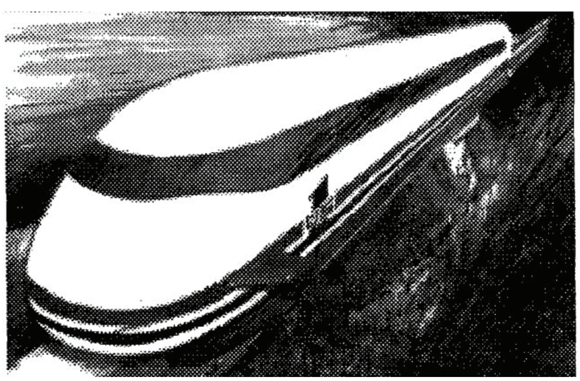
James H. Lever



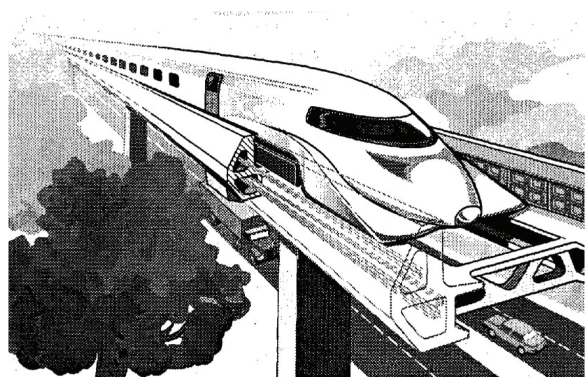
High Speed Rail—TGV



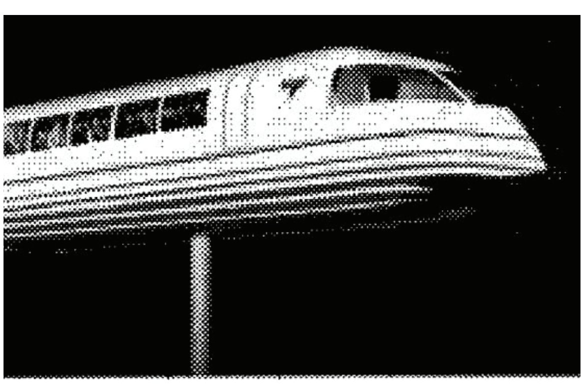
Transrapid 07



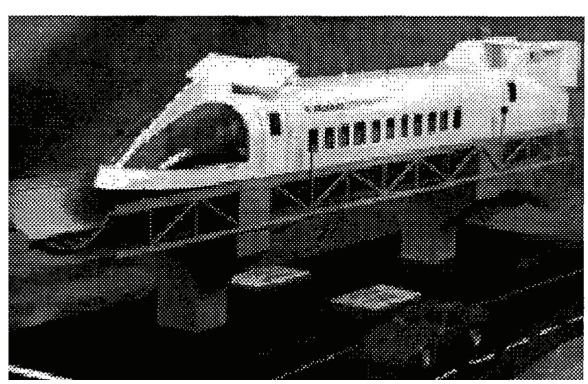
Bechtel Concept



Foster-Miller Concept



Grumman Concept



Magneplane Concept

CHARACTERISTICS OF EXAMPLE HSGT CONCEPTS.

Each of the HSGT concepts chosen for the assessment report have their own unique characteristics that warrant their own section. Listed below are the individual characteristics of each train system.

1. HIGH-SPEED RAIL—TGV:
The TGV train is the only HSGT concept that uses a conventional rail system. It relies on a traditional set of cars, tracks and power systems that are typical with most high speed rail trains.

2. TRANSRAPID TR07:
TR07 is an older style maglev system that runs using an EMS (Electromagnetic Suspension) system. It uses separate pairs of magnets to help generate lift and guide it along the rail. Due to its design, it is capable of levitating at all speeds.

3. BECHTEL CONCEPT:
The Bechtel concept is a type of EDS system that uses flux-canceling to hover. It does this by positioning superconducting magnets on the sides of each car. Like the TR07 train, it also straddles a concrete guideway.

4. FOSTER-MILLER CONCEPT:
The Foster-Miller concept is another EDS system, but instead of straddling a rail, it sits in a guideway. It works very similar to the L0 train system that is used at the Chūō Shinkansen test track.

5. GRUMMAN CONCEPT:
The Grumman concept is a type of EMS system that looks very similar to the TR07 rail cars. The main difference is that the Grumman design sits on a Y-shaped guideway as opposed TR07's T-shaped guideway.

6. MAGNEPLANE CONCEPT:
The Magneplane concept is a single vehicle EDS testbed that sits in a semicircle guideway lined with magnets. It uses this trough-shaped guideway to allow centrifugal force to allow the cars to bank whenever it enters a turn.

Of the six concepts, only two of them were ever in actual service outside of a test track. Those two are the High Speed Rail—TGV and the Transrapid 07 trains. It is for this reason that they were benchmarked against each other in the report.

Technical Assessment of Maglev Concepts - Final Report by the Government Maglev System Assessment Team

James H. Lever

Table 24. Summary of system criteria assessment.

Parameter	*Weight*	*TGV-A*	*TR07*	*Bechtel*	*Foster-Miller*	*Grumman*	*Magneplane*
System							
Speed	3	–1	1	1.2	1.2	1.2	1.2
Capacity	3	1.2	1.2	1	1.2	1.2	1.2
Ride comfort	3	1	1	0	1	1	1
Noise/vibration	0	—	—	—	—	—	—
Magnetic fields	3	1	1	1	1	1	1
Weather	2	1	1	1	1.2	1.2	1.2
Controls	3	1	1	1	1	1	1
Safety	3	1	1	1	1	1	1
Station operation	0	—	—	—	—	—	—
Availability/reliability	3	1	1	1.2	1.2	1.2	1
Aesthetics	0	—	—	—	—	—	—
Communications	0	—	—	—	—	—	—
Human factors	0	—	—	—	—	—	—
Subtotal	23	18	24	21	25	25	25
Vehicle							
Capacity	2	1	1	1	1	1	1
Braking	3	1	1.2	1.2	1.2	1.2	1.2
Structural integrity	0	—	—	—	—	—	—
Onboard power	3	1	1	-1	1	1	1
Emergency syst.	0	—	—	—	—	—	—
Instr./controls	3	1	1	1	1	1	1
Sanitary facilities	0	—	—	—	—	—	—
Subtotal	11	11	12	6	12	12	12
Guideway							
Structural integrity	3	1	1	1	1	1	1
Configuration	2	–1	1	1	1	1	1
Structure	3	1	1	1	1	1	1
Entry/exit	3	1	1	1	1.2	1	1.2
Instr./controls	3	1	1	1	1	1	1
Tunnels	0	—	—	—	—	—	—
Power systems	3	–1	–1	1.2	1	1	1
Superelevation	2	1	1	1	1	1	1
Subtotal	19	9	13	20	20	19	20
Total	53	38	48	46	56	56	56

Based off of the information listed in the report, maglev systems provide substantial benefits over traditional rail. The exceptions not listed in this table being initial cost and construction.

THOUGHTS:

This technical document presented detailed information on five different maglev systems and benchmarked them against traditional high speed rail. In the paper, it gave specific advantages and disadvantages for both systems. Based off of the paper’s findings, traditional rail is currently the better option based off of initial cost and development. However, if and when maglev technologies mature enough, they have a greater long term potential than traditional rail with significantly superior performance at a lower cost.

Since this thesis project is hypothetical in nature, this technical document helps to ground the project in reality. Once the initial cost of maglev goes down, there is not much benefit a traditional rail system can provide over it. Sometime in the future, we may end up seeing some existing rail systems being converted to a maglev design once the technology becomes more widespread.

LITERATURE REVIEW

High-Speed Ground Transportation Noise and Vibration Assessment: Final Report

Carl E. Hanson, Miller Harris, Miller & Hanson Inc.

ABSTRACT
"This report is the second edition of a guidance manual originally issued in 2005, which presents procedures for predicting and assessing noise and vibration impacts of high-speed ground transportation projects. Projects involving high-speed trains using traditional steel-wheel on steel-rail technology as well as magnetically levitated (maglev) systems are included. Procedures for assessing noise and vibration impacts are provided for different stages of project development, from early planning through preliminary engineering and final design. For both noise and vibration, three levels of analysis are described including a preliminary impact screening, a general assessment and a detailed analysis. This updated guidance contains models for predicting high-speed train noise and vibration as well as criteria for assessing the
magnitude of potential impacts. A range of mitigation measures are described for dealing with adverse noise and vibration impacts. There is a discussion of noise and vibration during the construction stage and also a discussion of how the technical
information should be presented in the Federal Railroad Administration's environmental documents. This guidance will be of interest not only to technical specialists who conduct the analyses but also to project sponsors, Federal agency reviewers, and members of the general public who may be affected by the

This document goes into the technical details of the noise and vibration impacts of high speed ground transportation projects. It covers systems such as traditional steel-wheel on rail and maglev designs. The document is divided up into eleven chapters, but can be divided up into primarily three sections: Basics of HSGT noise, Noise impact analysis, and Vibration impact analysis.

1. BASICS OF HSGT NOISE:

High speed train systems are defined primarily as a train that is capable of speeds in excess of 125 mph. As a result of the systems that are being assessed in the report, the train systems are divided into three sections based on speed: 125+ mph, 250+ mph, and 300+ mph. The sound coming from these HSGT systems are analyzed in three different parts: noise descriptors, sources, and paths.

2. NOISE IMPACT ANALYSIS:

When considering the noise that can come from a HSGT system, all manner of components must be considered both on and off the train. Items such as the propulsion, the rail/guideway, and the aerodynamics must be considered when assessing the noise that these trains can make. Depending on the location of the system, these vehicles can be a bother for people. As such, the less ambient noise an HSGT system can produce, the better.

3. VIBRATION IMPACT ANALYSIS:

Due to the sheer weight of any train system, the vibrations that are present whenever a train in approaching can be a possible hazard/detriment to surrounding infrastructure and people. When considering the vibrations an HSGT system can produce, geologic and regional conditions provide a large effect on the intensity of said vibrations. These vibrations can be mitigated using clever design features on both the rails and train cars.

High-Speed Ground Transportation Noise and Vibration Assessment: Final Report

Carl E. Hanson, Miller Harris, Miller & Hanson Inc.

TRAINS REFERENCED IN HIGH-SPEED GROUND TRANSPORTATION NOISE AND VIBRATION ASSESSMENT: FINAL REPORT

Amtrak Acela

TGV

Eurostar

X2000

KTX-I/KTX-II

ETR 500/Pendolino

IC T

ICE 3

AVE S103

ETR 450

KTX-III

Rohr RTL-2

TR08

Table 5-2 Noise Source Reference Levels for High-Speed Trains (SELs at 50 ft)									
				Subsource Parameters		Reference Quantities			
System Category and Features [a]	Example Systems		Subsource Component	Length Definition, *len*	Height above rails (ft)	SEL_{ref} (dBA)	len_{ref} (ft)	S_{ref} (mph)	*K*
HS and VHS ELECTRIC LOCOMOTIVE-HAULED TRAINS	Amtrak Acela TGV Eurostar X2000 KTX-I /KTX-II ETR 500		Propulsion	len_{power}	12	86	73	[b]	[b]
			Wheel-rail	len_{train}	1	91	634	90	20
		AERO	Train Nose	len_{power}	10	89	73	180	60
		AERO	Wheel Region	len_{train}	5	89	634	180	60
		AERO	Pantograph	[c]	15	86	[c]	180	60
		(Only include aerodynamic subsources for very high-speed trains above 150 mph.)							
HS and VHS EMU TRAINS	IC T ICE 3 AVE S103 ETR450 KTX-III		Propulsion	len_{power}	2	86	634	[b]	[b]
			Wheel-rail	len_{train}	1	91	634	90	20
		AERO	Train Nose	len_{power}	10	89	73	180	60
		AERO	Wheel Region	len_{train}	5	89	634	180	60
		AERO	Pantograph	[c]	15	86	[c]	180	60
		(Only include aerodynamic subsources for very high-speed trains above 150 mph.)							
HS GAS-TURBINE LOCOMOTIVE-HAULED TRAINS	Rohr RTL-2 Bombardier Jet-Train		Propulsion	len_{power}	10	83	73	20	10
			Wheel-rail	len_{train}	1	91	634	90	20
MAGLEV	TR08		Propulsion	len_{train}	1.5	68	165	90	8
			Guideway/Structural	len_{train}	-5	80	295	90	30
		AERO	Train Nose	[c]	0	61	[c]	90	50
		AERO	TBL [d]	len_{train}	10	78	295	120	50

[a] ***HS*** *(High-Speed)* = maximum speed 150 mph
VHS *(Very High-Speed)* = maximum speed 250 mph
MAGLEV = maximum speed 300 mph
[b] Source level is not adjusted for train speed
[c] Source level is not adjusted for train length
[d] Turbulent Boundary Layer

Maglev, compared to traditional steel-wheel on rail systems are noticeably quieter across the board on all sections. This is one of the advantages that maglev presents over other HSGT systems due to there being zero contact between the train and the track. Due to their design, they are also typically more aerodynamic resulting in less noise as it travels past a point despite traveling significantly faster than its contemporaries.

High-Speed Ground Transportation Noise and Vibration Assessment: Final Report

Carl E. Hanson, Miller Harris, Miller & Hanson Inc.

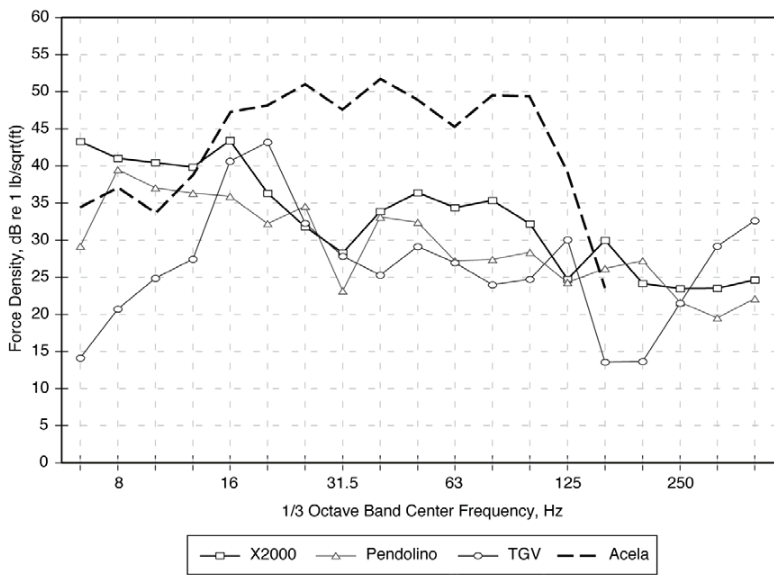


Figure 9-5 Force Densities for High-Speed Trains

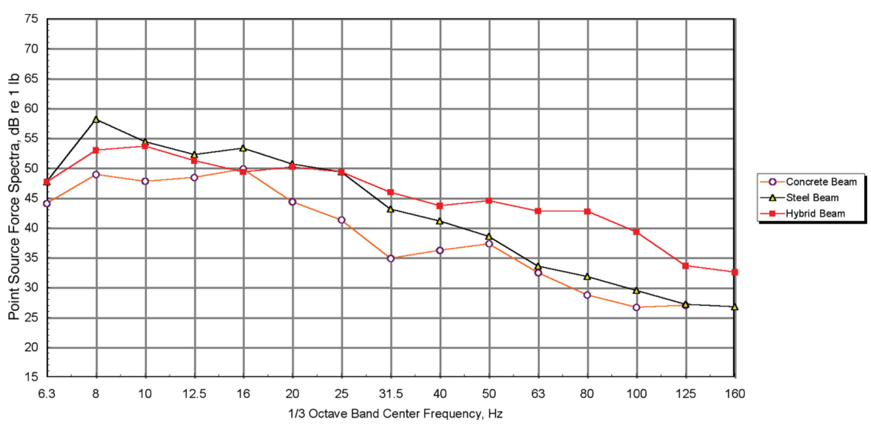


Figure 9-6 Characteristics Force Spectra for the TR08 on Each Type of Guideway

The vibrations produced by the maglev TR08 system compared to the X2000, Pendolino, TGV and Acela systems are very similar in terms of the decibels they put out. The TR08 system is around average with the vibrations it outputs.

THOUGHTS:

The technical document went in-depth into the noises and vibrations that high speed ground transits systems output. Despite having only one type of maglev system, it puts a focus on it throughout the document. When you compare the thirteen HSGT systems present in the report, maglev produces substantially less noise compared to the others even through it operates at a higher average speed. Part of this can be attributed to its frictionless design. When comparing maglev to the other systems in regards to vibrations, it ends up being about average with some of the more popular rail systems producing better results overall.

Noise and vibrations can cause quite a few issues on a thesis project as large as this one. Since it is expected to run through several large and small cities, the amount of noise it produces both during construction and operation is essential to its success. If it produces too much noise, it may cause substantial complaints and make it significantly more difficult to expand the system to other routes in the future.

LITERATURE REVIEW SUMMARY

SUMMARY:
These two literature sources have helped provide insight into the technical side of maglev systems and how they stack up to traditional steel-wheel on rail projects. I plan on using the information gathered on these two technical documents when creating my design solution for this thesis project.

TECHNICAL ASSESSMENT OF MAGLEV CONCEPTS - FINAL REPORT BY THE GOVERNMENT MAGLEV SYSTEM ASSESSMENT TEAM:
This document covers the technical details of the maglev system as a whole and compares it to traditional rail systems. The idea of the report is to gauge the feasibility of introducing maglev to the United States. It achieves this by breaking down six different rail concepts and going over the advantages and disadvantages of each system and well has how the technologies they present may be improved upon. While maglev does provide substantially better performance over traditional rail, it is still a relatively expensive new technology.

This report is extremely important to my thesis project because it provides a broad overview of the advantages and disadvantages of maglev technologies. The information presented in the document provides a footing for my claim that maglev could compete with car and plane if it was implemented.

HIGH-SPEED GROUND TRANSPORTATION NOISE AND VIBRATION ASSESSMENT: FINAL REPORT:

The noise and vibration assessment report goes in depth into how HSGT systems can affect their surroundings. Maglev is one of these systems covered in the report. Compared to standard rail technologies, maglev systems are substantially quieter than their contemporaries despite being able to produce significantly better performance. Despite their sound output however, they are still lacking in the vibrations they produce when moving. Some traditional rail systems are substantially better at lower an higher frequencies.

This report is similar to the first source in the way that it helps to ground my thesis project in reality. Typically, whenever a train is driving past a building you are in, it is quite the annoyance. With maglev systems, it drastically cuts down on this noise which may end up helping to spread the technology to other rail systems outside of the one I am proposing.

CONCLUSION:

These two technical documents have been invaluable in my understanding of maglev and traditional rail systems. With both reports covering the macro and micro of maglev design, they will help to provide information when designing the stations that will be located at each major city along the route I have chosen.

PROJECT EMPHASIS

1. CONNECTING COMMUNITIES ACROSS THE NATION:
In order to reduce the amount of plane and car traffic across the nation, the maglev system has to connect to many cities both large and small. By using site analysis, the best possible route can be determined in order to connect these cities.

2. PROMOTE INCLUSIVE AND SAFE ENVIRONMENT:
New technologies always cause a small amount of unease before their widespread adoption. In the case of something like a nationwide maglev line, this unease will be a potential issue. It will be crucial to focus on dispelling this unease by researching ways to educate people and spread awareness on this type of transportation.

3. FUTURE PROOFING CLEAN ENERGY:
The world is currently trying to make a shift towards green and renewable energy. Current maglev systems are also in the process of making this shift. Locations will have to be researched in order to find suitable spots to power the electromagnetic rail that the train runs on.

4. CREATION OF A NEW RAIL LINE:
Due to the incompatibility between tradition rail and maglev, new rail lines will have to be built. Considering the cost of current maglev systems, specific cities along the proposed route will have to be analyzed to see which ones will receive parts of the line first. As a result the project will be divided up into phases to reflect this situation.


SMT

PROJECT GOALS

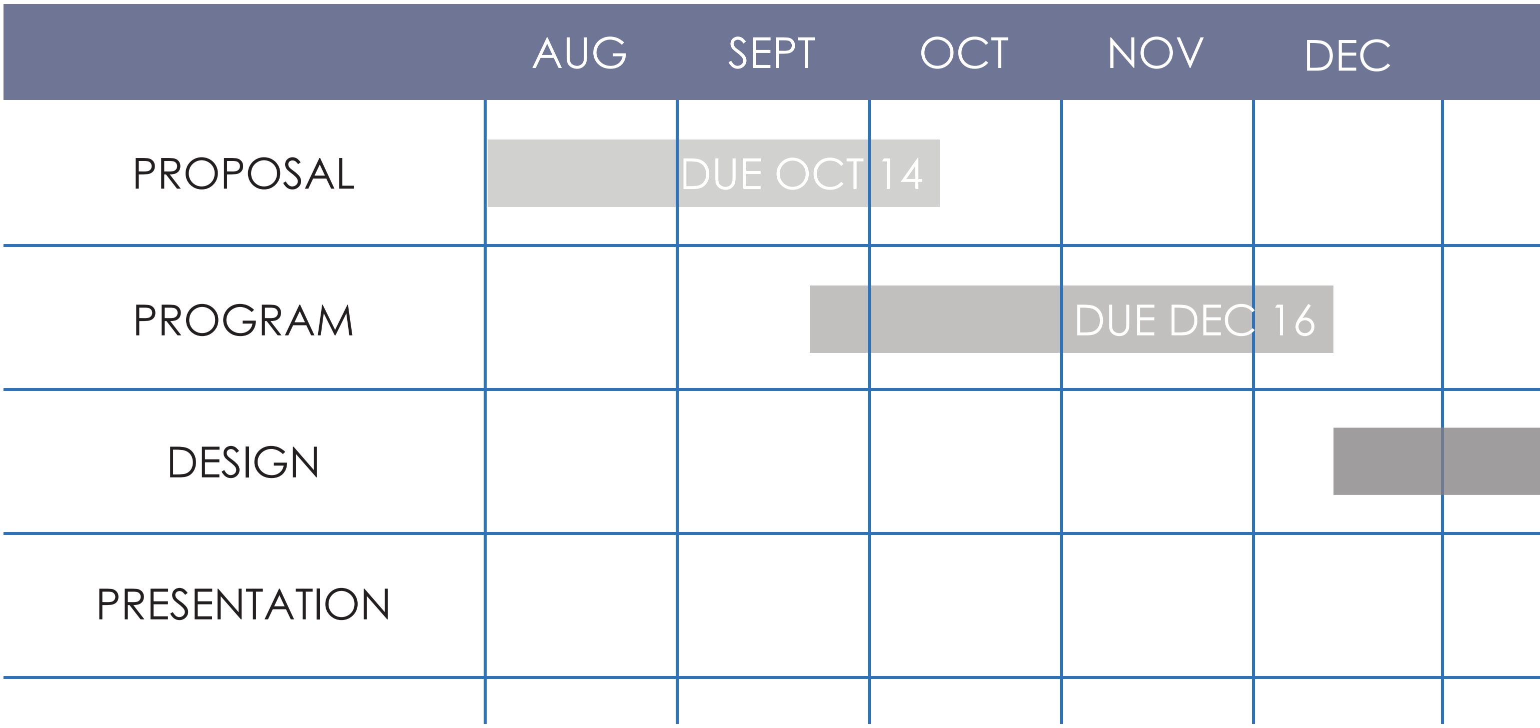
1. REDUCE VEHICLE TRAFFIC:
Determine the amount of traffic that could theoretically be reduced using research and site analysis.

2. PROVIDE AN EASIER AND FASTER FORM OF TRAVEL:
Compare existing timetables from point to point throughout the proposed rail line. By compiling information, an informative list can be constructed that shows the amount of time and money required per transportation option.

3. ANALYZE RAIL LINES FOR NEW ROUTE:
Consider existing rail lines for inspiration on the placement of the new maglev line. By using analytical research, a proper route can be deduced in order to minimize costs and maximize efficiency.


3L

PROJECT SCHEDULE

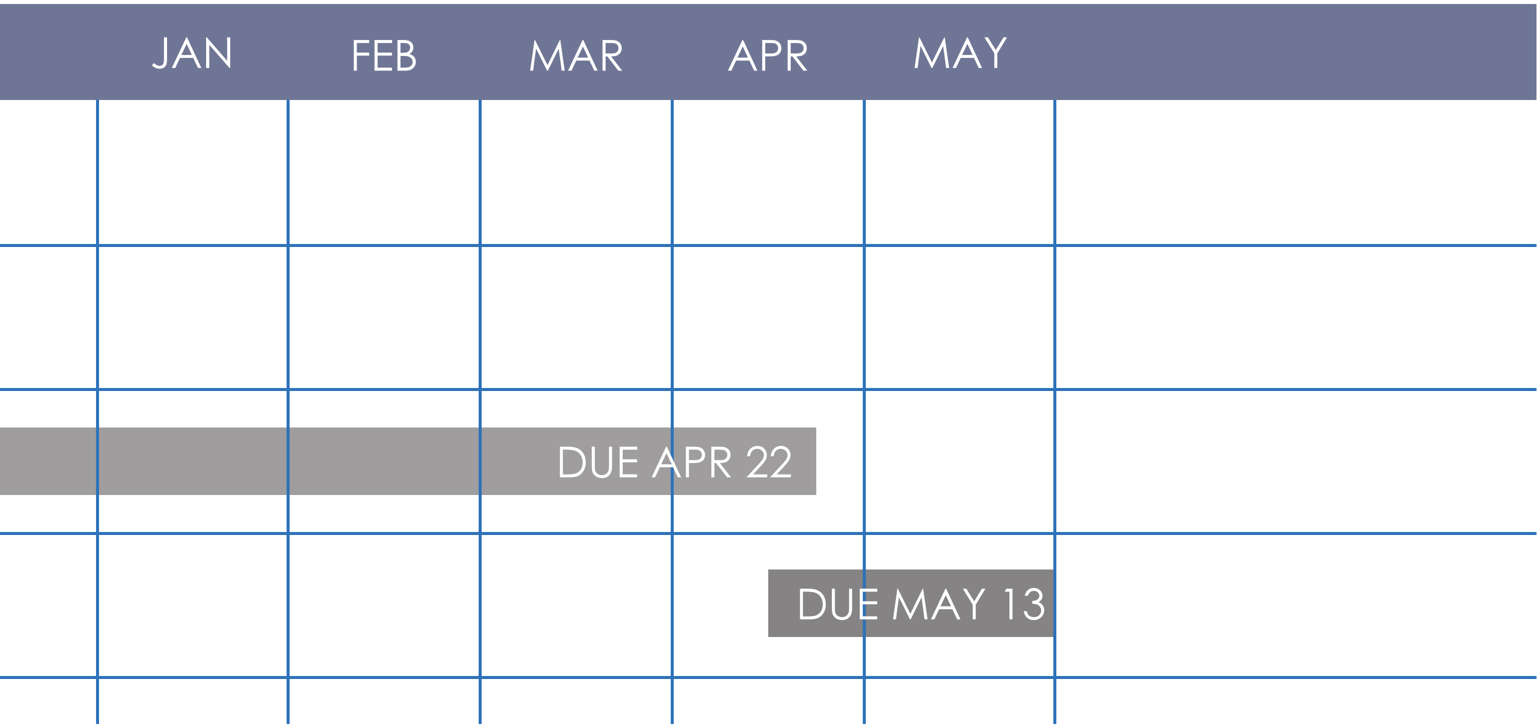


1. PROPOSAL

This phase started at the end of 4th year when we were told to begin thinking about what we want our thesis project to be about. This phase ends on October 14th when the Thesis Proposal Draft is due.

2. PROGRAM

This phase starts once we have our Thesis Proposal Draft completed and our site narrowed down. It continues with the creation of our Thesis Proposal Book, the site analysis, and the thesis research



3. DESIGN

This phase is marked by the end of our thesis research. Afterwards, we start on the creation of our design based of our prior research. It is during this phase that we construct and finalize our models and presentation boards.

4. PRESENTATION

This final phase is where we present our final thesis project both orally and digitally. This phase begins on the 22nd of April with our digital copies being due and ends on the 13th of May with our Thesis Books being due.

PRESENTATION INTENTION

In order to accurately present the research and ideas brought about by this thesis, a variety of mediums will be used. These mediums will include a variety of methods such as:

1. THE THESIS BOOK:
This document will include not only the thesis proposal, but also the thesis program, analytical research, and the final design concept and solutions.

2. PROJECT BOARDS:
One of the two ways the thesis project will be presented is with a pair of project boards. These boards will include a variety of graphics and information relating to the final design and may be used in conjunction with the thesis presentation mentioned below.

3. DEMONSTRATIVE MODEL:
In order to showcase maglev technology, a small model will be constructed consisting of a magnetic rail and a "train" to run on top of it. This model will be designed to be interactive so people can move the car along the rails to see the maglev effect in action.

4. PHYSICAL MODEL:
A physical model will also be constructed of one of the stations that the rail system will connect to. This will be included with the project boards and demonstrative model to convey design elements.

5. THESIS PRESENTATION:
The research findings will be presented both orally and digitally. This presentation will utilize the previous four elements to explain the thesis process and finalized design solution.

PLAN FOR PROCEEDING

The overall plan for my thesis project is to follow a rigid schedule with frequent deadlines in order to stay on to of work. Similarly to how this thesis project would be constructed in real life, I plan of doing it in phases. With the amount of work that needs to be done on this project, it is imperative that I stick to this schedule and set realistically achievable goals.

After the finalized proposal is submitted, I plan on looking into the analytics and graphs set up by the owners of EDS maglev systems. This research will help guide my project and help create a stronger starting point for this project to take off from.

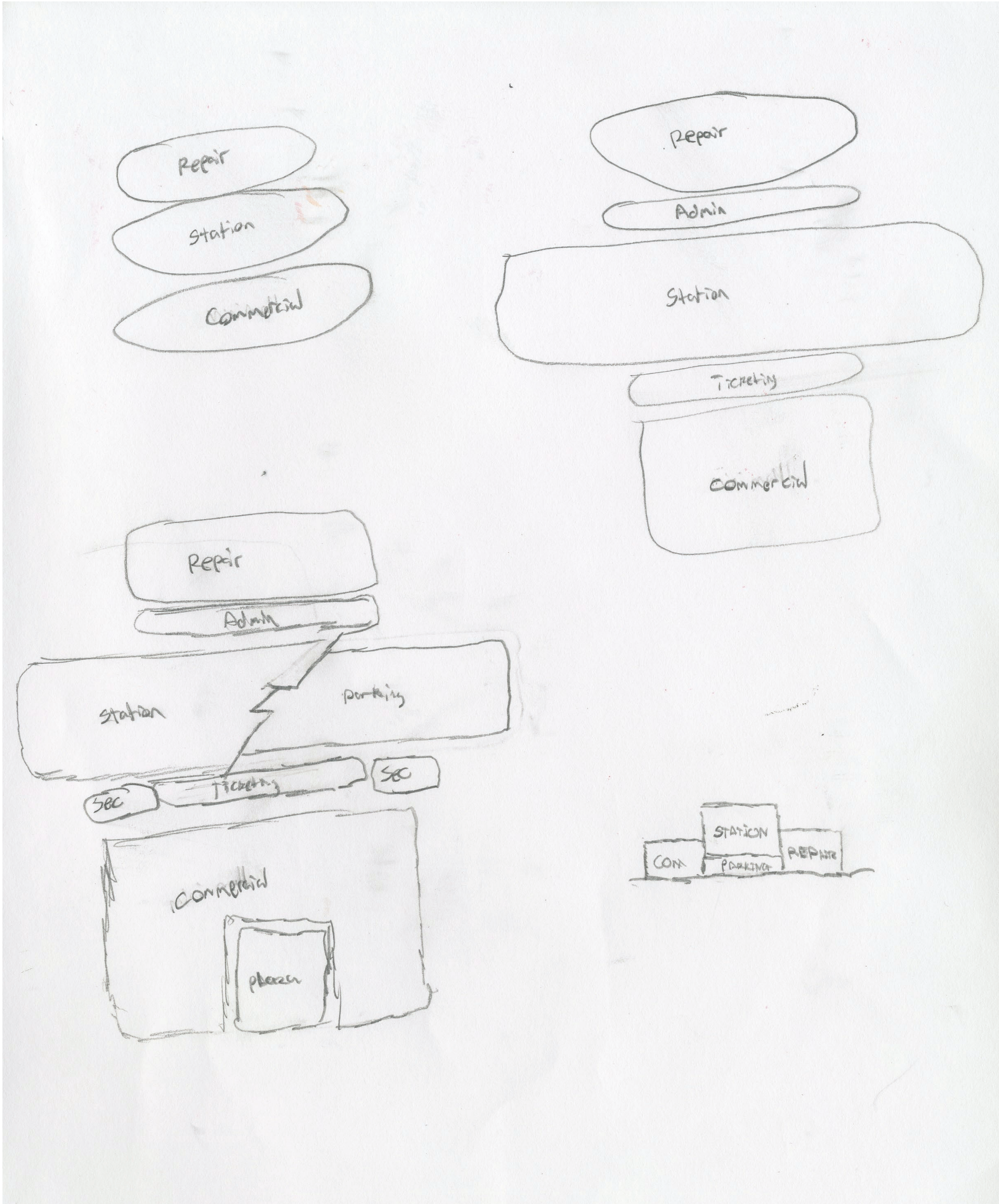
During the research phase, I will pick one of the major cities as a starting point to construct the first maglev station which will be used as a template for future ones along the route. A thorough examination of the site and surrounding area will be required before any design is started.

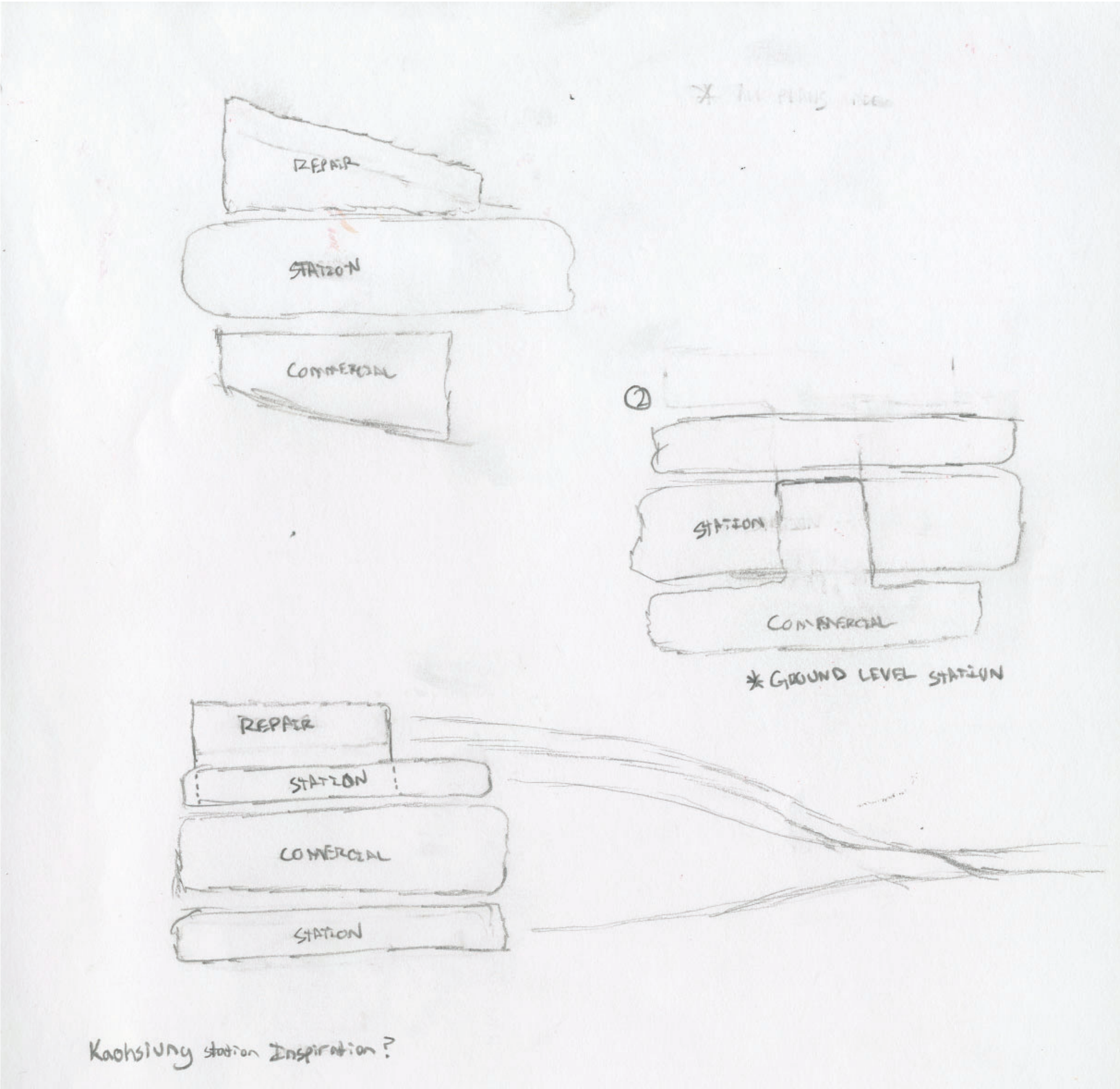
After the research phase is completed , I will begin work on a design solution set at that initial starting point. This solution will is planned to be a full service station consisting of a commercial area, the station, and a repair center for the trains.

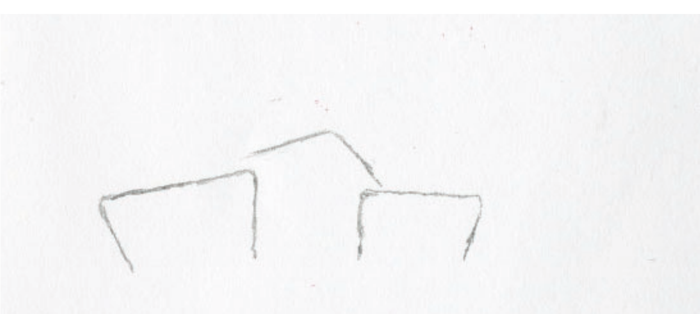
Once the design phase is nearing completion, I will begin the design an layouts of the presentation boards. This will require various graphics and writing strategies in order to explain the full design process and solution.

DESIGN SOLUTION

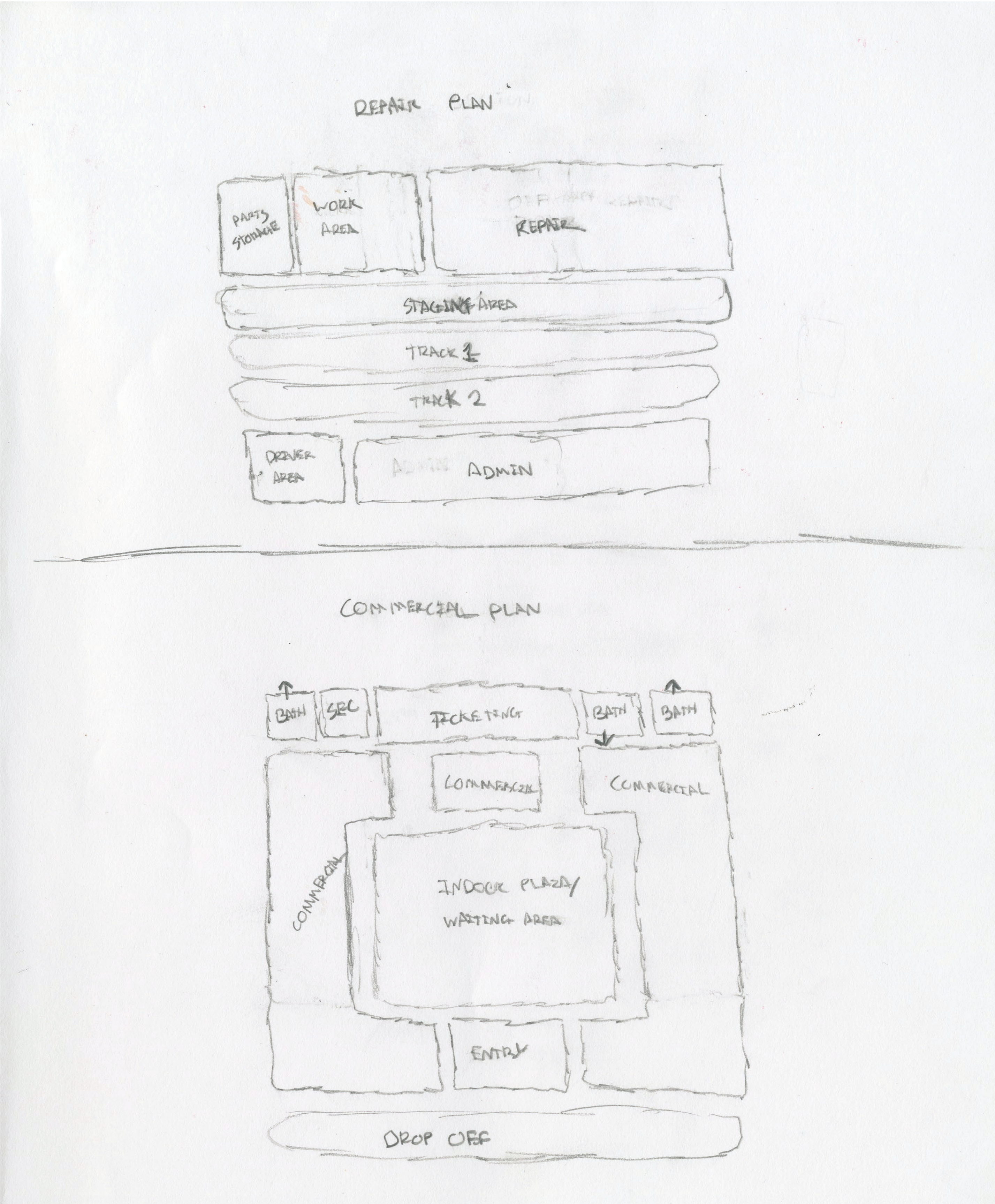
PROCESS DOCUMENTATION

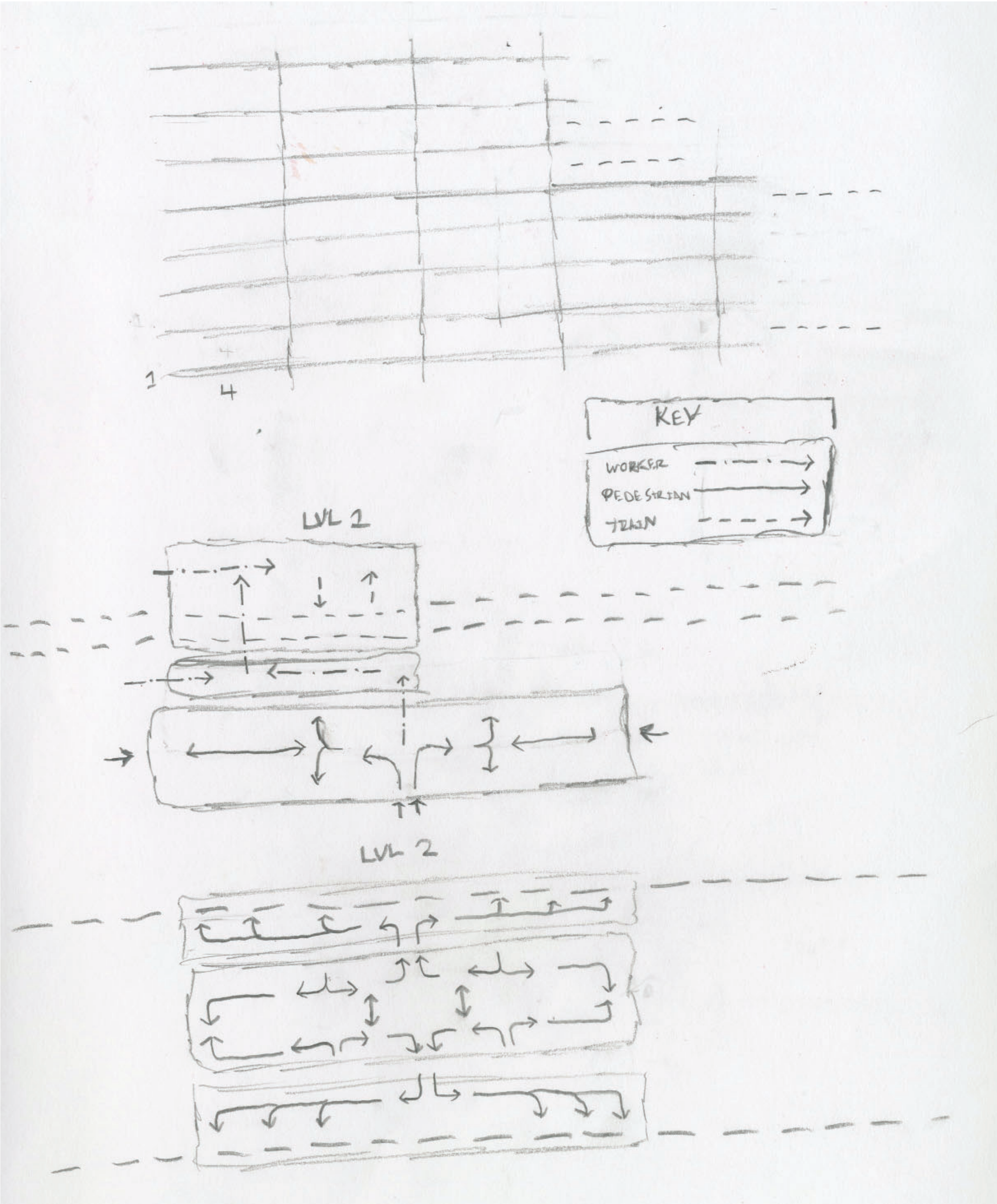



REPAIR
STATION
COMMERCIAL
②
STATION
COMMERCIAL
* GROUND LEVEL STATION
REPAIR
STATION
COMMERCIAL
STATION
Kaohsiung station Inspiration?

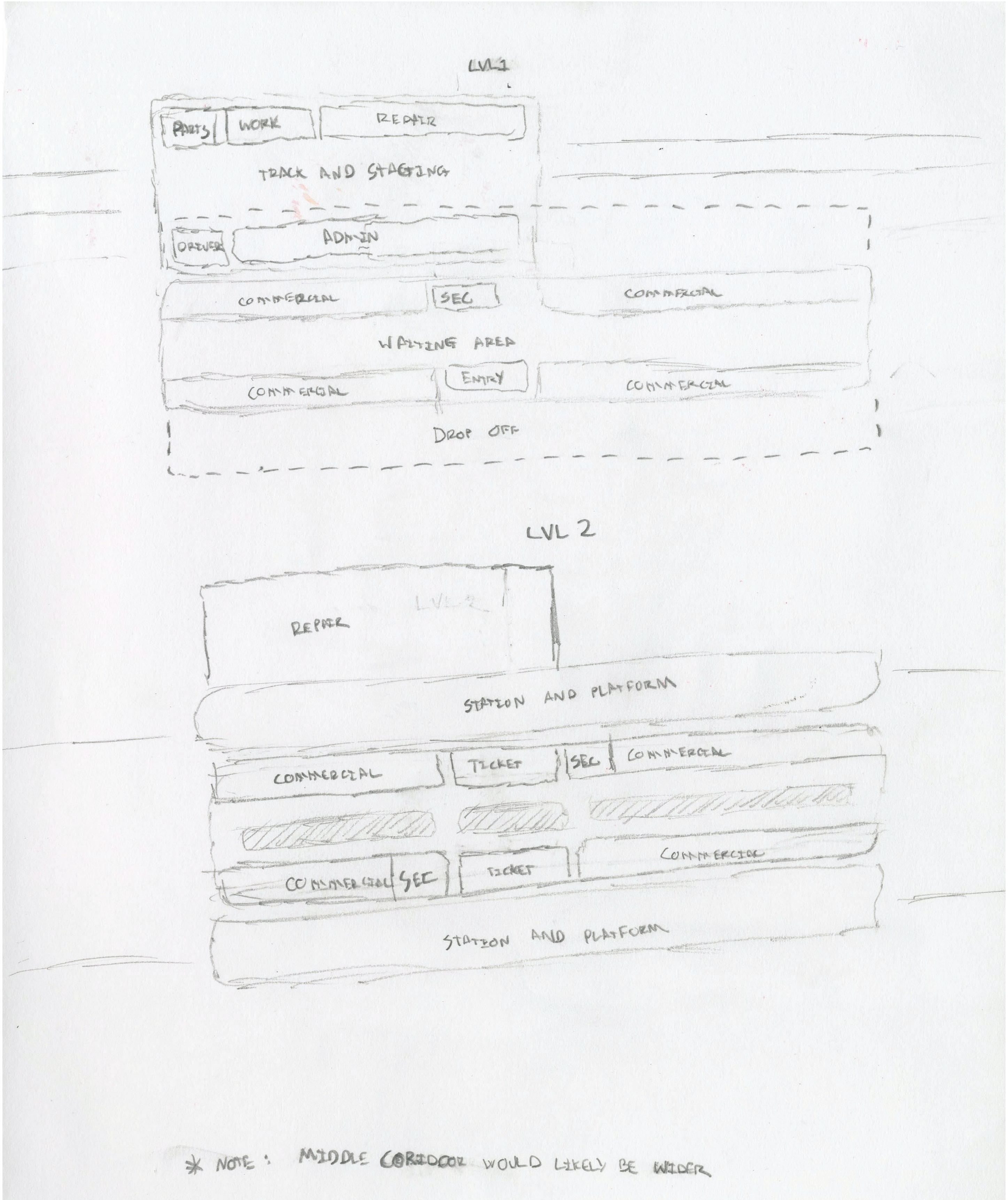


PROCESS DOCUMENTATION

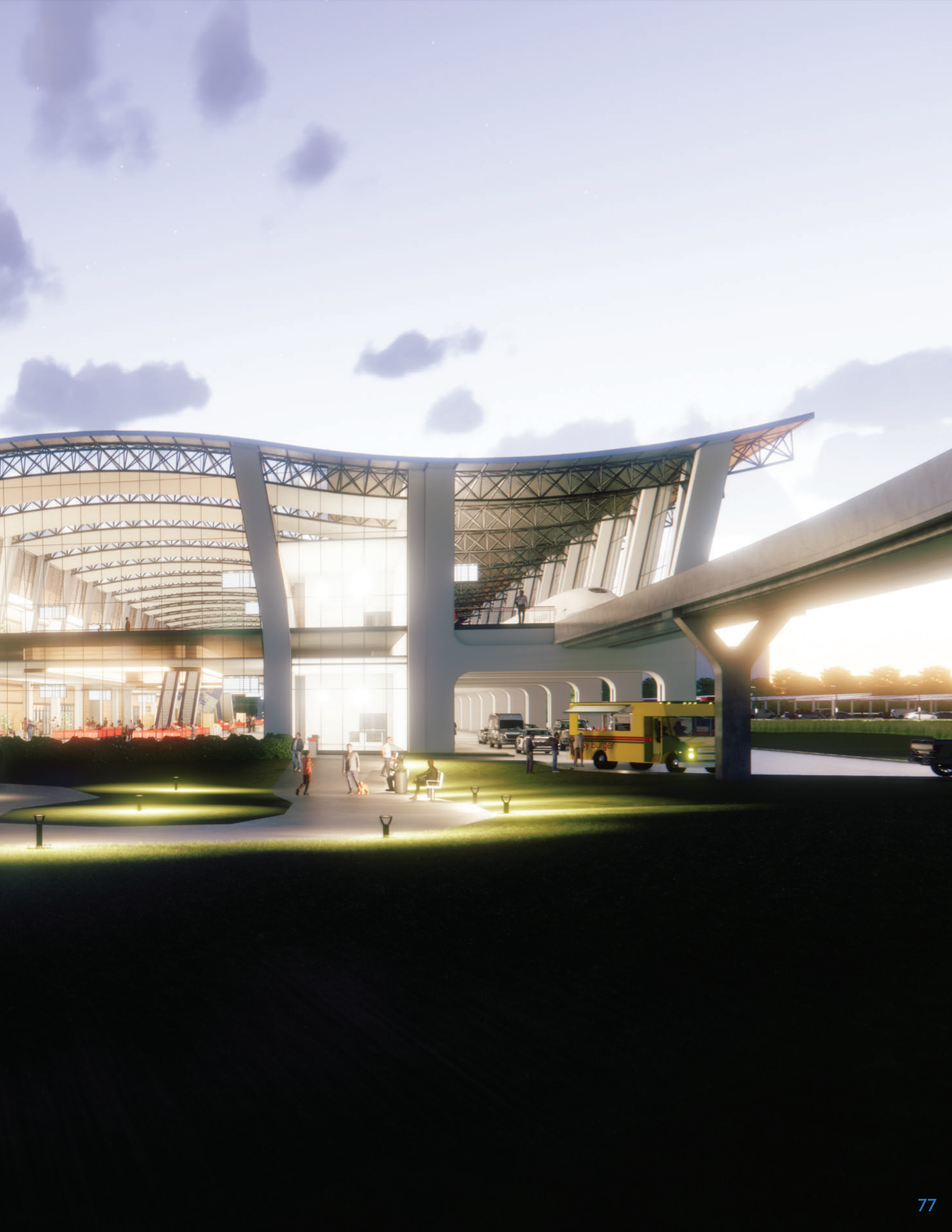




1
4
KEY
WORKER
PEDESTRIAN
TRAIN
LVL 1
LVL 2

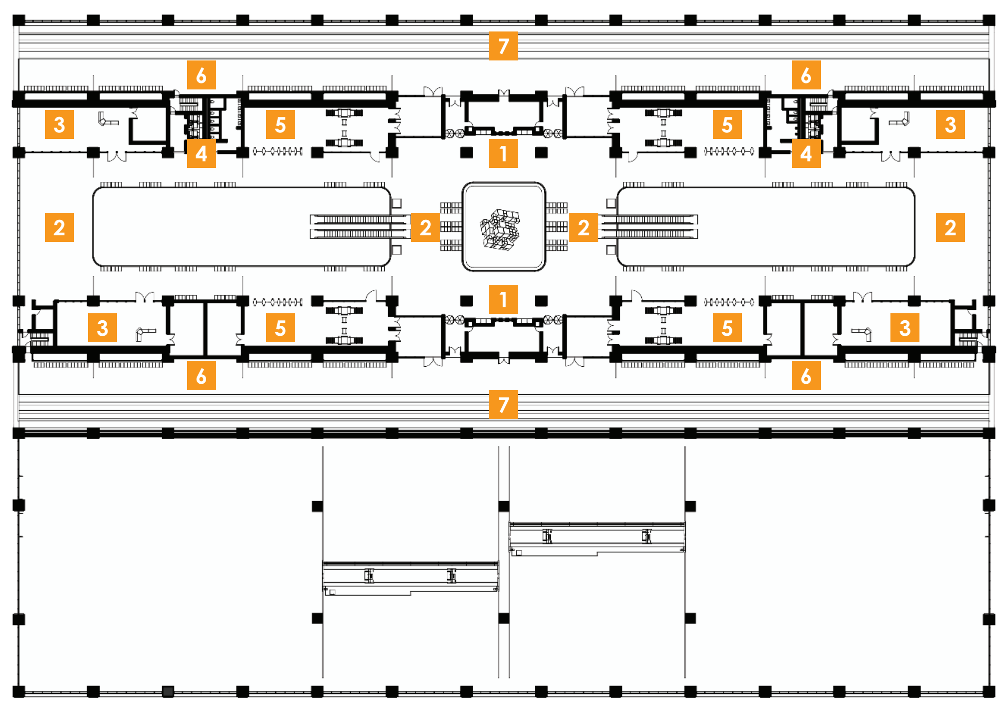

LVL 1
PARTS
WORK
REPAIR
TRACK AND STAGING
DRIVER
ADMIN
COMMERCIAL
SEC
COMMERCIAL
WAITING AREA
COMMERCIAL
ENTRY
COMMERCIAL
DROP OFF
LVL 2
REPAIR
STATION AND PLATFORM
COMMERCIAL
TICKET
SEC
COMMERCIAL
COMMERCIAL
SEC
TICKET
COMMERCIAL
STATION AND PLATFORM
* NOTE: MIDDLE CORIDOOR WOULD LIKELY BE WIDER


RAIL
UTILITY
UTILITY
ROAD
TREES
FRIARS RD
USER PARKING
VEHICLE
STATION
REPAIR PARKING
EXISTING RAIL

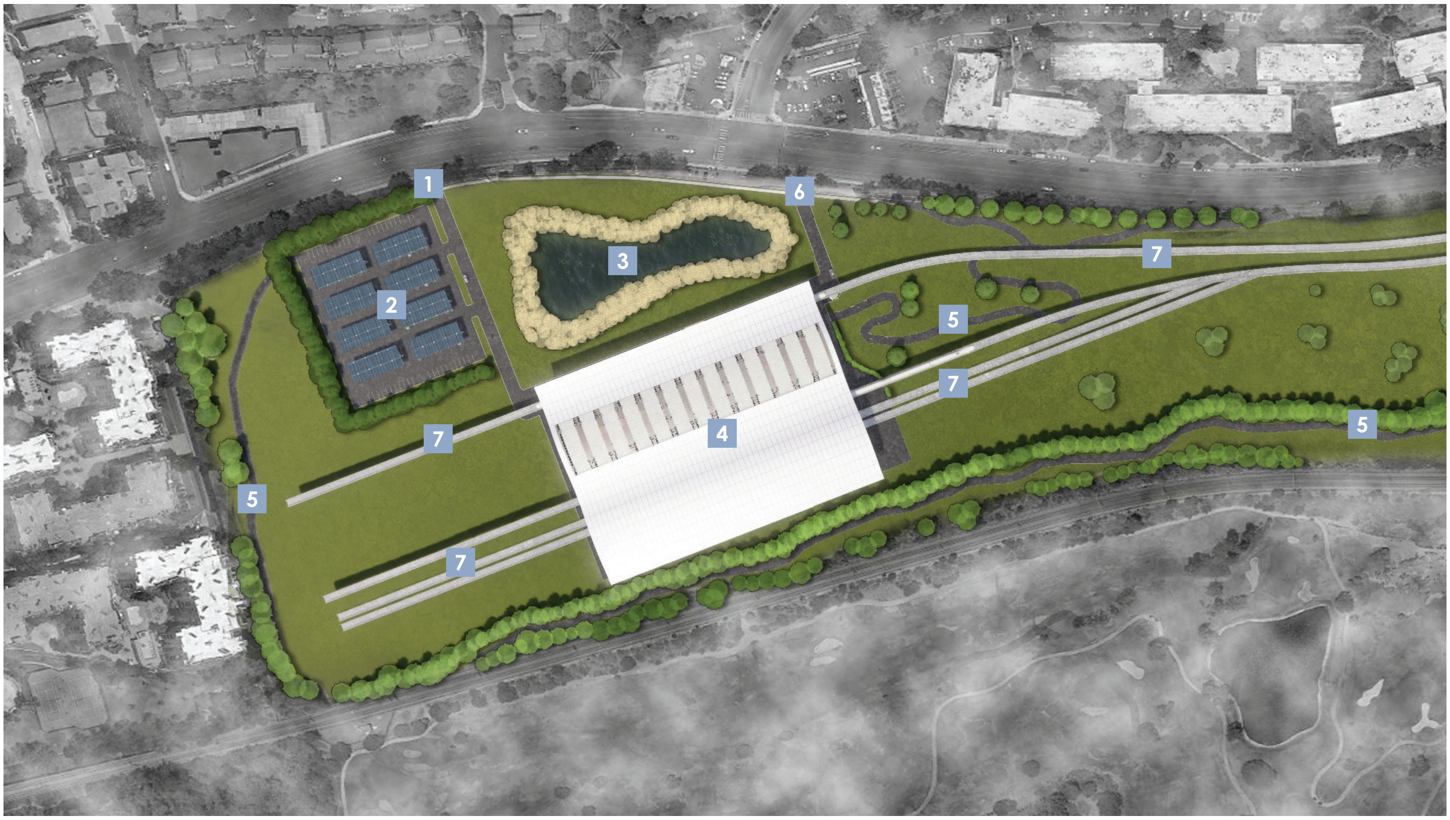


FINAL DESIGN

FIRST FLOOR



SECOND FLOOR



SITE PLAN

FIRST FLOOR (STATION)

1. DROP-OFF
2. ENTRY
3. TICKETING
4. WAITING AREA
5. COMMERICIAL
6. BATHROOMS
7. ELECTRICAL
8. MECHANICAL

SECOND FLOOR (STATION)

1. TICKETING
2. WAITING AREA
3. COMMERCIAL
4. BATHROOMS
5. SECURITY
6. PLATFORM
7. MAGLEV TRACK

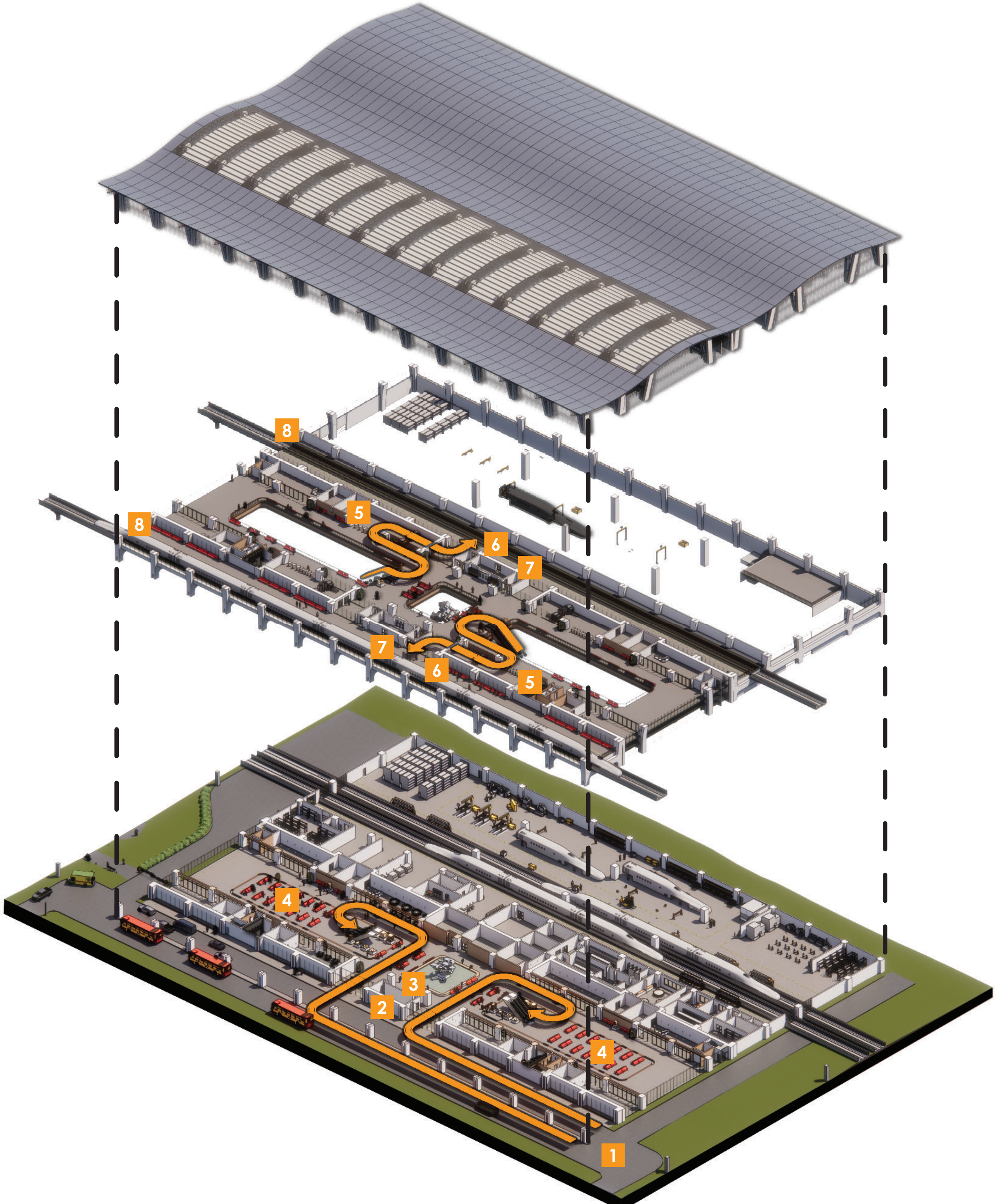
FIRST FLOOR (MAINTENANCE)

1. MAGLEV TRACK
2. REPAIR BAY
3. ITEMS STORAGE
4. CNC MACHINING
5. HEAVY REPAIR
6. BULK STORAGE
7. BATHROOMS
8. TOOL SHOP
9. TECHNICAL DOCUMENT'S
10. MAINTENANCE OFFICE
11. BREAK ROOM
12. LOCKER ROOM
13. TOOLBOX STORAGE
14. COMMON WORK AREA
15. COMPONENT CLEANING
16. WATERJET MACHINES
17. WELDING AREA
18. SMALL PARTS STORAGE

SITE PLAN

1. SITE ENTRY
2. PARKING
3. DRAINAGE POND
4. TRAIN STATION
5. SITE PATHS
6. SITE EXIT
7. MAGLEV TRACKS

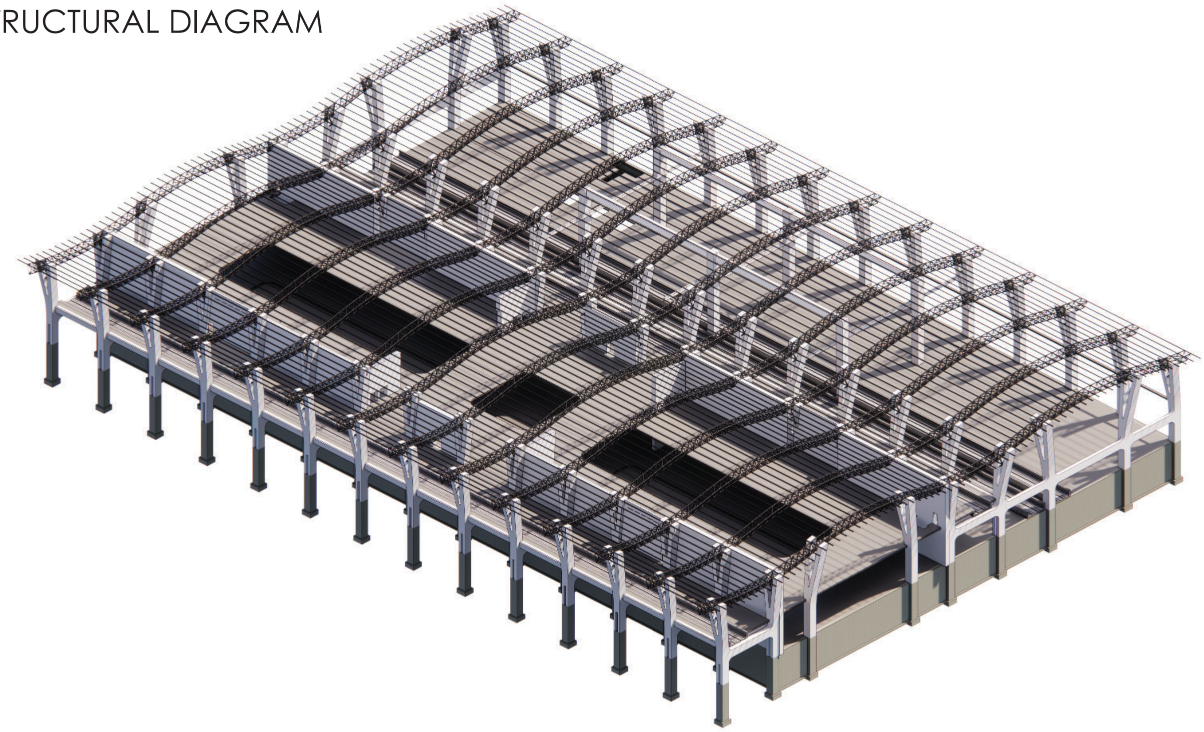
FINAL DESIGN



EXPLODED CIRCULATION DIAGRAM

1. ENTER SITE
2. WALK THROUGH FRONT DOORS
3. AQUIRE TICKETS AT ENTRY
4. WAIT FOR TRAIN TO ARRIVE
5. ENTER SECURITY TO CHECK BAGS
6. WALK ONTO PLATFORM
7. BOARD TRAIN
8. DEPART FOR DESTINATION

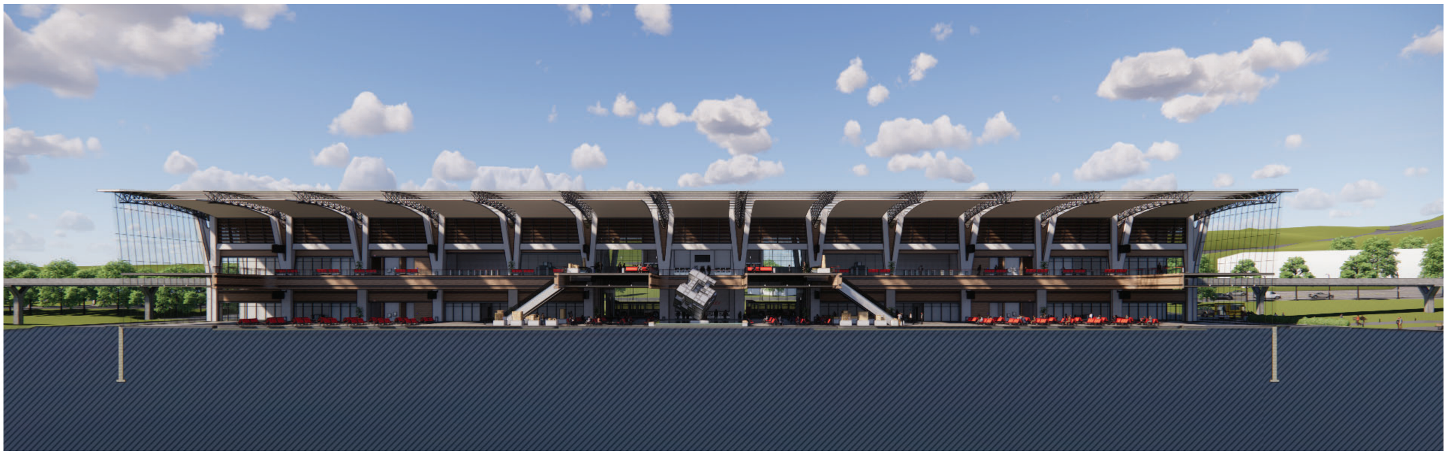
STRUCTURAL DIAGRAM



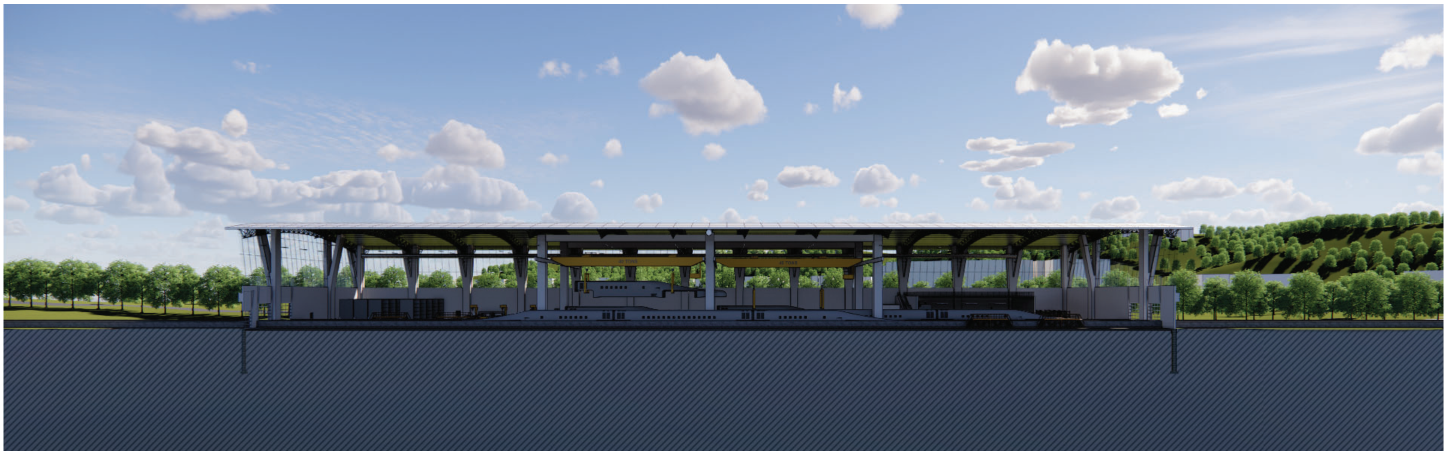
PERFORMANCE ANALYSIS

LOCATION		DISTANCE	TIME
1.	SAN DIEGO, CA TO LOS ANGELES, CA	120 MILES	00 HR 20 MIN
2.	LOS ANGELES, CA TO LAS VEGAS, NV	235 MILES	00 HR 38 MIN
3.	LAS VEGAS, NV TO FLAGSTAFF, AZ	210 MILES	00 HR 34 MIN
4.	FLAGSTAFF, AZ TO ALBEQUERQUE, NM	285 MILES	00 HR 46 MIN
5.	ALBEQUERQUE, NM TO DALLAS TX	589 MILES	01 HR 34 MIN
6.	DALLAS, TX TO MEMPHIS, TN	421 MILES	01 HR 08 MIN
7.	MEMPHIS, TN TO ST. LOUIS, MO	240 MILES	00 HR 38 MIN
8.	ST. LOUIS, MO TO CHICAGO, IL	260 MILES	00 HR 42 MIN
9.	CHICAGO, IL TO CLEVELAND, OH	340 MILES	00 HR 55 MIN
10.	CLEVELAND, OH TO PITTSBURG, PA	120 MILES	00 HR 20 MIN
11.	PITTSBURG, PA TO WASHINGTON D.C.	190 MILES	00 HR 31 MIN
12.	WASHINGTON D.C. TO BALTIMORE	35 MILES	00 HR 12 MIN
13.	BALTIMORE, MD TO PHILIDELPHIA	90 MILES	00 HR 25 MIN
14.	PHILIDELPHIA, PA TO NEW YORK CITY	80 MILES	00 HR 23 MIN
15.	SAN DIEGO, CA TO NEW YORK CITY, NY	3,215 MILES	08 HR 35 MIN
16.	SAN DIEGO TO NEW YORK CITY (BY PLANE)	2,433 MILES	05 HR 35 MIN

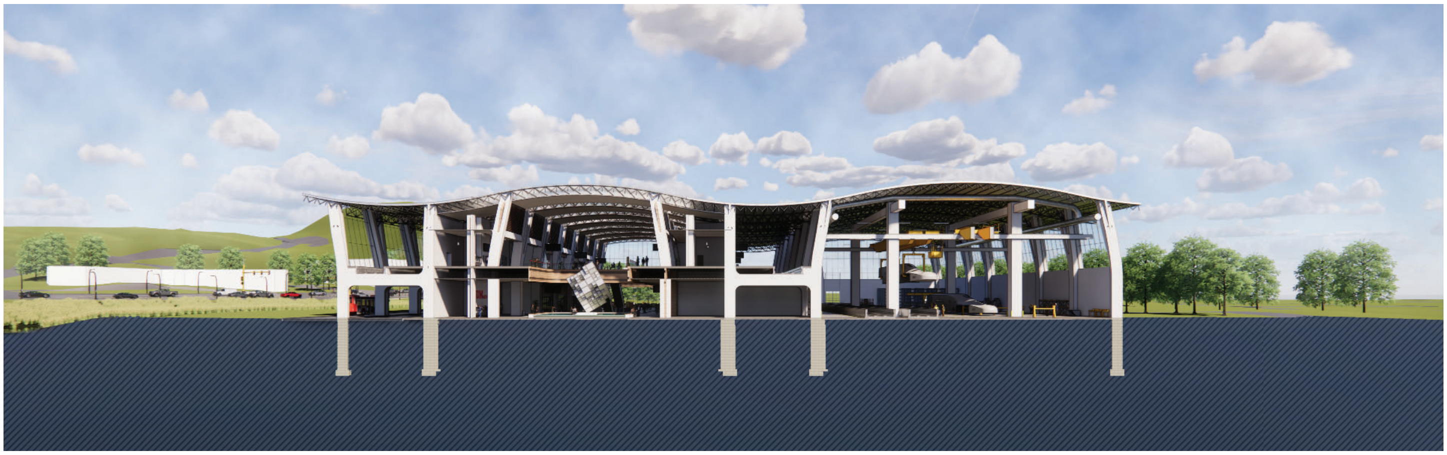
FINAL DESIGN



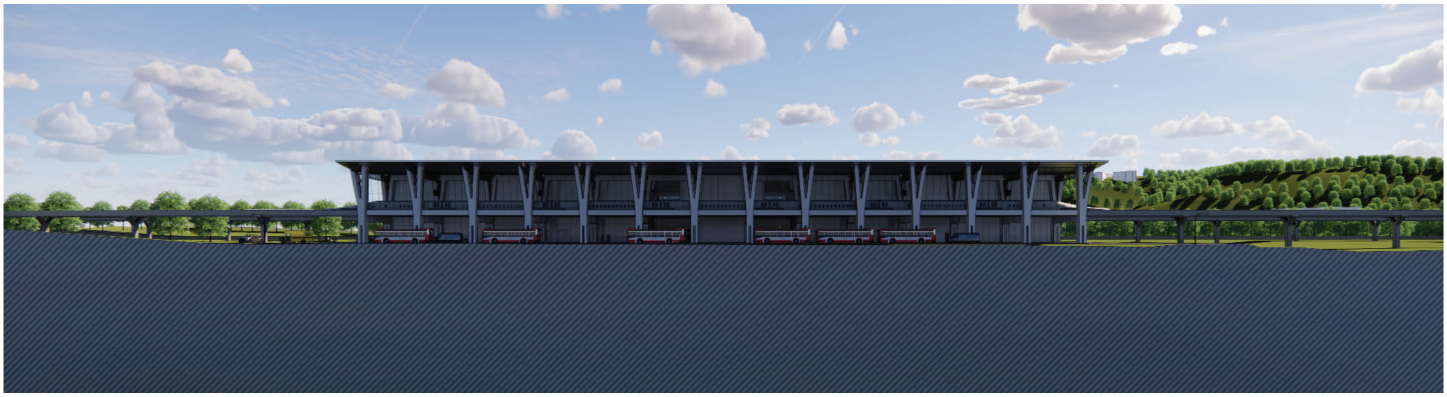
LONGITUDINAL SECTION: STATION



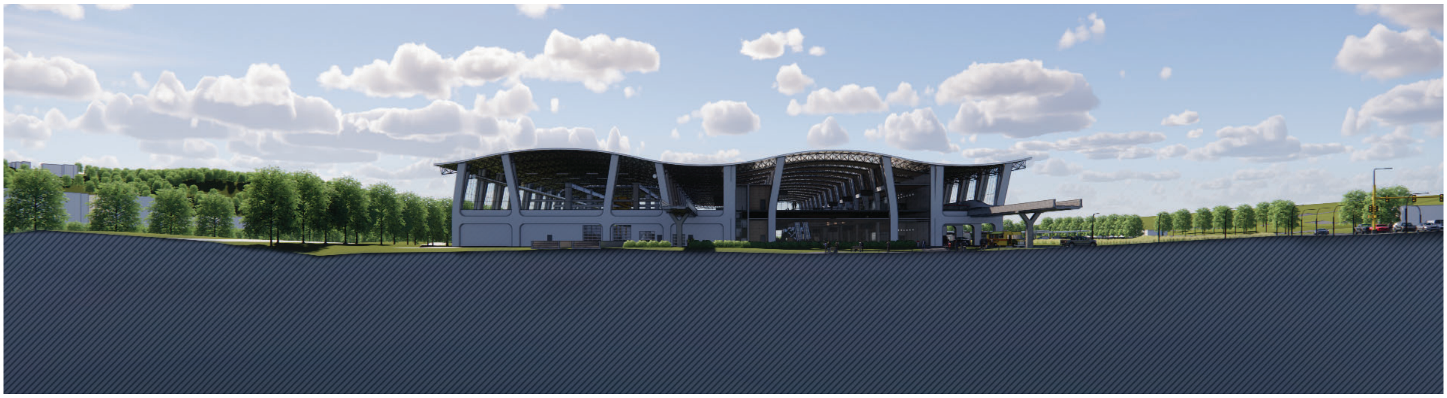
LONGITUDINAL SECTION: MAINTENANCE



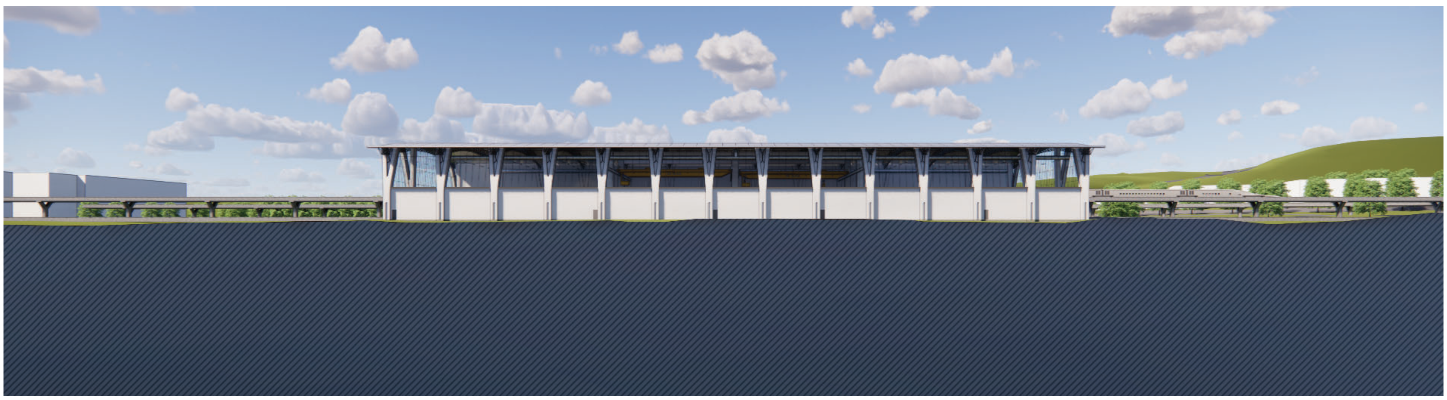
TRANSVERSE SECTION



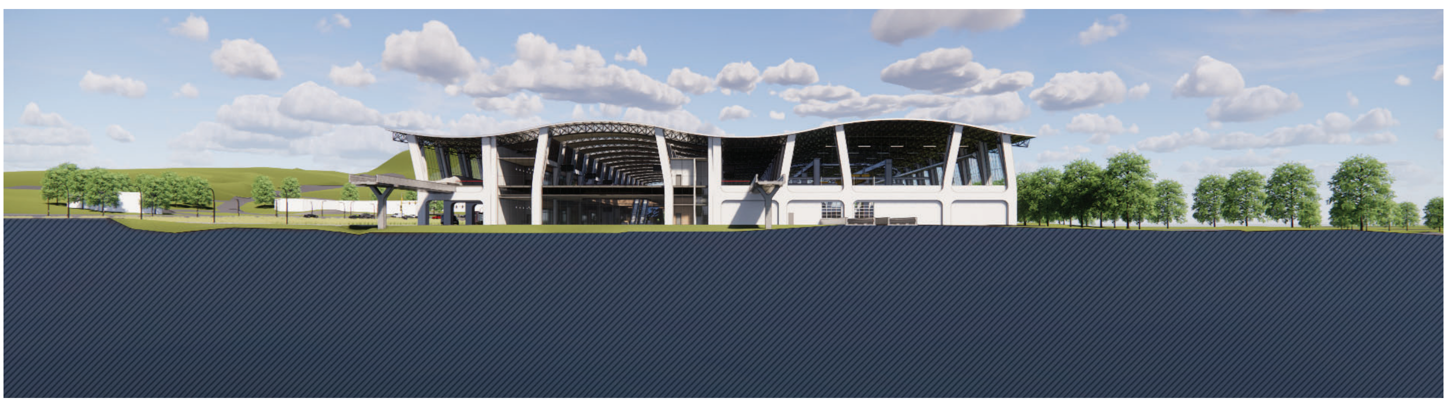
NORTH ELEVATION



EAST ELEVATION



SOUTH ELEVATION



WEST ELEVATION

FINAL DESIGN

MONEY SHOT: DAYTIME

SITE VIEW

NIGHT VIEW

ENTRY

FINAL DESIGN

LOBBY

ATRIUM

SECOND FLOOR

PLATFORM

MAINTENANCE BAY

DEMONSTRATIVE MODEL FROM 5TH GRADE

DISPLAY INSTALLATION

THE APPENDIX

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Special thanks to Sina Lee for photoshop help

STUDIO EXPERIENCE

2ND YEAR

- ARCH 271 | Architectural Design I | Fall 2018 | Milton S. Yergens
  Meditation Garden | Moorhead, North Dakota
  Boathouse Project | Jamestown, North Dakota
- ARCH 272 | Architectural Design II | Spring 2019 | Charlott Greub
  Dwelling Project | Cripple Creek, Colorado
  Mixed Use Project | Moorhead, North Dakota

3RD YEAR

- ARCH 371 | Architectural Design III | Fall 2019 | Regin Schwaen
  Oscar Zero Visitor Center | Cooperstown, North Dakota
  Blackbox Art Museum | Nekoma, North Dakota
- ARCH 372 | Architectural Design IV | Spring 2020 | Bakr Aly Ahmed
  Rise House | Fargo, North Dakota
  Fracture | Bismark, North Dakota

4TH YEAR

- ARCH 471 | Architectural Design V | Fall 2020 | Cindy Urness
  1541 Northeast (High Rise) | Miami, Florida
- ARCH 472 | Architectural Design VI | Spring 2021 | David Crutchfield
  Crutchfield House | Fargo, North Dakota
  45th Street Crossroads | Fargo, North Dakota

5TH YEAR

- ARCH 771 | Advanced Architectural Design | Fall 2021 | Bakr Aly Ahmed

PERSONAL IDENTIFICATION