

The UTSA Main Campus Electromagnetic Monorail System and Infrastructure

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Introduction

Idea Formulation

It was necessary for our classroom to assemble and form a group of four of our peers with the intention of producing a STEM related project that would be viable to be given mention onto any of the members resumes. Our group members are as follows: Jayson Clinton, Nicholas Hinkel, Marc Legarde, and Sara Sandoval. Each of our members has a diverse set of skills and interests to contribute to the project. One of us is an electrical engineering major, another a civil engineering major and the remainder mechanical engineering majors. With our groups varying fields we were able to formulate a project that allowed all of our members to contribute to their desired fields. Our group chose to produce a prototype of an electromagnetic railing system for a monorail train. However, our group also found it necessary to establish a complementary rail infrastructure network to accompany the electromagnetic railings. With our group converging onto this idea we were ready to proceed further into the assignment.

Assignment Qualification

Proceeding with our chosen project design, we then had to make sure that our proposal satisfied the requirements granted to us by our instructor. Our group was given four weeks to work on the project and required us to prepare a formal proposal and a pitch to our hypothetical investors. Our proposal must also satisfy one of the United Nations Department of Economics and Social Affairs 17 Sustainable Development Goals ([THE 17 GOALS | Sustainable Development \(un.org\)](https://un.org/sustainabledevelopment/the-17-goals)). Our proposal satisfies two of their goals, firstly goal No 9, Industry, Innovation and Infrastructure and goal No 11, Sustainable Cities and Communities. The enhancement of the current monorail system design proposed by Nicholas Hinkel satisfies the

innovation necessity of our project and it gives us the opportunity to present a brand-new model to our target audience using the medium of SolidWorks CAD Software to present a virtual three-dimensional model and allow capabilities to produce a physical model using the facilities provided by the UTSA Engineering Building's 3D printer ([Try SOLIDWORKS | MySolidWorks](#)). The second portion of our project, proposed by Sara Sandoval, is the construction of a non-intrusive annotated map of the UTSA Main campus in which our group would formulate a design for the current infrastructure of the track system to incorporate and accommodate the current features of the campus. This portion of the proposal then satisfies the requirements for the Sustainable Cities and Communities goal.

Project Advocacy

We are petitioning the board of directors of the University of Texas at San Antonio in regards to our prototype monorail model. Our project provides a service to the students, the staff, and the visitors who often traverse the lengthy campus. This has been an ever-increasing problem on campus as the number of students that are enrolled on campus cannot be supported by the current infrastructure of the campus and must resort to offsite parking lots. Also taking in consideration the expanding field of construction protruding from the current campus according to the history of buildings ([UTSA-Construction-History-Fact-Sheet.pdf](#)). These buildings include five story laboratories and classrooms as well as new dormitories and utility buildings. By implementing our system, it would allow for the current transportation of campus personnel as well as the transport of equipment, but most relevant is the smooth transition into a higher potential of the main campus.

Prototype Research and Development

Object Research Phase

Our project was applicable to be divided into two primary groups with one group researching the projected route of the model and the latter group constructing a tangible model for the modification to the monorail system. From this point onward, the construction group had to begin research by looking at the current map of the UTSA Main campus and deciding target areas where people were in dire need of assistance. Considering the student demographics determined by the UTSA Student Life page ([University of Texas at San Antonio Student Life - US News Best Colleges](#)), an overwhelming majority of students are off campus commuters who rely upon the parking lots provided by the campus. The most used parking lots typically located along the interior of the campus are overpopulated by cars and leaving many empty spots in the exteriors of the lots located around the map.

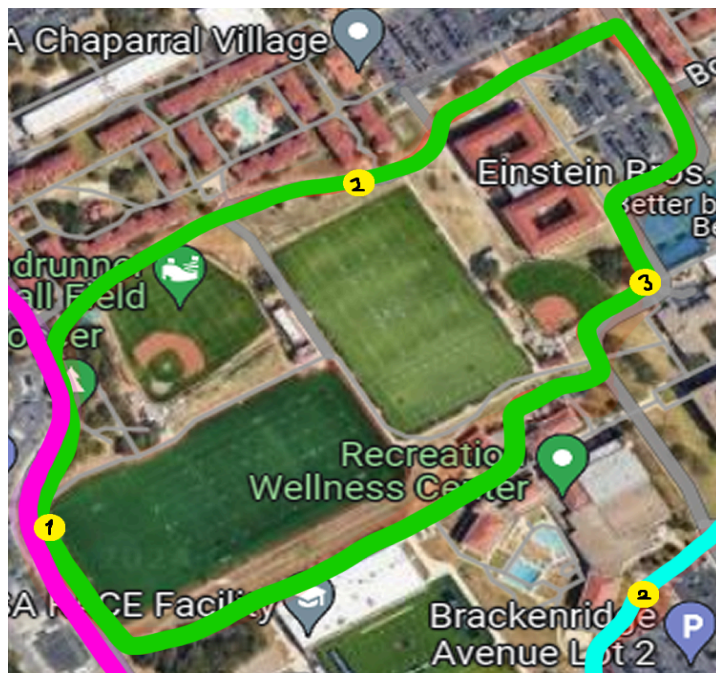


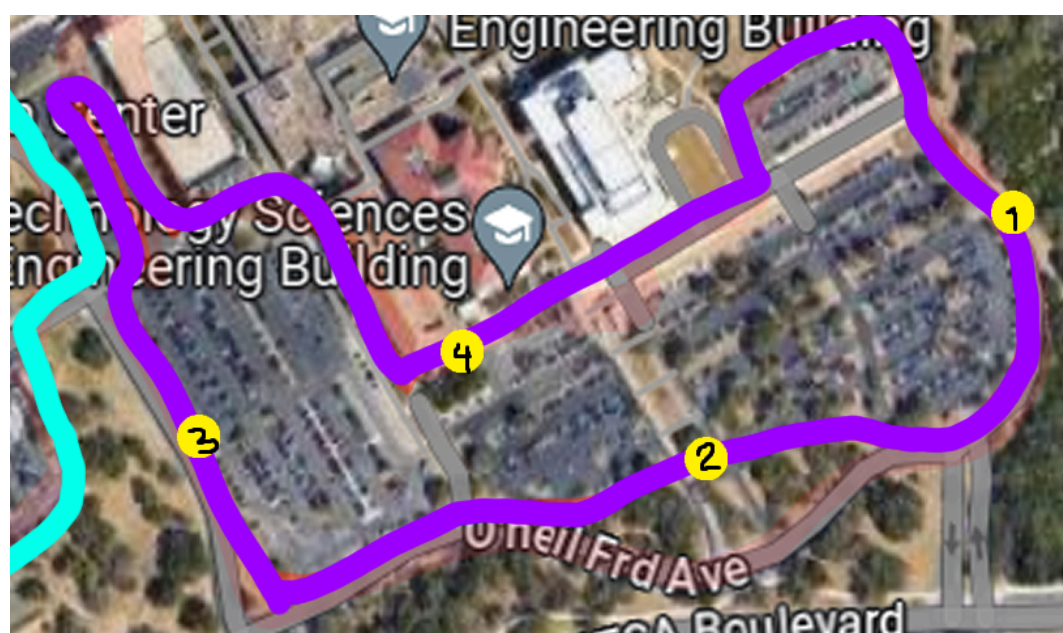
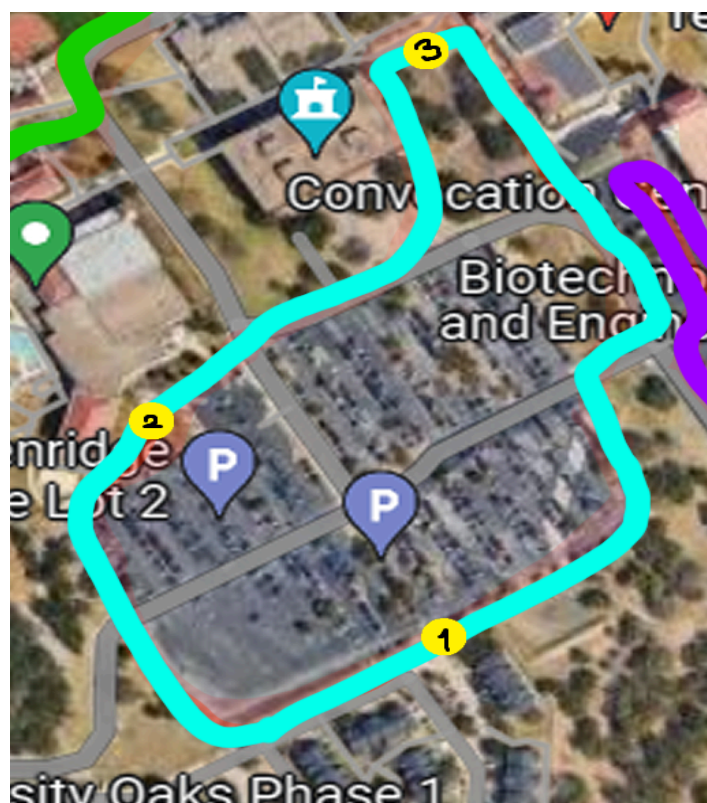
The group in charge of the modeling of the prototype modification to the monorail design shall henceforth be referred to as the design group and their research phase targeted more diverse categories. Starting with the analysis of current types of monorail models from the Technical Page Index ([Technical Page index \(monorails.org\)](https://monorails.org/technical-page-index)) and then by assessing the benefits of the monorail system over other forms of transportation. To summarize an excerpt from the HowItWorks Newsletter, the monorail system is a safer transportation system while incorporating the presence of active foot traffic as well as being a medium that releases less noise pollution taking into account the busy and studious nature of the UTSA campus. Then the design group determined after notable research that by constructing the track to propel the cart unit through the usage of electromagnetism. Looking at the iterations of commonalities in the modern units such as the following model in Japan. ([Japanese Maglev Train: World's Fastest Bullet Train - JRailPass](https://www.jrailpass.com/en/japanese-maglev-train-worlds-fastest-bullet-train)) and an explanation of the system can be found in [How Maglev Works | Department of Energy](https://www.energy.gov/monorail)

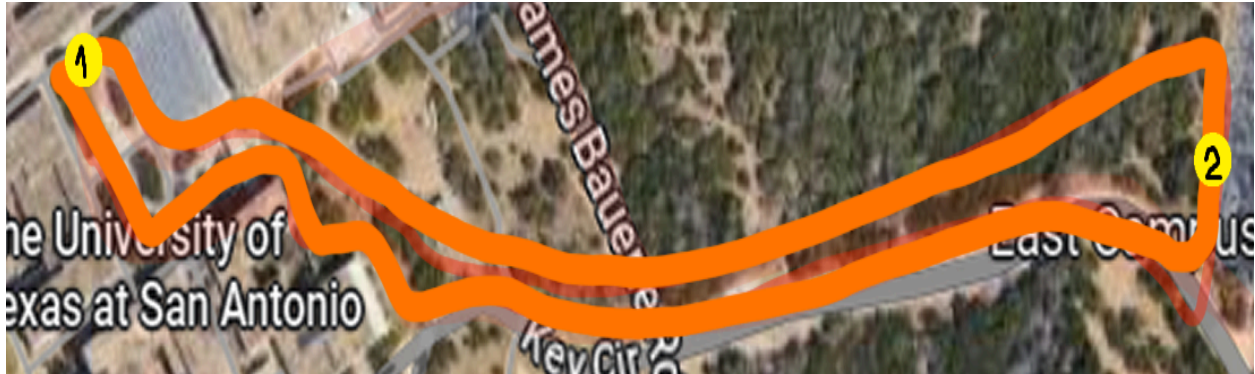
Object Manufacturing Phase

The construction group produced a map with all of the proposed routes and stops associated with the prototype track and the routes are presented as the Clinton Route, Hinkel Route, Blanco Route, and Legarde Route. The speed of all the monorail systems in establishment are to be set originally at 30 mph according to the already standing Disney World Track (https://en.wikipedia.org/wiki/Walt_Disney_World_Monorail_System). However, to encourage safety within some of these high traffic areas considering that our group will not be implementing an elevated system, the speed of the monorail will be decreased to 20 mph. The Clinton Route (green) targets the area around the recreational facilities to include the soccer,

football, and baseball fields and extends past that to reach the parking lot adjacent to the Alvarez Dormitories. The track is 1.03 miles long and takes around 3.21 minutes to complete without consideration of the loading times. The Hinkel Route (aqua) connects the east side of the university oaks complex, the south part of the Brackenridge lot 2 and 1 and the recreation center to the HEB student union building area. This track is 0.81 miles long and takes around 2.38 minutes to complete. The Blanco Route (purple) links the furthest parts of the Ximenes, Ford, and Bauerle lots to the Applied Engineering and Technology building and the Biotechnology, Science and Engineering building. The route is 1.04 miles long and takes around 3.14 minutes to complete. The Legarde Route (orange) bridges the east campus lots with the Sombrilla plaza area of the main building area. This route is 1.03 miles long and takes 2.41 minutes to complete. Each route has 3 stops except the Blanco Route which has 4. At each stop, the monorail will be there for 5 minutes to allow students to load into the cart while remaining efficient. Each route with the added stop times should take around 15 minutes to 20 minutes to complete.







The manufacturing of the maglev prototype was undertaken by the design group using the SolidWorks CAD software to produce a 3D virtual model with capabilities to produce a tangible physical representation of the design. Using inspiration from research of monorails with current implements the two following models were produced. The monorail cabin was produced to hold a smaller number of people with capabilities to attach secondary cabins to the rear of the lead cabin. The monorail track was produced to match with the monorail cabin by measurement. The hollowed out portion of the track located in the interior is a cavity for the installation of the magnetic and electrical equipment necessary for operation of the monorail cabins.



The Cabin has been adorned with UTSA insignia and the University colors as a means of further advertising the monorail system. The monorail cabins hold only a few passengers to prevent the struggles of a lengthy loading process and to reduce the required amount of power to produce movement in the system. This same feature allows for the short durations of the routes produced by the construction team. The monorail will be built at ground level to reduce the costs of construction and also to allow for the disabled and the handicapped to load and unload from the cabin of the monorail with ease. The current shape of the cabin was inspired by smaller tram systems used at places like theme parks and similar places of business.

Post Production Analysis

Budget Analysis

For the **Track's Budget**, SolidWorks was used to design the track. Using the **mass properties** in Solidworks, the mass of each track was given. Switching the track's material to **Carbon Steel** provides many benefits as it's strong, light, and cheap. The company, Metal Miner, provides the cost of carbon steel per pound (lbs) on their website

(<https://agmetalmminer.com/metal-prices/carbon-steel/>).

$$\text{Cost of Carbon Steel per track} \times \frac{\text{Length of total track in feet}}{\text{Length of each track}} + \text{Electromagnetic Suspension} = \text{total track \$}$$

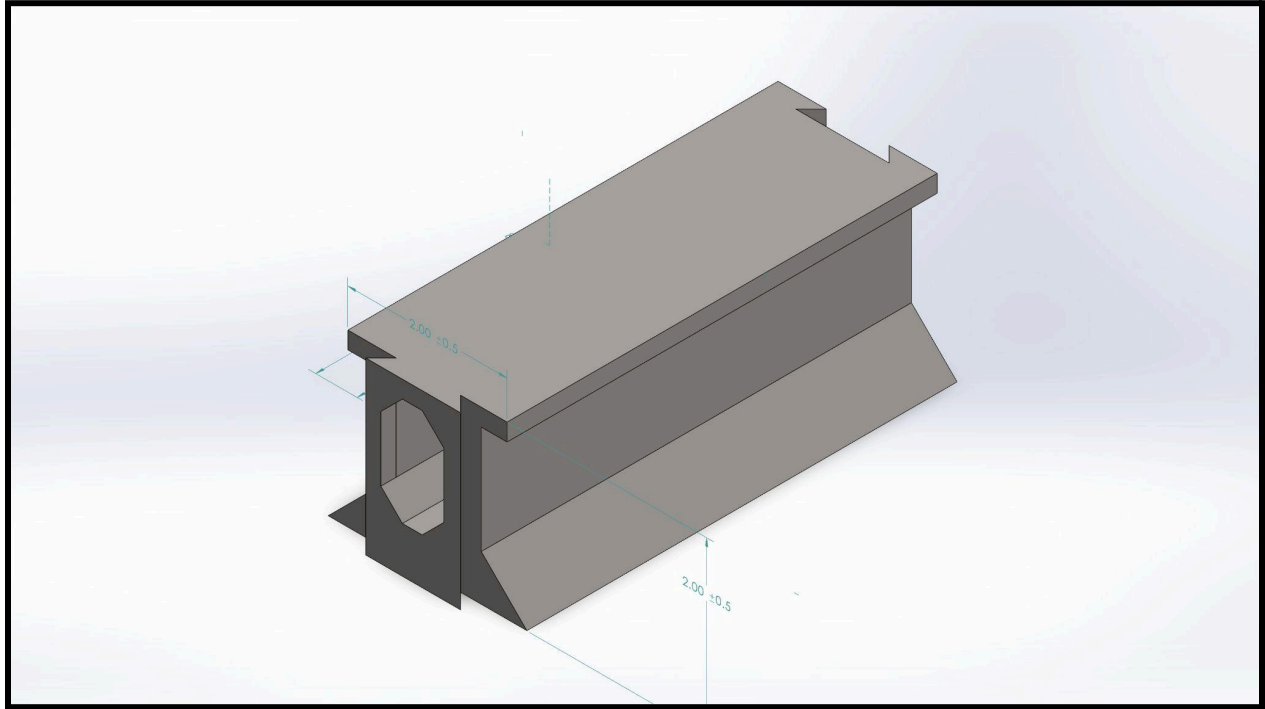
Each track is 10 lbs and 1 lbs of Carbon Steel is \$40.55, so the “Cost of Carbon Steel per track” is \$405.50 The total length of the track is given by Jayson or Sara and dividing their number by the length of each track (8.00 ft) will provide us the number of tracks needed. Multiplying the “Cost of Carbon Steel per track” by the calculated number of tracks will give us the cost of the tracks without the electromagnetic suspension (EMS) technology. To find the cost of EMS, www.science.gov claims that the cost is \$10 million per mile (10 million/1 mile).

Using this equation:

$$\text{Electromagnetic Suspension (EMS)} = \$10,000,000 \times 3.91 \text{ mi}$$

This equation gives us the total cost of EMS used in the monorail track. 39.1 million

Adding the cost of the tracks with the total cost of EMS gives us the total cost of the track system.



Cost of Maglev

It is difficult to determine the cost because almost all monorails are designed to go much greater distances, thus have more expensive power systems and are larger to fit more people. The UTSA design is much smaller, fitting roughly 6 people. These smaller cars also require less powerful systems.

[A maglev project in Japan](#) planned to be completed in 2027 is estimated to cost \$55 billion. The route is 177 miles. The total length of track for the UTSA version is 3.91 miles. Assuming the cost is proportional, which it isn't, it would cost \$1.21 billion.

A more specific approach to determining cost would be to break the cost into components. However, parts for a maglev aren't on the market and prices aren't released publicly.

Because the scale of the UTSA monorail is smaller than traditional trains, it is better to compare them to something smaller. [Disneyland](#) has its own Railroad system. The two Disneyland trains cost over \$240,000, while the locomotives cost \$40,000 each. However, the cost of a regular train vs. a maglev is not comparable.

The most accurate measure of determining the cost of the UTSA maglev system is using the [EMS](#) rate for another system. As mentioned above, using that rate multiplied by the 3.91 miles of UTSA track, the cost comes out to:

$$\frac{\$10 \text{ million}}{1 \text{ mile}} \times 3.91 \text{ miles} = \$39.1 \text{ million}$$
$$\text{Cost of Carbon Steel per track } \$405.50 \times \frac{\text{Total track length } 20645 \text{ ft}}{\text{Length of each track } (\approx 8.00 \text{ ft})} + \text{EMS } \$39.1 \text{ million}$$
$$\text{Total Maglev Cost} = \$40,146,443.44$$

Physical Constraints

The project itself is in its infancy as the project will take many years and will encounter many troubles for the individuals on campus for the duration of the construction of the project. First of all many of the main walking routes that are currently in use and would be replaced by the utilization of our groups electromagnetic monorail system would be out of order or at least heavily blocked off during the construction phase, causing irritation in people and possible detours in the current routes. Additionally, the project itself costs a considerable amount of money when comparing it to other construction projects in the history of the UTSA campus. It would likely draw funds away from other projects either in implement or in future implement in

order to complete the project within an ideal portion of time. Projects like the UTSA Master Plan [Home | Campus Master Plan | UTSA | University of Texas at San Antonio](#)) would fall prey to this reality. Some constraints would present themselves after construction as well, while the monorail is built to be small, it was designed to operate on the ground which could be cause for accidents or possible physical injuries. Preventative measures could be made to disable the possibilities for these accidents such as railings however, such actions would constrict already existing walkways along the current routes. The electromagnetic monorail system is designed to be cleaner than the traditional monorail systems; it would still cost the school money to provide the necessary energy for these monorail tracks and upkeep of the cabins and infrastructure is something the school should also consider.

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