THE EFFICIENCY OF MAGNETIC TRANSPORTATION

Team Name: Justice Code Team 2

New Mexico Super Computing Challenge

Final Report

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Executive Summary

With the world becoming a "smaller place", new technologies are abounded with regards to methods of efficient transportation. On a local level, public transportation can oftentimes be either expensive and/or inefficient in getting someone to their destination in a timely fashion. Of course, there are subways in applicable cities that people use on a day-to-day basis, but what about cities that don't have the infrastructure necessary to support a subway system? Additionally, subway systems tend to be rather slow in practice. As Ben Franklin noted "Remember that Time is Money" (Fisher, 1748). We believe that magnetic levitation can be a method of transit that will assist in creating both an inexpensive and less time-consuming method of public transportation. The science of Magnetic Repulsion and Propulsion can revolutionize the transportation industry on a mass scale. Maglev transportation does currently exist but only currently in China, Japan and Korea in the form of trains. There are a few High-Speed Rail Systems (HSR) within the United States, but the differences between two are drastically different. HSR's are constructed with steel wheels mounted to a track and uses friction, propulsion and braking technologies. As a result of the continual friction, HSR's require much more maintenance. Additionally, HSRs have a typical cruising speed of around 124mph to 221mph. Maglev trains superior in construction as they are created using magnetic levitation, thereby creating little to no friction in their movement. The zero friction allows for both a smoother ride with faster cruising speeds easily exceeding over 310mph. Furthermore, because of their construction, maglev trains require far less maintenance, thereby significantly reducing operating costs. We believe that this form of transportation could be used in the United States to transform both short and long-distance travel opportunities and the costs and times associated.

Problem Statement

In this project, we will use Excel to create sets of formulas that will assist in simulating standard forms of high-speed rail transportation and contrast those numbers against maglev transportation and the costs that are potentially involved. We will use the data collected to determine the feasibility of building maglev transportation systems within the United States.

Background Research

We first wanted to research about the types of magnets that are used for magnetic trains and their polarity. But after doing a small bit of research, we couldn't figure out how we wanted to make it relevant since it really isn't "new" technology. Then we realized that there are no maglev trains anywhere else in the world other than Asia and wanted to know why. Since the technology has been around for a while and it seems that it would only make sense to have them in the United States, why do we not have any? We decided to research if the benefits outweighed the costs. Like we said earlier, "Time is Money". We know there is an Amtrak train station right here in Albuquerque, so we decided to look up Amtrak distances from certain cities and what a standard ticket would cost. We then decided to research maglev trains in Asia to see what we could find out. There are currently three maglev train systems operating in Asia. They operate in The People's Republic of China, Japan, and Korea. We picked the rail system in The People's Republic of China and randomly chose train distances that were comparable to the same routes we chose on Amtrak in the United States. We believe that this would allow us to pretty much compare "apples to apples" with regards to both distance and pricing. During our research, we found that despite the high travel velocity as compared to traditional trains, maglev trains are extremely safe as they are nearly impossible to derail. Maglev trains have "the potential to be a cheaper, faster, safer, and greener form of transportation that we have today" (Wilson, 2022). In addition to gathering information on distance and ticket prices, we also researched the general costs of what it would take to build a maglev train system. We ended up with several staggering numbers that where anywhere from $236M to $1.4B (Aukema, 2024). For example, the Shanghai Maglev had a total cost of $1.2B and that was just for a 20-mile system!

Although certain tracks within the Amtrak network can be considered High-Speed Rail systems, they are nowhere in comparison to the performance of maglev trains. The California High Speed Rail Authority project is currently in production to build a HSR system that would span a total 776 total miles. The project was initially approved in 2008 with Phase 1 to begin production in 2015. Upon our research, we learned that the project has experienced a myriad of problems. Although initial costs were projected to be $35B, "As of 2024, the entirety of Phase 1 was projected to cost $106.2 billion" (California High-Speed Rail, 2024). That is a $70B dollar difference in initial projections vs. estimated costs today for a distance of 494 miles! We can see how such a cost difference can be such an overwhelming factor in determining whether a HSR should be built. In comparison, Japan is currently building a maglev train from Tokyo to Nagoya with an estimated cost of $82B with relative distance of 178 miles.

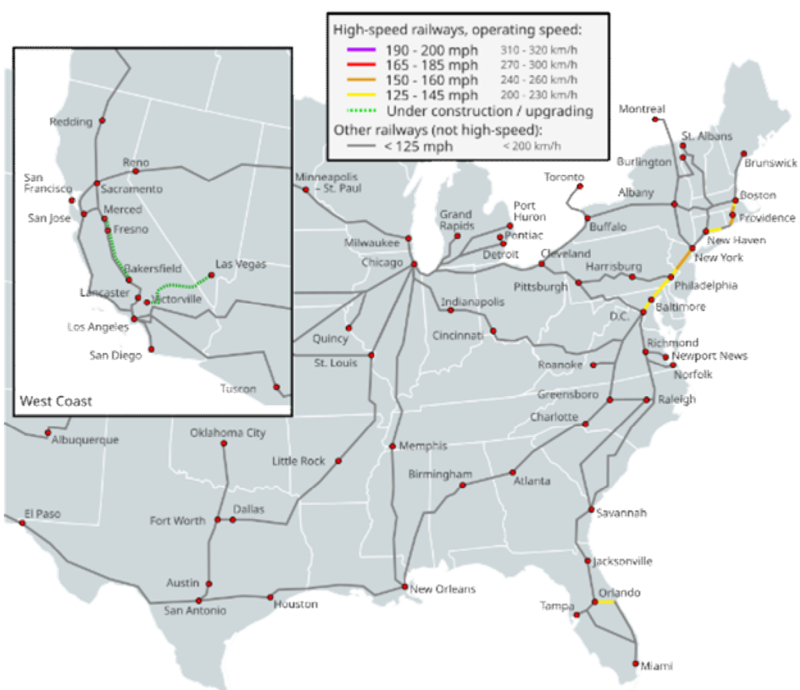

Figure 1: US High Speed Rail Systems 2024

Although both systems (HSRs and Maglev) are extremely expensive to construct, there are pros and cons associated with both...

High Speed Rail System		
Pros		**Cons**
Can use existing rail infrastructure		Lower speeds than Maglev.
Initial build cost is less than maglev		Longerterm operational costs associated with continual maintenance as result of friction.
Verfiable date is available as there are a few HSR systems operating within the United States. Able to apply US costs/stds.		Noise level created as system is NOT frictionless.

Maglev Transportation		
Pros		**Cons**
Reduced maintenance costs as result of "0" friction. Less wear and tear on equipment.		Extremely expensive as system requires new structures to be built. Unable to retrofit existing rail systems.
Efficiency of higher speeds @ reduced energy output.		HSR offers hybrid capabilities.
Ride quality as train is traveling on magnets vs. train tracks.		Longterm capital investment.
Significantly reduced noise levels.		Undetermined if the total costs and length of construction is worth the $$$ tax payer dollars.
		Frequency and savings of inter-regional trips cost-benefit undertimerined.
		Uses significant amount of energy.

Computational Model

We chose 2 HSRs currently in operation, a Maglev Train system and the California High Speed Rail System projected #'s for our calculations. Our formulas and parameters consisted of...

- **Return on Investment = Net Profit / Cost of Investment * 100**
- **Annualized Return on Investment = 1 + ROI ^ (1/N) – 1** *(where "^" = exponent, N = Time)*
- **Average Cost Per Person Per Mile (Coach Ticket) = Route Mileage / $$$ Per Ticket**
- **A standard rider frequency of 5000 passengers per day** *(to provide consistency)*
- **Train operation 365 days per year**

In determining the Return on Investment and the Annualized Return on Investment, we can at least make an informed decision to what type of train system would provide the best return. We will couple these values along with the relevant cost-per-mile-per-person totals to assist us in making a final decision. Although the different tracks are different mileages, we will break down the total cost associated with construction and maintenance on a per mile of track basis, use a standardized distance of 200 miles as so they are fairly equal, and use a standard construction timeframe of 20 years (N) as that is the typical time of construction that we found during our research. All of these factors will help us in our decision-making process.

Peoples Republic of China	
Total construction costs per mile	$21,000,000
Random 200 miles of track	200
TOTAL COST FOR 200 MILES OF TRACK	$4,200,000,000
Frequency (people per day avg)	5,000
Avg tkt price	$86
Days in a year	365
Payback Period years	**27**
Return on Investment	-25.64%

Amtrak - Northeast Corridor	
Total construction costs per mile	$385,000,000
Random 200 miles of track	200
TOTAL COST FOR 200 MILES OF TRACK	$77,000,000,000
Frequency (people per day avg)	5,000
Avg tkt price	$227
Days in a year	365
Payback Period years	**186**
Return on Investment	-89.25%

California High Speed Rail System	
Total construction costs per mile	$208,000,000
Random 200 miles of track	200
TOTAL COST FOR 200 MILES OF TRACK	$41,600,000,000
Frequency (people per day avg)	5,000
Avg tkt price	$119
Days in a year	365
Payback Period years	**192**
Return on Investment	-89.56%

Shanghai Maglev	
Total construction costs per mile	$19,000,000
Random 200 miles of track	200
TOTAL COST FOR 200 MILES OF TRACK	$3,800,000,000
Frequency (people per day avg)	5,000
Avg tkt price	$11
Days in a year	365
Payback Period years	**186**
Return on Investment	-89.24%

Problem Solving Method

The most conventional method of calculating a ROI (Return on Investment) for potential costs savings in maglev transportation would be comparing the costs of standard high-speed rail systems vs. maglev opportunities. For this project, obviously we have chosen trains as our model basis. We chose train transportation as so we could generate real-time costs of standard train travel in the United States via Amtrak against costs associated with Maglev transportation currently being used in Japan, China and Korea. As stated, we will use Excel to generate formulas and decision tables that will assist us in determining the cost effectiveness of introducing maglev transportation via trains into the United States. We believe that we will be able to research the initial cost of building a maglev train to assist us in our initial cost per mile evaluation. We will use current routes that are provided by Amtrak in the United States to generate relevant miles needed in our calculations. We will then choose routes on one of the Asian high speed rail routes that are the same comparable miles. Additionally, as a reference point, we will use the projected routes from the in-production Phase 1 California High Speed Rail System as a basis for relevant distances. Once we have these relevant miles, we will then use standard ticket prices to help us calculate the cost-per-person-per-mile and compare the two systems. We believe we can research the projected costs of building a maglev train system and compare those costs against the current cost of the California High Speed Rail system as we would have solid data. We will finalize all of these calculations and then generate a model that will give us the relevant return on investment of building a maglev train to determine whether it is worth the expense in the United States.

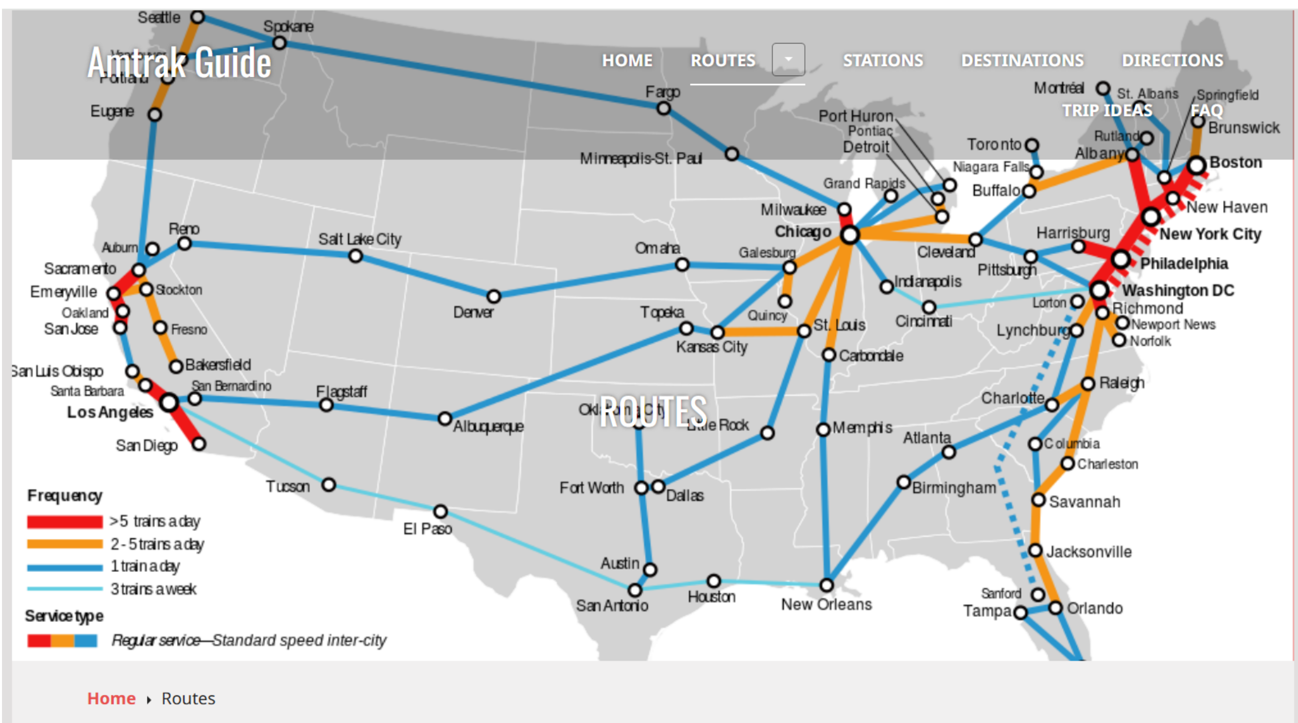

Figure 2: Amtrak Rail System

We were able to acquire Amtrak ticket prices through the official website *Amtrak.com*. We simply chose routes that could be considered both local and regional.

Amtrak Rail System				
Starting Location	**Final Destination**	**Mileage**	**$ per Coach ticket**	**$ per mile**
Houston, TX	New York City, NY	1628.46	$226.00	$0.14
Seattle, WA	Fargo, ND	1426.39	$223.00	$0.16
Orlando, FL	Springfield, MA	1058.91	$170.00	$0.16
Atlanta, GA	Kansas City, MO	801.22	$319.00	$0.40
Los Angeles, CA	Albuquerque, NM	792.68	$61.00	$0.08
El Paso, TX	Dallas, TX	569.32	$114.00	$0.20
San Francisco, CA	San Diego, CA	502.40	$65.00	$0.13
Boson, MA	Wasington, DC	456.00	$321.00	$0.70
Wilmington, DE	Westwood, MA	293.60	$336.40	$1.15
Boston, MA	Newark, NJ	233.50	$187.00	$0.80
Providence, RI	Stamford, CT	141.00	$63.00	$0.45
		Total Mileage	**Average $$ per ticket**	**Average $$ per mile**
		7903.48	$189.58	$0.40

Figure 3: People's Republic of China HSR & Shanghai Maglev

To acquire ticket prices for the People's Republic of China routes, we sourced *Chinadiscovery.com*. This site allows you to pre-purchase tickets for multiple routes throughout Asia.

People's Republic of China, Shanghai Maglev Train System (Relevant Distances)				
Starting Location	Final Destination	Mileage	$ per Coach ticket	$ per mile
Urumqi	Shanghai	2475.30	$52.00	$0.02
Beijing	Kunming	1598.00	$177.00	$0.11
Shanghai	Harbin	1472.20	$38.00	$0.03
Chengdu	Xuzhou	967.60	$135.00	$0.14
Shanghai	Guangzhou	893.40	$121.00	$0.14
Beijing	Wuhan	717.70	$21.00	$0.03
Chongqing	Xian	427.30	$55.00	$0.13
		Total Mileage	Average $$ per ticket	Average $$ per mile
		8551.50	$85.57	$0.08

Hypothesis

We hypothesize that although the overall costs per person, per mile will be less expensive because of both the reduced travel time and the overall cost per ticket, that the potential costs savings (ref pros and cons chart) associated with producing a maglev system may would NOT be enough justification to override building high-speed rail systems in the United States. We also believe that although the government may not decide to build, that private industry could possibly build routes for short distances (cities within the same state) as it may prove more cost effective than trying to build nationwide or regional maglev transportation systems. We hypothesize that this option may be easier to complete as we anticipate significant backlash from citizens using tax-payer dollars for such a lengthy and expensive project (as we've seen with the current California High Speed Rail System). Maglev construction may simply be better for private industry vs. mass transportation.

Results

The best results are detailed below with respect to…

- Total construction costs
- Average coach ticket prices
- The number of years needed to reach payback
- Return on Investment *(although negative, it was the least amount of loss throughout the life of the construction period of all the data collected)*

Peoples Republic of China	
Total construction costs per mile	$21,000,000
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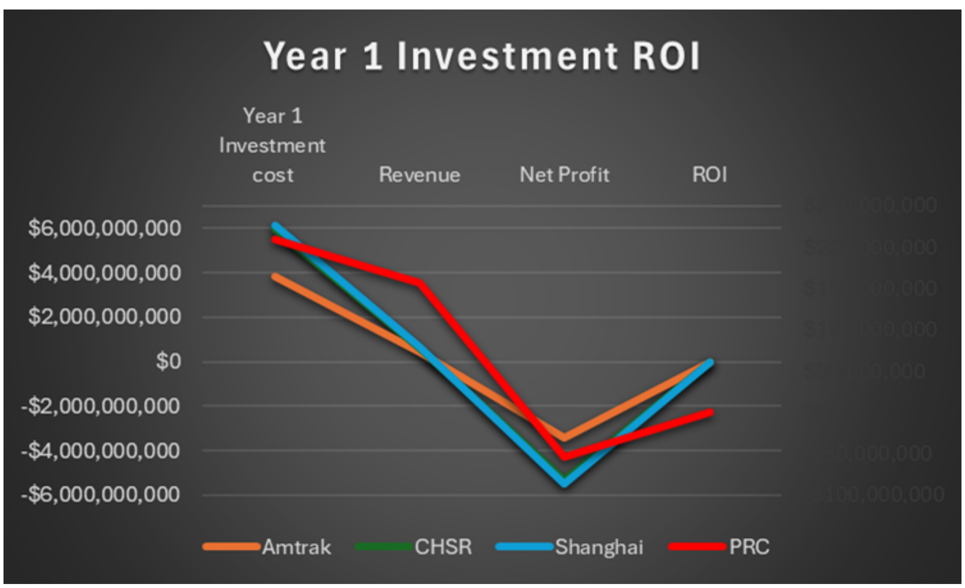

Conclusions

Factors we used to determine our results include…

- Total cost associated with building either a High-Speed Rail System or a Maglev Train System
- A standardized timeframe of 20 years to build
- The Return on Investment for each type of track both on the initial investment and annualized
- The cost per person per mile assessment
- Equal distance of 200 miles of construction

We concluded that introducing a Maglev Train System into United States is an economically smarter option vs. continuing to expand or build standard High-Speed Rail Systems. We reached this conclusion primarily from the annualized costs, return on investment, and the cost per mile differences associated between the four systems compared. Although we hypothesized differently, *the long-term costs associated with a Maglev train system has proven to be the best economical option.*

Most Significant Achievement of the Project

We honestly weren't sure where we wanted to go with this subject. We started with researching the different types of magnets but that was kind of boring. We then started working with distances and routes but had a difficult time trying to use StarLogo to help with an algorithm. We didn't realize how much math we actually knew in trying to use Excel. We had help with the formulas, but we still learned a lot as a team. We had a lot of fun doing this project!

Acknowledgements

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Kevin Walker

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