Ride the Rails!

Summary

In today's world transportation has become a major issue. As population rises, possibilities of a large public transportation system become more and more prominent. Of course, saving time is another rising issue, which is where high-speed railways come into play. High-speed railways solve both of these problems. However, the cost of building high-speed railways is what is holding it back. High-speed railways use electricity to run rather than gasoline. This makes them much more economically efficient. This will be addressed later in the solution. We are looking to build an International High-Speed Railway that will connect major cities around the United States.

In order to model the cost of building the railway, we took into factor the distance it would need to cover which was 7662.9 miles in total. This number came from the sum of all distances between the cities that the railway passed through (See diagram below). Other factors that came into the cost of the total were maintenance, labor used to build, power used to run the railway, amount of trains and cars used, and of course the track itself. We find it to be more advantageous to have three railways, two passenger railways and one freight railway, between each city; however, we left the formula up to the discretion of the user. We wrote a formula that lists variables that will be determined in any situation needed. This gives our solution flexibility and accuracy.

The speed of the railway is more than double that of the average interstate travel speed, which we will look in more detail in the following pages. This amounts up to a much faster commute; thus, allowing one not only to get to work faster but to allow one to work from farther away from their home. This improves productivity and efficiency of many companies dependent on workers. This also opens up a huge job market not only working on the railway but in distant cities one could not quickly reach by car.

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Analysis

We chose the following cities: Boston, New York, Philadelphia, Cleveland, Chicago, St. Louis, Oklahoma City, Dallas, New Orleans, Nashville, Jacksonville, Atlanta, Raleigh, Washington D.C., Kansas City, Denver, Salt Lake City, Sacramento, Los Angeles, Portland, and Seattle, because of their location, population, and tourist attraction. These cities covered 9 of the 10 High Speed International Public Railway (HSIPR) regions. The cities covered the North East region, Great Lakes region, South California region, Texas Triangle region, Piedmont Atlantic region, Front Range region, Cascadia region, Gulf Coast region, and North California region.

Due to the fact that the railway runs on electricity rather than gasoline, this makes the railway more efficient, as stated before. This makes our dependency on foreign energy less as well. Right now in today's world, the main mode of transportation over long distances is airplane, which just so happens to run on foreign bought oil. This is expensive and politically unstable for our government. With the railway running through different geographic locations, the possibilities of using different alternative energy resources are increased. Resources such as: solar, wind, and hydroelectric power, can be used to successfully power these railways. This means a clean and efficient way of travel rather than cars and airplanes. Like interstates, these high-speed railways provide a direct route to major cities at incredible speeds.

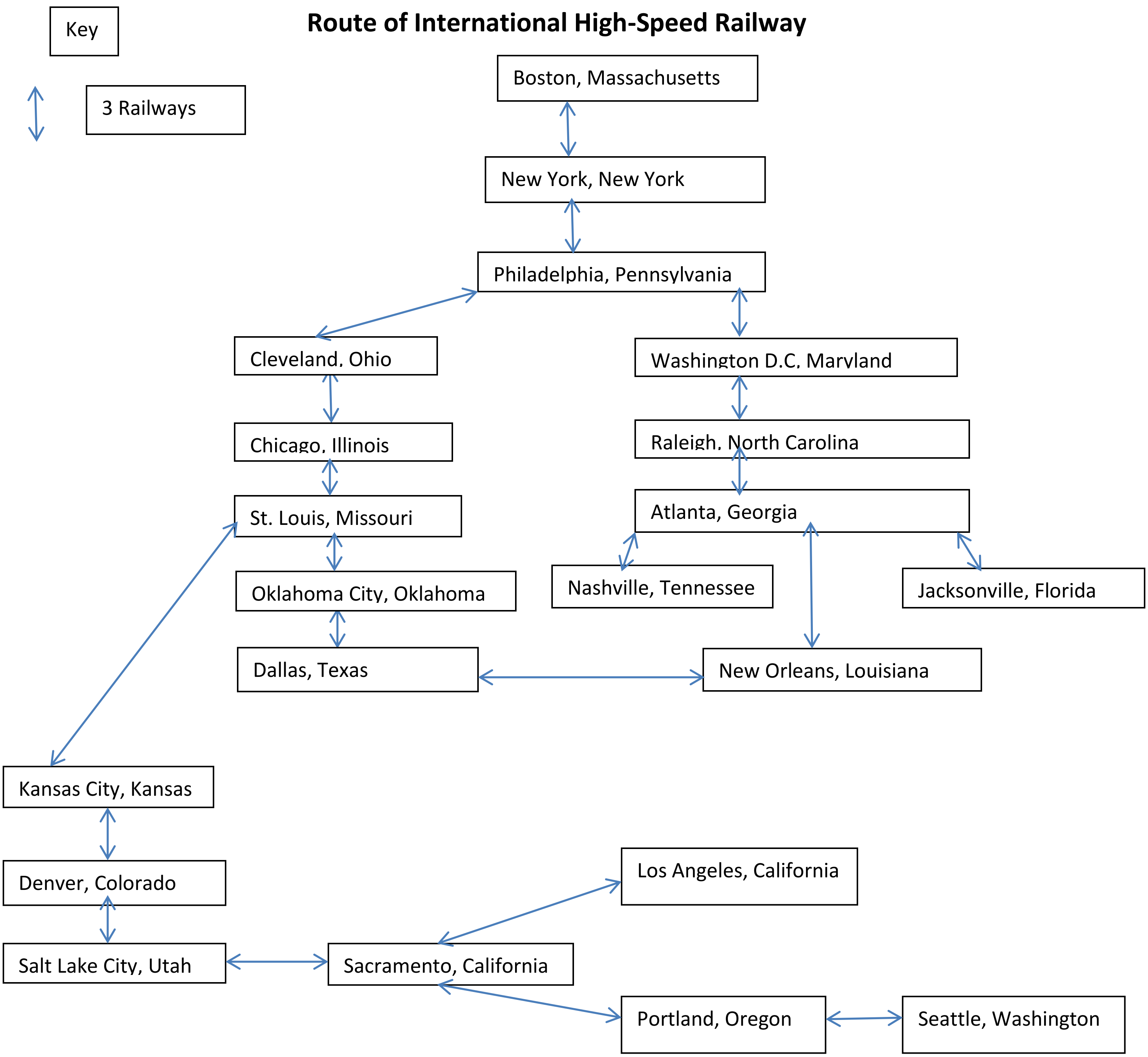
We chose the HSIPR-identified regions by their population, size, geographic location, activity, production, trade, and tourist attraction. The most prominent of these factors was population and geographic location. We found that there was very little ways to get through the Rocky Mountains and we chose a path from Salt Lake City to Sacramento that seemed to be the most direct way without causing turmoil with activist groups. This was the connection of the west coast and the Midwestern United States and ultimately connecting the West and East coasts, thus, bringing the idea of "Manifest Destiny" to its greatest point.

Restatement of the Problem

In November 2011, Congress ceased funding for HSIPR, an international highway building company, claiming it was not a lucrative business, considering the current economic conditions in the country. A need for a new and revised plan for HSIPR would have a greater chance of being passed in Congress. We have consulted together to provide the best route, most efficient build, and best reasoning for an International High-Speed Railway. We must take into consideration the following points:

- Will this mode of transportation attract passengers? How will it affect other modes of transportation?
- The cost of building the railway and all of the factors included in production. How will this affect the dependency on foreign energy that haunts our nation today?
- Finally, what regions dictated by the HSIPR are going to be used and why will they be used?

Route of International High-Speed Railway



Distances between Cities

City 1 - City 2	Distance Between (Miles)
Boston - New York	224.6
New York - Philadelphia	97
Philadelphia - Cleveland	431
Philadelphia - Washington D.C.	136.9
Washington D.C. - Raleigh	126.2
Raleigh - Atlanta	412.8
Atlanta - Nashville	249.9
Atlanta - Jacksonville	317.1
Atlanta - New Orleans	471.6
New Orleans - Dallas	518.4
Cleveland - Chicago	345
Chicago - St. Louis	296.8
St. Louis - Oklahoma City	499.7
Oklahoma City - Dallas	207.7
St. Louis, Kansas City	247.8
Kansas City - Denver	603.3
Denver - Salt Lake City	534.4
Salt Lake City - Sacramento	649.4
Sacramento - Los Angeles	384.2
Sacramento - Portland	580.2
Portland - Seattle	173.1
Total Distance Through All Cities	7662.9

The graph to the left shows the distances between major cities and the stops that the International Highway will be making on its route. This information shows the total distance between all cities and is used to determine how much track and the total cost of assembling the railways.

Average Interstate and Railway Travel Time between Cities and Difference between Travel Times

City 1 - City 2	Average Interstate Travel Time	Average High Speed Railway Travel Time	**Difference In Travel Times**
Boston - New York	3 hours 13 minutes	1 hour 27 minutes	**1 hours 46 minutes**
New York - Philadelphia	1 hour 24 minutes	38 minutes	**46 minutes**
Philadelphia - Cleveland	6 hours 7 minutes	2 hours 47 minutes	**3 hours 20 minutes**
Philadelphia - Washington D.C.	1 hour 58 minutes	53 minutes	**1 hour 5 minutes**
Washington D.C. - Raleigh	1 hour 48 minutes	49 minutes	**59 minutes**
Raleigh - Atlanta	5 hours 54 minutes	2 hours 40 minutes	**3 hours 14 minutes**
Atlanta - Nashville	3 hours 34 minutes	1 hour 37 minutes	**1 hour 57 minutes**
Atlanta - Jacksonville	4 hours 32 minutes	2 hours 3 minutes	**2 hours 49 minutes**
Atlanta - New Orleans	6 hours 44 minutes	3 hours 2 minutes	**3 hours 42 minutes**
New Orleans - Dallas	7 hours 25 minutes	3 hours 20 minutes	**4 hours 5 minutes**
Cleveland - Chicago	4 hours 56 minutes	2 hours 14 minutes	**3 hours 20 minutes**
Chicago - St. Louis	4 hours 14 minutes	1 hour 55 minutes	**2 hours 39 minutes**
St. Louis - Oklahoma City	7 hours 8 minutes	3 hours 26 minutes	**3 hours 52 minutes**
Oklahoma City - Dallas	2 hours 58 minutes	1 hour 20 minutes	**1 hour 38 minutes**
St. Louis, Kansas City	3 hours 32 minutes	1 hour 36 minutes	**1 hour 56 minutes**
Kansas City - Denver	8 hours 37 minutes	3 hours 53 minutes	**4 hours 44 minutes**
Denver - Salt Lake City	7 hours 36 minutes	3 hours 26 minutes	**4 hours 10 minutes**
Salt Lake City - Sacramento	9 hours 16 minutes	4 hours 11 minutes	**5 hours 5 minutes**
Sacramento - Los Angeles	5 hours 29 minutes	2 hours 29 minutes	**3 hours**
Sacramento - Portland	8 hours 17 minutes	3 hours 44 minutes	**4 hours 33 minutes**
Portland - Seattle	2 hours 28 minutes	1 hour 7 minutes	**1 hour 11 minutes**
Total Distance Through All Cities	108 hours 53 minutes	49 hours 11 minutes	**59 hours 42 minutes**

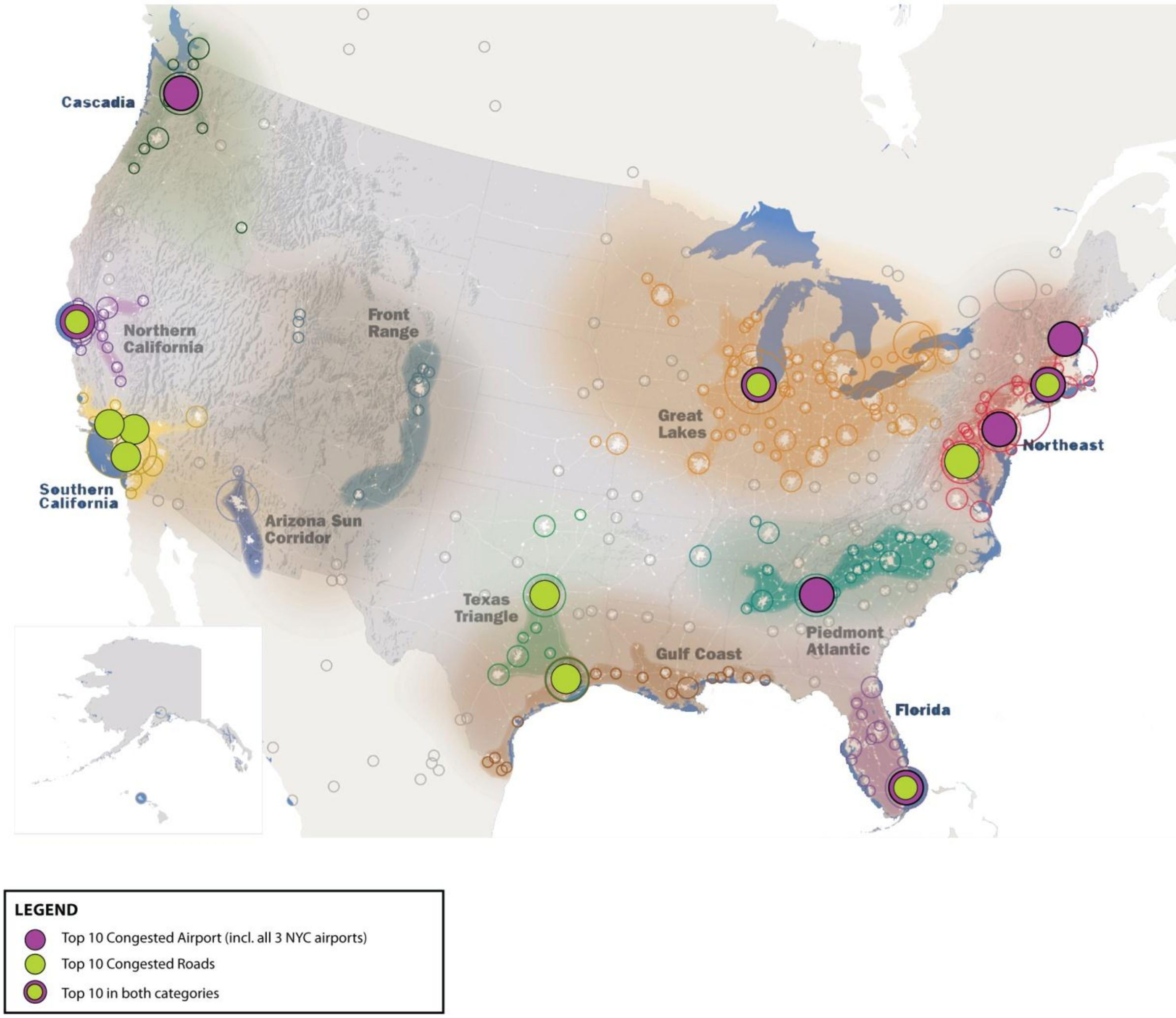
The graph above shows the relationship between traveling on the interstates versus traveling on a high-speed international railway. The average speed traveled on an interstate is 70 mph while the average speed of a high-speed railway is 155 mph. This causes a significant difference in travel time as shown on the far right hand column of the table. Because of this significant difference in travel time, more people are likely to travel on a high-speed railway; consequently, this will also open up distant job opportunities. A person wanting to work in New York that lives in Boston can commute there in 1 hour and 27 minutes by railway rather than 3 hours and 13 minutes by car.

City, Population, and Region

City	Population	HSPIR Region
Salt Lake City	181,698	Front Range
Cleveland	396,815	Front Range
Raleigh	403,892	Piedmont Atlantic
Atlanta	420,003	Piedmont Atlantic
Kansas City	459,787	Front Range
Sacramento	466,488	Northern California
New Orleans	484,674	Gulf Coast
Oklahoma City	579,999	Texas Triangle
Portland	583,776	Cascadia
Denver	600,158	Front Range
Nashville	601,222	Piedmont Atlantic
Washington D.C.	601,723	Piedmont Atlantic
Seattle	608,660	Cascadia
Boston	617,594	North East
Jacksonville	821,784	Piedmont Atlantic
St. Louis	998,881	Great Lakes
Philadelphia	1,526,006	North East
Dallas	2,377,351	Texas Triangle
Chicago	2,884,382	Great Lakes
Los Angeles	3,792,621	Southern California
New York	8,175,133	North East

HSIPR REGION RANKING	
North East	1
Great Lakes	2
South California	3
Texas Triangle	4
Piedmont Atlantic	5
Front Range	6
Cascadia	7
Gulf Coast	8
North California	9

The graph to the left shows the total populations for each city that the railway will pass through. It also shows the region in which each city lies. To the right is a ranking system for order of importance for each region, from most to least important ,to received funding based upon total population in each region.



The above map shows the United States and the regions in which HSIPR has identified as being the most heavily congested airports and roads. This helped with determining where the International High-Speed Railway should run through to attract the most passengers, make the most profit, and benefit the most people, while still being efficient.

Formula for Total Cost

Variables	Definition of Variables
T_C	Total Cost
C_T	Cost of Track Per Mile
C_P	Cost of Power Per Mile
C_m	Cost of Maintenance Per Mile
C_L	Cost of Labor Per Mile
T_P	Lead Passenger Car
T_F	Lead Freight Car
A_P	Price of Passenger Cars
A_F	Price of Freight Cars
P_0	Initial Number of Passenger Cars
F_0	Initial Number of Freight Cars
P_1	Number of Extra Passenger Cars
F_1	Number of Extra Freight Cars
d	Total Distance in Miles
T_1	Number of Railway Tracks

$$T_C = T_1 * d[C_T + C_P + C_M + C_L] + (P_0 * T_P) + (F_0 * T_F) + (P_1 * A_P) + (F_1 * A_F)$$

The information above is the formula along with a chart defining the variables used in it to determine the total cost of building the high-speed international railway. The formula takes into account all possible expenses in the material, workers, and maintenance that will be needed. From the formula you can see that the total cost of building the international high-speed railway is equal to the sum of the cost of track per mile, power per mile, maintenance per mile, and labor per mile multiplied by the distance covered by the rail from city to city and the number of railway tracks to be built. Then that is added to the product of the initial number of passenger cars and the lead passenger car, then added to the product of the initial number of freight cars and the lead freight car, then added to the product of the number of extra passenger cars and the price of each car, and then added to the product of the number of extra freight cars and the price of each freight car.

Model for Increasing Ridership

The formula below represents the increasing number of riders from its initial start over the next twenty years. The variables are listed in the table beside the formula. This formula states that the total number of riders is equal to the initial amount of riders multiplied by the exponential rate at which the amount of riders increases over time, t in years.

Variables	Definition of Variables
t	Time in Years
r	Factor of increasing value.
$\mathbf{x_g}$	Initial number of riders
$\mathbf{x_t}$	Total number of riders at t time.

$$x_t = x_0 * e^{r*t}$$

Conclusion

Overall there are many factors to deciding upon the necessity and benefits of an international high-speed railway. The factors are as follows: efficiency, price, location, and energy. The efficiency of high-speed railways is undisputable. They use a cheaper, more reliable, and cleaner energy source. This source can vary from hydro-electricity, wind energy, to solar energy, rather than depending on foreign oil as cars and airplanes find themselves doing. This changes the overall transportation system. Now people of average wealth can easily commute to far away state for jobs, family, or recreation. This also opens up a huge job market, not only on the railway itself, but it allows people to take a job in Boston while living in New York or vice versa. The cost of building this railway is dependent on many factors. The distance the railway will cover, the power needed to run the railway, maintenance of the railway, labor to build the railway, and the amounts of cars and trains that will run on the railway are all of the factors we predicted. In a matter of twenty years after the initial start of running the railway we predict an exponential increase in the ridership of people. This form of transportation is not only fast, cutting average interstate travel time in half, but it is also reliable and picturesque to passengers. The railway passes through HSIPR-identified regions of high congested airports and roads; which means, that the railway provides a way transportation and trade within a nation that is more efficient and cheaper than airplanes.

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