California High Speed Rail:

Effect of Ridership Projections on Economic and Environmental Sustainability

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Table of Contents

1.0 Executive Summary

2.0 Introduction

3.0 Conceptualization of California High Speed Rail Project

4.0 Modeling Ridership and Cost Projections for Megaprojects
4.1 How does CAHSR Fit into the Megaproject Misrepresentation Trend?

4.2 Why CAHSR is Especially Difficult to Model

5.0 Economic Sustainability
5.1 Existing Business Model Analysis
5.1.1 Existing CAHSRA Ridership Model
5.1.2 Operations and Maintenance Cost Model
5.1.3 Lifecycle Capital Cost Model

5.2 Sensitivity Analysis with Respect to Ridership and Costs
5.2.1 Data
5.2.2 Methodology and Results

6.0 Environmental Sustainability
6.1 High Speed Rail Environmental Analysis
6.1.1 Data and Methodology
6.1.2 Results

7.0 Public Perception
7.1 Content Analysis
7.1.1 Methodology
7.1.2 Results
7.1.3 Data Analysis

7.2 Link to Ridership

8.0 Conclusion

9.0 References

10.0 Appendix

1.0 Executive Summary

Overview

In 2008, California voters passed Proposition 1A (Prop 1A), which authorized the first public funds for California High Speed Rail (CAHSR). Prop1A passed on the pretense that the system would require no operational subsidies and would decrease the harmful environmental impacts of transportation in California. The project has since been both an emblem of advancement for the state and a symbol of public political frustration. Over the past nine years, project costs have doubled, deadlines have been delayed, and alignments have been renegotiated. In this report, we analyze the extent to which the evolution of the CAHSR system has allowed the promises of economic and environmental sustainability promises of Prop 1A to be met. Since these goals hinge mainly on the ridership of the future system, we analyze the development of ridership projections with respect to other megaprojects. With this analysis, we determine ridership levels needed to accomplish subsidy-free operation and environmental competitiveness with other modes of transport. Lastly, since perception will be an important factor how Californians' choose to use the system, we track how public perception has shifted as the system has developed.

Findings

- *Economic*

In our analysis of California High Speed Rail Authority (CAHSRA) ridership projections, we conduct a sensitivity analysis on how low, medium, and high ridership will affect the ability of the system to operate without subsidies, as dictated by Prop1A. Our analysis indicates that the ability to operate without subsidies is highly sensitive to the accuracy of the ridership projections.

- *Environmental*

Prop 1A promised voters that CAHSR would reduce air pollution and greenhouse gas emissions. To understand the environmental impacts of CAHSR, we analyzed a comprehensive life cycle assessment and identified what ridership is necessary to ensure environmental competitiveness with other modes of transportation.

- *Public Perception*

To study how public perception has shifted since 2008, when voters favored the CAHSR project, we conducted a content analysis on 62 related articles and searched for significant positive, negative, and neutral keywords. We found that public perception of CAHSR is strongly correlated to world events such as the California drought and the global recession.

Limitations and Future Research

Our research is largely limited because CAHSR is in such early stages of the project. Our research would be improved if our study were iterated multiple times as the project progresses.

2.0 Introduction

California is facing massive transportation challenges in the form of debilitating under capacity in airports and on roads. A high speed rail (HSR) system was proposed as new transportation choice with the potential to alleviate these problems.

When Proposition 1A (Prop 1A) was placed on the ballot in 2008, supporters detailed the promises of a potential HSR system in California. Among their arguments to voters were that such a system would be safe, convenient, reliable and affordable. Proponents argued that an HSR system would be able to operate with minimal subsidies and would reduce greenhouse gas emissions, providing an economically and environmentally sustainable transportation option.

However, shortly after Prop 1A passed, cost estimates increased rampantly and ridership projections dropped dramatically. As time has passed, even the basic characteristics of the system have evolved, including the alignment and potential date of operation. With this evolution, questions have risen about whether a future CAHSR system will match what voters approved in 2008.

In this report, we analyze the extent to which the evolution of the CAHSR system has allowed the economic and environmental sustainability promises of Prop 1A to be met. Since these goals hinge mainly on the ridership of the future system, we analyze the development of ridership projections with respect to other megaprojects. With this analysis, we determine ridership levels needed to meet the goal of subsidy-free operation and environmental competitiveness with other transport modes. Lastly, since perception will be an important factor in Californians choosing to utilize the system, we track how public perception has shifted as the system has developed.

3.0 Conceptualization of California High Speed Rail Project

California HSR is the most ambitious and developed new rail project in the United States. Governor Jerry Brown first proposed a HSR system in the early 1980's. After he left office, the idea floundered. However, in 1991, the Intermodal Surface Transportation Efficiency Act called for the designation of a high speed rail corridor that links San Diego and Los Angeles with San Francisco and Sacramento through the Central Valley. In 1996, the California High Speed Rail Authority (CAHSRA) was formed to begin planning for a ballot measure, which did not make the ballot until 2008. Nevertheless, the proposition was approved by almost 53% of voters and marked the first authorization of public monies for the CAHSR project in the form of bonds.

Since the passage of Prop 1A, the system has evolved dramatically. The links from L.A. to San Diego and the Central Valley to Sacramento have been indefinitely disregarded. The first phase to be constructed will be the Initial Operating Segment (IOS) and will link the Central Valley from Merced to the San Fernando Valley. Construction has begun on the IOS and the segment is due to be operational in 2022. The Bay to Basin segment will extend the system to San Jose in 2026. Finally, in 2028, the system will extend to the San Francisco. Transbay Transit Center and L.A. Union Station and Anaheim sharing track with Caltrain and Metrolink in these areas.

Along with the development have come detractors and challenges. Interest groups posed legal challengers to construction plans and environmental impact reports. While these challenges were initially upheld, many were ultimately overturned on appeal. The proposed alignment has been challenged by localities and environmental groups, and other groups have and will continue to challenging the environmental assessments for the project. Additionally, political and public perception challenges still remain.

There are still many details that are not yet decided. While a combination of State and Federal funding is in place for the IOS and some CA cap and trade funds have been directed to the project, the funding streams for later stages have not been confirmed.Neither the full alignment nor the exact train type nor the entity operating the system has been decided. Furthermore, the ability of the HSR to meet the ambitious trip time goals set out in Prop 1A is still undecided. Nonetheless, construction is underway on a small section of the IOS between Fresno and Bakersfield. It may face many future obstacles, but the CAHSR project is barreling down the tracks.

4.0 Modeling Ridership and Cost Projections for Megaprojects

Megaprojects are exciting. They fulfill visions, turn policymakers into stars, and lead whole regions into the future. But at what cost? Overruns, construction delays, and legal battles cast dark shadows on many of these high profile multibillion dollar undertakings. In Megaprojects and Risk, An Anatomy of Ambition, Danish infrastructure and city planning guru, Bent Flyvbjerg researches the discrepancies between megaproject promises and realities.

Much of the data gathered in his report is centered on 258 transportation megaprojects sourced from four different research studies[1]. Out of the 258 projects analyzed around the world, 90% experienced capital cost overruns. On average, the 58 rail projects analyzed had 45% cost overruns with a standard deviation of 38%.

It is clear that there is systematic error in how the finances for mega transportation projects are estimated. From Flyvbjerg's research the reasons for these inaccuracies can be summed up in two main points[2].

1. Overoptimism

Humans in general have a more positive view of the future. This phenomenon, known as cognitive bias, causes knowledgeable transportation, economics, and planning professionals to disregard lessons from past projects.

2. Strategic Misrepresentation

In the case of megaprojects and in particular transportation projects, stakeholders have significant incentive to get projects built as soon as possible despite actual usefulness to the community. Because construction timescales for megaprojects are so long, there is little accountability for politicians who deliberately push projects ahead for their own political gain.

4.2 Why CAHSR is Especially Difficult to Model

While CAHSR fits the criteria of a project that has well exceeded initial estimates, it has significant deviations from other high speed rail projects, which contribute to why it is so difficult to model. To better understand why CAHSR is exceedingly complicated to model accurately, we examine reference class forecasting, the method Flyvbjerg suggests megaprojects implement to avoid overoptimism and strategic misrepresentation. Reference class forecasting[2] was developed by economists Daniel Kahneman and Amos Tversky and can be summed up in the following three steps:

1. Identify a relevant reference class of past projects. The class must be broad enough to be statistically significant but limited enough to be comparable.

2. Establish a probability distribution for the selected reference class. This necessitates, vast amounts of empirical data within the reference class to make meaningful conclusions.

3. Compare the specific project with the reference class distribution in order to establish the most likely outcome for the specific project.

Step one, identifying a reference class of past projects, is particularly difficult in the case of CAHSR. In 2008, Californians voted to pass Proposition 1A which mandates that the CAHSR operational costs are completely self funded. This is not the criteria for success of other high speed rail projects such as Shinkansen in Japan. These projects were built more out of the ambition of a national project and had no promise of operational independence. For this reason, it is not possible to find other high speed rail projects that are truly comparable to CAHSR in the they way they are being funded.

It is also infeasible to identify projects with a similar ridership base as CAHSR. Besides Acela Express in the Northeast Corridor, the very fast but not "high speed" train, CASHR will be the first high speed rail project in the United States. Compared to other countries that currently have successful high speed rail, Americans are significantly less accustomed to using rail to travel. According the the International Union of Railways data[3] displayed in Figure 1, the US had just 1% of the world passenger kilometers share in 2011. Even Acela Express, which serves a ridership base with the highest rates of rail usage in the US, has experienced ridership that fell short of estimates during initial operation. Due to the lack of similarly funded projects with a similar ridership base, it is infeasible to compile a reference class for CAHSR that is comprehensive enough to be significant but narrow enough to be comparable.Without establishing a proper reference class, it is impossible to carry out Flyvbjerg's recommendations for accurate ridership and cost projections.

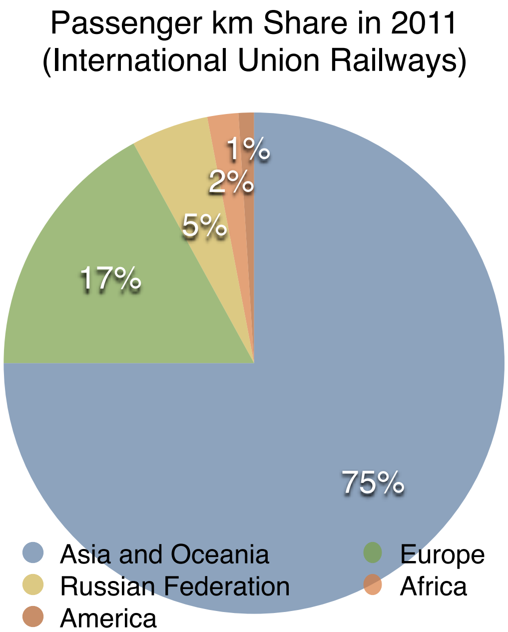

Figure 1

Due to the limitations of data surrounding existing high speed rail projects, we decided to develop our estimates based on CAHSR Authority's cost and ridership data. We believe, that the Authority's projections are sufficiently rigorously developed, due to their independent oversight. Nevertheless, we still view the authority's projects with some skepticism given the inevitable roles that overoptimism and strategic representation play in the planning of high profile, high stakes megaprojects. However, we account for this skepticism, by conducting a sensitivity analysis on the Authority's data and compile more realistic picture of their findings.

5.0 Economic Sustainability

Given the results of our literature review, we believed it was prudent to explore the effects of overestimated ridership values and underestimated costs on the Prop1A statement that the CAHSR will require no operational subsidies.

5.1 Existing Business Model Analysis

The CAHSRA projected business model relies on three main models to project cash flows when the system enters operations: the Ridership and Revenue Forecasting model, the Operations and Maintenance Cost model, and the Lifecycle Capital Cost model.

5.1.1 Revenue and Ridership Model:

To compose their business plan, CAHSRA commissioned a ridership and revenue forecast model.[5] The most recent model, developed in 2013, was reformulated to incorporate new details regarding the development of the system, as well as criticisms of previous models. In response to a legal requirement of the authority dictated by CA AB528, the forecast model incorporated high, medium, and low projections of ridership, constituting a form of sensitivity analysis. These ridership scenarios correspond to a 75%, 50%, and 25% probability, respectively, that ridership will fall below the scenarios' level.

In developing the ridership model, CAHSRA argued that projected revenue was highly correlated to projected ridership. Accordingly, the authority developed a model for projecting revenue, and used what they considered to be average fares to determine the associated ridership. To project revenue, the modelers combined trip frequency, destination choice, and mode choice models with the associated available data. In creating these models, the authority made assumptions regarding the following factors: auto operating costs, air fares, socioeconomic factors (growth in total population, households, and employments and associated spatial distribution), a HSR mode choice constant, and a trip frequency model constant. To make the revenue projections, the modelers developed a regression equation that relates these factors to revenue, and used this equation in a Monte Carlo simulation.

It is important to note that the Monte Carlo simulation also included potential risk factors regarding expectations for California development (demographically and fiscally), transportation system changes with respect to automobile and air travel, and model related risks that address the expected use and impacts of the introduction of HSR. Thus, the simulation allowed for revenue probability distributions based on combinations of these risks. These distributions are the basis for their high, medium and low revenue projections.

In addition to revenue from fares (fare box revenues), the authority also anticipates ancillary revenue sources such as commercial development, parking, on-board services, advertising, third party use of right-of-way, et cetera. To determine the extent of these revenues, the CAHSRA reviewed public information available from U.S., Asian, and European HSR systems. They found that these supplementary revenues compose 3-30% of net revenue. For their analysis, the CAHSRA used a relatively conservative value of 4%.

As the Authority enhanced the revenue model from the last business plan, ridership expectations have increased by 25%, but projected revenue has decreased by 10%. This dichotomy is due to lower projections for business travel and shorter average trips, and thus fares.

5.1.2 Operations Cost Model

To test the system's "ability to meet the requirements of Prop 1A to operate without a subsidy[6]," the Authority developed an operation and maintenance (O&M) model. The model is based on the current CAHSR system details and assumptions regarding its operation. It details the cost of train and station operations, maintenance of equipment and infrastructure, security, commercial operations, and general and administrative functions. In creating the model, the Authority relied on best practices as dictated by the U.S. DOT Inspector General and HSR expertise, experience, and estimates.

The O&M model provides high and low cost scenarios based on changes in assumptions to the medium (base case) scenario for a less or more efficient private sector operator. Paired with the revenue/ridership model and the capital cost model, the O&M model should allow for a projection of necessary subsidies to operate the system.

This model should be viewed with reasonable skepticism as major HSR system details, such as the entity responsible for operation, have yet to be fully developed.

5.1.3 Lifecycle Capital Cost Model

The lifecycle capital cost model[7] estimates the cost of capital rehabilitation and replacement costs of the infrastructure and assets of the CAHSR system. The model considers rehabilitation and replacement costs for all of the asset categories, including track structures, stations, support facilities, communications and signaling, and vehicles and their propulsion systems. By relying on industry standards, experience and expertise, the model estimates the composition of each asset category and the necessary rehabilitation and replacement schedules and costs and arrives at an order of magnitude cost estimate over a fifty year timeline.

It should be noted that since many system details are not defined, the model represents the best estimate of these costs given the current state of the system. Also, since many of these assets are far from entering service, the model should only be used for rough estimation purposes.

5.2 Sensitivity Analysis with Respect to Ridership and Costs

Given the results of our literature review, we believed it was prudent to explore the effects of overestimated ridership values and underestimated costs on the Prop1A statement that the CAHSR will require no operational subsidies.

5.2.1 Data Sources

To explore this question, we performed a series of sensitivity analyses using data from the CAHSRA that estimated potential cash flows from the HSR system using their high, medium, and low projections for ridership (and revenue), operational costs and capital replacement costs. To neglect possible variations of inflation rates, the data is computed in constant dollars relative to 2013. Most of the analysis was performed with low revenue/ridership projections given the findings of the literature review.

5.2.2 Methodology and Results

In the CAHSRA-provided estimated cash flows, CAHSRA only computes cash flows with high revenues matched with high costs, medium revenues matched with medium costs, et cetera. A more sensible method of analysis is to match low revenue expectations with the highest projected costs. When this is tabulated (Figure 2) using the given data, it is clear that some early years of the IOS will require an operational subsidy, mainly due to the ramp-up period. As the system is constructed through Phase 1, the lowest revenue projections easily overcome the highest operational and capital replacement costs.

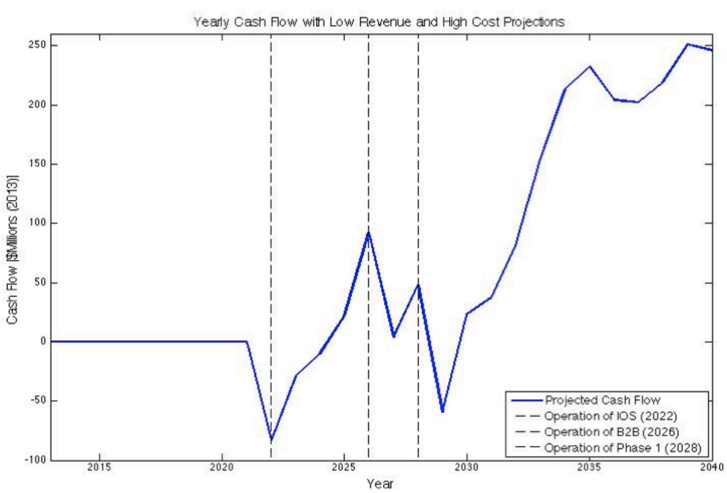

Figure 2

Maximum Deficit (2022)	$-83 million
Sum of Cash Flow (2022-2040)	$1.85 billion

Table 1

In their modeling of operational costs, CAHSRA performed a review of publicly available data regarding operating cost deviations from plan of rail projects constructed relatively recently. While none of the projects match the large scope of CAHSR, they used the cost variance data (below) to construct probabilistic sensitivity models for the operating costs of the project.[4] The magnitudes of these variations are captured in the sensitivity analysis on operation costs performed by CAHSRA

Deviation of Operations from Plan - Related Projects	
Median	5%
Mean	12%
Max	34%

Table 2

Deviation of Sensitivity Level from CAHSRA Medium Operations Cost	
High	+12.58%
Low	-10.4%

Table 3

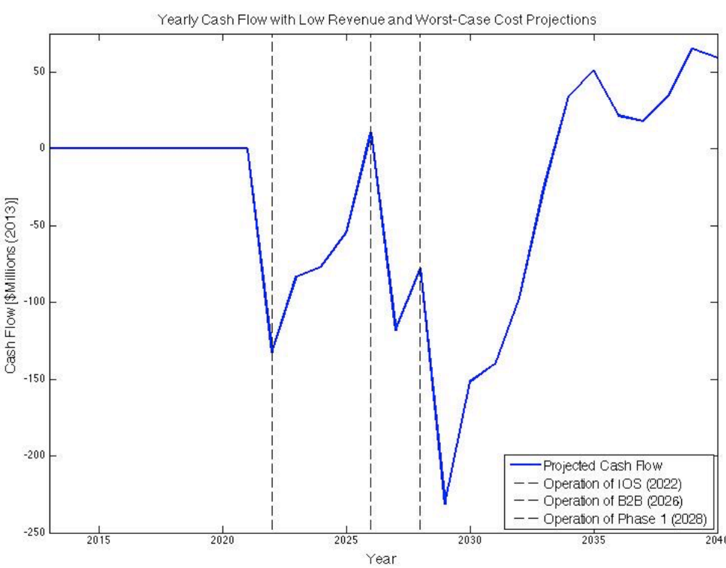

Figure 3

Since the high operations cost case projected by the CAHSRA does not reach the maximum variance of other projects, an analysis was performed to determine the extent of operation subsidies necessary in this worst case scenario with maximum variances from cost projections and minimum revenue expectations. Nearly $900 million in subsidies will be needed to operate the system through 2040.

Maximum Deficit (2022)	$-231 million
Sum of Cash Flow (2022-2040)	$-895 million

Table 4

To operate the system without subsidies under low revenue assumptions, the maximum allowable deviation from projected medium operating costs is 27%, which is within the boundaries of related projects.

The literature review regarding accuracy of ridership projections indicates that actual traffic for rail projects was 51% lower than forecasted on average, with a 95% confidence interval of 40% to 63% lower than projected.[4] With this information, we performed a sensitivity analysis to determine the allowable extent of overestimation for the CAHSRA projected ridership scenarios. That is, the extent to which each of these scenarios can be over projected and still meet the highest CAHSRA operating and capital replacement costs without requiring an operational subsidy.

Maximum Deviation from Projected ridership before Subsidies are Required	
Low Ridership Scenario	5%
Medium Ridership Scenario	26%
High Ridership Scenario	43%

Table 5

This analysis indicates that the ability to operate without subsidies is highly sensitive to the accuracy of the ridership projections. A variation of even 5% from the projected low ridership would necessitate operational subsidies. Given the results of the literature, it is imperative that the ridership projections be accurate in order to uphold the promise of no operational subsidies. This is especially true given that actual costs may be higher than even the highest projections.

It is important to note that since this analysis explores the feasibility of operating HSR without subsidies, the initial capital cost to construct the system is ignored. When Prop1A was passed, it was well established that the public would be responsible for a significant portion of the construction costs. Additionally, while data is projected out to 2060, our analysis period extends only until 2040, at which point Phase 1 is projected to be in operation for 10 years. Beyond this period, we believe there may be significant changes relative to the assumptions made by the Authority for projections.

6.0 Environmental Sustainability

In voting materials regarding Prop 1A, voters were promised that CAHSR would reduce air pollution and greenhouse gas emissions. The proponents argued that electric powered trains would remove over 12 billion pounds of carbon dioxide, and have energy requirements that are a fifth of auto travel and a third of air travel. Professors Mikhail Chester and Arpad Horvath, of Arizona State University and UC Berkeley, respectively, have challenged these assertions with their life cycle assessment (LCA) of CAHSR.

6.1 High Speed Rail Environmental Analysis

The purpose of the LCA is to quantify the energy inputs and greenhouse gas emissions of the construction, operation, and maintenance of the entire HSR system. These life-cycle stages have significant implications on the environmental profile of the system. For example, the infrastructure construction and electricity production needed for the system, "adds forty percent to the energy consumed by the trains' operations alone."[8] 2010) And due to the carbon footprint of cement production, including the construction phase in accounting for the HSR environmental impact increases greenhouse gas (GHG) emissions by fifteen percent. Without including these life-cycle impacts, its impossible to quantify the true effect that creating the HSR system will have on the environment.

In their comprehensive LCA of CAHSR, Chester and Horvath compare the impacts of HSR with automobiles and aircraft.[9] Our analysis utilizes the data provided from their LCA to determine the ridership of HSR that makes the system environmentally competitive with the two other modes, and fulfills the nature of the promises made in Prop1A.[10]

6.1.1 Data and Methodology

Chester and Horvath performed the LCA under various scenarios using passenger mile traveled (PMT) as their functional unit. Firstly, their data contains different electricity profiles for propelling the train represented by: the current electricity mix of the California grid, a 2020 electricity mix that satisfies the RPS goals of 33% renewable electricity, a hypothetical 2040 mix with 60% of current emissions, and an ambitious plan proposed by the CAHSRA to power the train with 80%/20% renewable wind/solar.

Also, the authors include different train sizes (by number of total seats), with options for 400, 670, and 1200 seats. According to the authors, most European and Japanese trains have 600 or fewer seats, so we excluded the 1200 seat train. Additionally, the CAHSRA released a request for proposal for trains that called for a minimum of 450 seats.[11] Thus, we considered only the 670 seat option as it best embodies current technology and technical requirements of the CAHSRA.

For comparison purposes, the authors included three alternative automobiles, a 35mpg sedan, a 55mpg sedan, and a PHEV that can travel 60 miles on grid electricity. We utilized the latter two, as we believe them to be a good representation of future vehicle development given State and Federal policy, namely CAFE standards. Additionally, the authors included three aircraft, of which we chose the Boeing 737-800. This aircraft represents the most advanced model, and is likely to be used well into the operation of the HSR system.

Using the four different electricity profiles, combined with the two train sizes, we determined the ridership ratio (passengers/number of seats) of HSR to break even environmentally with automobile and aircraft, each with a given ridership ratio that is fixed. For ridership ratios of automobiles we included one and five passenger scenarios for each vehicle. For the ridership of airplanes, we reference the MIT Airline Data Project, which gives an average ridership ratio of 85% for all airlines in 2013.[12]

Our analysis looks specifically four environmental and health lifecycle impacts: Energy consumption [MJ/PMT], GHG emissions [grams $CO_{2(eq)}$/PMT], Acidification potential [mg $SO_{2(eq)}$/PMT], PM2.5 [mg/PMT]. We believed these to be representative of pertinent environmental and health impacts of transportation activities.

6.1.2 Results

The plots in Figure 4 illustrate the environmental impacts of California HSR versus the two other transportation modes. It is important to note that the horizontal axis refers only to the ridership ratio of the HSR system. The ridership ratios for other modes are fixed as determined above.

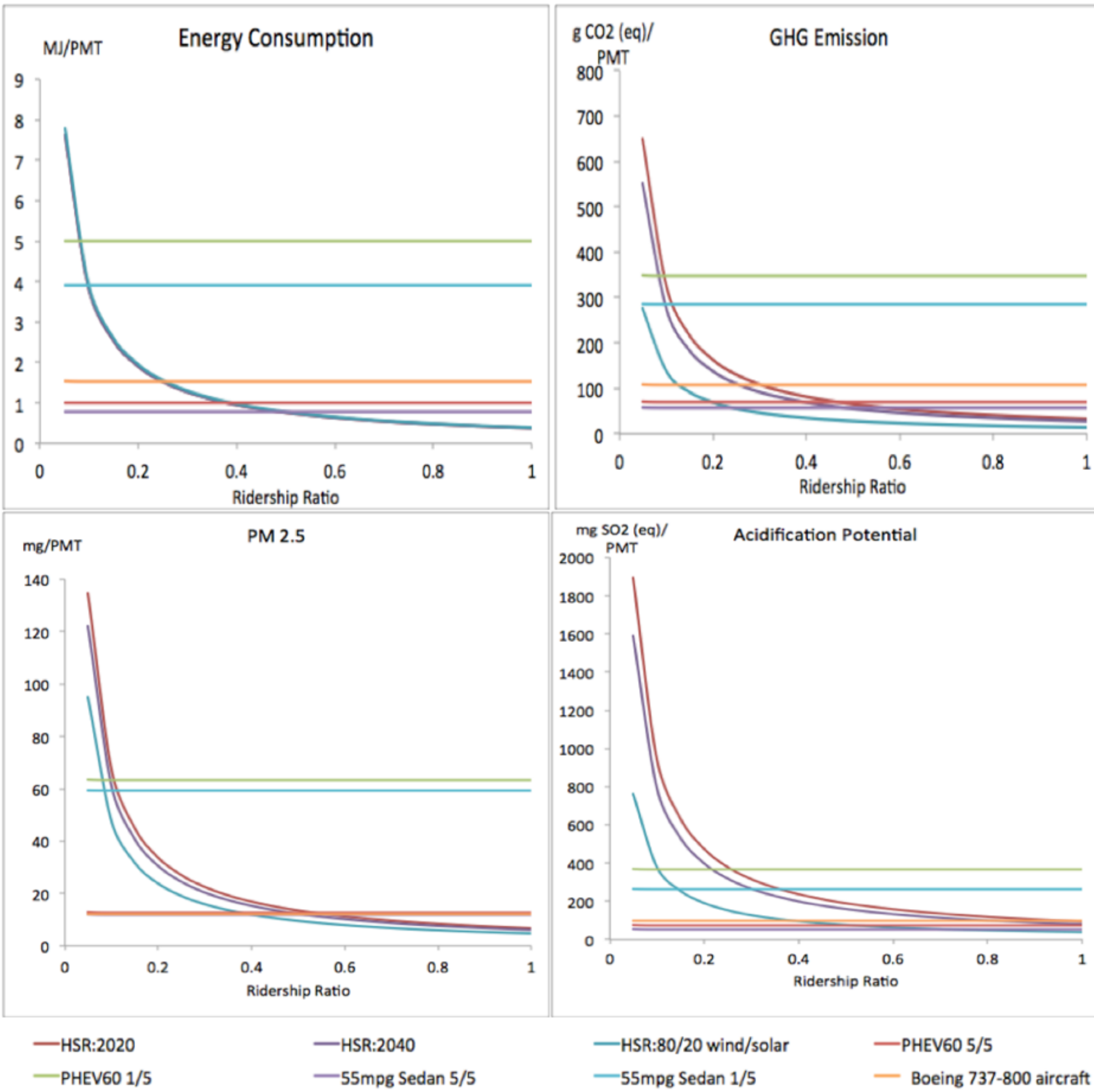

Figure 4

Energy Consumption	2020 RPS Grid	2040 Grid	80/20 Wind/Solar
PHEV60 5/5	0.38	0.38	0.39
PHEV60 1/5	0.08	0.08	0.08
55mpg Sedan 5/5	0.49	0.49	0.5
55mpg Sedan 1/5	0.1	0.1	0.1
737-800	0.25	0.25	0.25

GHG Emission	2020 RPS Grid	2040 Grid	80/20 Wind/Solar
PHEV60 5/5	0.47	0.4	0.2
PHEV60 1/5	0.09	0.08	0.04
55mpg Sedan 5/5	0.57	0.48	0.24
55mpg Sedan 1/5	0.11	0.1	0.05
737-800	0.3	0.26	0.13

Acidification Potential	2020 RPS Grid	2040 Grid	80/20 Wind/Solar
PHEV60 5/5	1.29	1.08	0.52
PHEV60 1/5	0.26	0.22	0.1
55mpg Sedan 5/5	1.8	1.52	0.73
55mpg Sedan 1/5	0.36	0.3	0.15
737-800	0.96	0.81	0.39

PM 2.5	2020 RPS Grid	2040 Grid	80/20 Wind/Solar
PHEV60 5/5	0.53	0.48	0.38
PHEV60 1/5	0.11	0.1	0.08
55mpg Sedan 5/5	0.57	0.51	0.4
55mpg Sedan 1/5	0.11	0.1	0.08
737-800	0.56	0.5	0.39

Table 6

First off, analyzing the energy requirements of HSR against the alternatives, the statements within Prop1A are fairly accurate. The HSR uses the stated 1/5 of the energy required for automobiles if the vehicles have an average of 2.2 passengers. Also, the HSR uses the stated 1/3 of required energy for aircrafts even if the aircraft ridership ratio is 100%.

From the analysis, it is clear that the method of electricity generation to propel the train significantly affects its environmental competitiveness with the other transportation modes. As the grid gets cleaner, the break-even ridership ratio of HSR with respect to GHG emissions decreases by about 40% for both other modes regardless of automobile or aircraft ridership. Acidification Potential and PM2.5 emissions follow a similar trend.

One interesting factor is Acidification Potential. A very high ridership ratio of HSR is required to break-even with aircraft, with an 85% ridership ratio, and automobiles, with a full vehicle. For this metric, HSR will not break even until the electricity generation reaches the 80/20 wind/solar scenario. Since this electricity scenario is decades away, it is fair to assume that HSR will have a greater contribution to acid rain than the other modes with high ridership.

These results indicate that switching passengers from aircraft and automobiles, especially those with low ridership, would be helpful in mitigating some of the environmental effects of transportation in California.

Lastly, it is important to note that no link can be drawn between these ridership ratios and future ridership projections. These ratios correspond only to the number of passengers per number of seats on a given train, whereas the ridership projections detail the total number of passengers per year. It is likely that the capacity of the system will slightly exceed demand, so that the system can transport additional passengers as ridership increases. With this situation, some trains will likely run below a perfect occupancy ratio of one. While this analysis allows some environmental comparison between the three transportation modes, it is impossible to make a full comparison until the HSR system is operational.

7.0 Public Perception

7.1 Content Analysis

Since CAHSR is a public megaproject, public approval is a central component of both successfully physically completing the project and providing meaningful environmental and economic benefits through adequate ridership. The purpose of this area of research was to determine how public perception with respect to CAHSR varied over time, and what major events and conflicts caused public perception shifts. Content analysis was identified as a means of tracking and identifying some of the reasons for which public support wavered or strengthened during the time period from when Proposition 1A was passed until the present.

7.1.1 Methodology

The basic methodology was developed by determining key governing factors to limit the scope of analysis. To avoid undesired bias, media gathered was from a variety of sources including news articles and CAHSRA-published material, as well as over the period of time from 2008 to the present. Articles and reports were gathered through Google searches targeting different time frames, and from different sources to avoid unnecessary bias induced by publishers. Each article or report was evaluated after being selected as a data source as having a negative, neutral, or positive bias.

The second aspect of developing the scope of this content analysis was determining key words and phrases used frequently enough to be common across most content while still differing in frequency as a function of public perception. Singular and plural forms of words were considered the same in this analysis. The lists below display both the words and phrases that were originally used in the analysis as well as an additional twelve which were added after one iteration to supplement words already chosen, giving a total of forty-one key words/phrases.

Words and Phrases Initially Used in Analysis

Renewable Energy	Abundance	Compromise	Driving
Existing	Risks	Politics	Affordable
Infrastructure	Connections	Political	Federal Funding
Travel/Trip Times	Partnerships	Have Capacity	Sustainable
Political Pressure	Revenue	Low Ridership	Communities
Private Investors	Costs	High Ridership	Lawsuits
Energy Consumption	Benefits	Sustainability	Land
Jobs	Feasible	Economy	

Words and Phrases Initially Added in the Second Iteration of Analysis

Subsidy	Drought	Investment	Traffic
Water	Taxpayers	Food	Legacy
Environmental	Estimates	Congestion	Emissions

Once key words/phrases were identified, code was written to detect the frequency of each identifier. This code was rigorously tested across multiple passages of lengths from one paragraph to three-page documents to insure the validity of its counting scheme. Counts were verified by manually counting occurrences. The counter was designed to incorporate the title of each article or publication, as news headers are typically carefully crafted to catch the reader's attention based on current events. To account for the difference in length of media studied, final frequency counts were normalized by article length, requiring that the counting code determine the total number of words in the publication in addition to the frequencies of each identified key word/phrase. Once raw data was collected, it was reduced and analyzed to track public perception trends over time and identify keyword frequency within each bias type.

7.1.2 Results

Initial data reduction and analysis looked at data as a whole to determine how representative it could be determined to be of overall public bias towards or against CAHSR. It also determined the most prevalent key words and phrases during the entire time period studied for all articles, CAHSRA-published work, and each bias type. Further analysis examined how key words and phrases changed over time.

7.1.2.1 All Articles over All Time

Figures 5-6 (below) show the distribution of bias in the entire sample surveyed over the whole time period with respect to number of articles as well as with respect to word count.

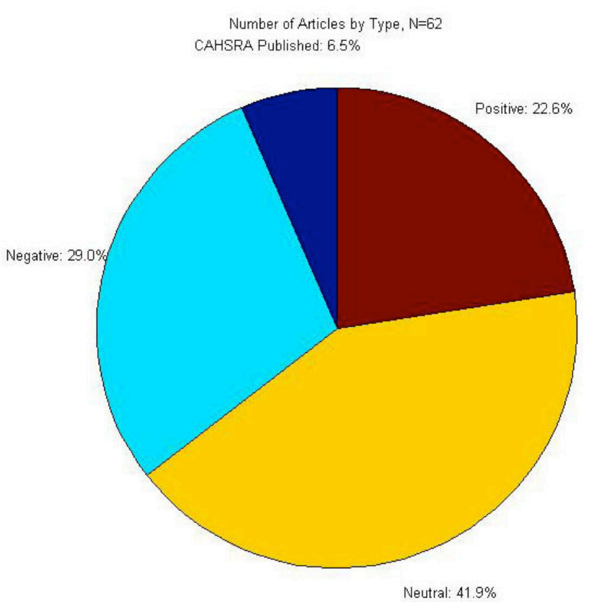

Figure 5

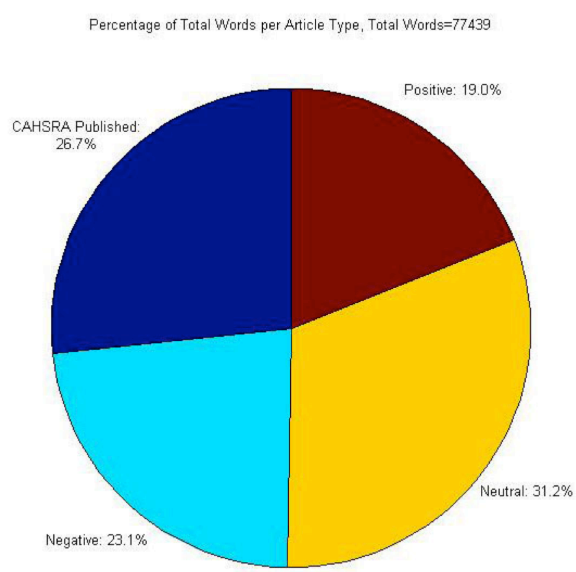

Figure 6

Table 7 (below) gives the three most frequent words or phrases in each bias type, across all media, and in CAHSRA-published material, over all time (2008-2015), as a normalized frequency.

Media Type	Most Common Word/Phrase and Frequency		2nd Most Common Word/Phrase and Frequency		3rd Most Common Word/Phrase and Frequency		Total Words
CAHSRA-Published	renewable energy	4.94e-3	cost[s]	4.46e-3	sustainability	3.20e-3	20651
Negative	cost[s]	2.13e-3	jobs	1.62e-3	water	1.57e-3	17866
Neutral	cost[s]	3.35e-3	environment[al]	1.20e-3	benefit[s]	8.27e-3	24192
Positive	benefit[s]	1.84e-3	environment[al]	1.43e-3	cost[s] emission[s]	1.02e-3 1.02e-3	14730
All Media	cost[s]	2.92e-3	renewable energy	1.32e-3	benefit[s]	1.06e-3	77439

Table 7

7.1.2.2 Time Variant Data

Figure 7 (below) shows how public perception with respect to CAHSR changed over time by tracking the percent of articles with each bias type by year.

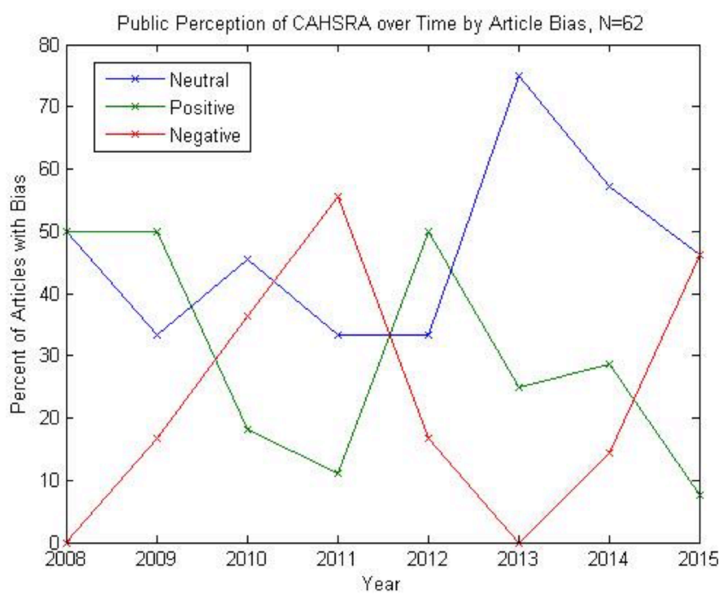

Figure 7

Table 8 (below) gives the three most frequent words or phrases in each bias type, across all media, and in CAHSRA-published material, in 2008-2009, as a normalized frequency.

Media Type	Most Common Word/Phrase and Frequency		2nd Most Common Word/Phrase and Frequency		3rd Most Common Word/Phrase and Frequency		Total Words
CAHSRA-Published	cost[s]	7.69e-3	renewable energy	7.00e-3	benefit[s]	1.03e-3	8712
Negative	environment[al]	5.40e-3	cost[s]	4.32e-3	emission[s]	3.24e-3	926
Neutral	cost[s]	9.06e-6	benefit[s]	4.38e-6	environment[al]	2.09e-6	2738
Positive	benefit[s]	3.24e-6	emission[s]	1.80e-6	environment[al]	1.66e-6	6117
All Media	cost[s]	2.21e-6	benefit[s]	1.83e-6	environment[al]	1.17e-6	18493

Table 8

Table 9 (below) gives the three most frequent words or phrases in each bias type, across all media, and in CAHSRA-published material, in 2010-2011, as a normalized frequency.

Media Type	Most Common Word/Phrase and Frequency		2nd Most Common Word/Phrase and Frequency		3rd Most Common Word/Phrase and Frequency		Total Words
CAHSRA-Published	sustainability	2.61e-3	environment[al]	2.36e-3	cost[s]	2.24e-3	8044
Negative	cost[s]	2.92e-6	jobs	2.41e-6	environment[al]	1.61e-6	8618
Neutral	cost[s]	2.28e-6	jobs	1.12e-6	benefit[s]	1.05e-6	6451
Positive	cost[s]	1.69e-6	jobs	1.20e-6	federal funding	9.96e-7	3601
All Media	cost[s]	1.86e-6	jobs	1.26e-6	environment[al]	7.39e-7	25857

Table 9

Table 10 (below) gives the three most frequent words or phrases in each bias type, across all media, and in CAHSRA-published material, in 2012-2013, as a normalized frequency.

Media Type	Most Common Word/Phrase and Frequency		2nd Most Common Word/Phrase and Frequency		3rd Most Common Word/Phrase and Frequency		Total Words
CAHSRA-Published	sustainability	1.43e-3	environment[al]	4.78e-3	emission[s]	2.55e-3	3136
Negative	economy	6.23e-4	environment[al]	6.23e-4	driving lawsuit[s]	6.23e-4 6.23e-4	1604
Neutral	cost[s]	3.08e-6	travel/trip times	1.05e-6	jobs	7.12e-7	4618
Positive	lawsuit[s]	3.46e-6	environment[al]	2.07e-6	politics	1.32e-6	2478
All Media	sustainability	1.21e-6	lawsuit[s]	1.01e-6	environment[al]	8.92e-7	11836

Table 10

Table 11 (below) gives the three most frequent words or phrases in each bias type, across all media, and in CAHSRA-published material, in 2014-2015, as a normalized frequency.

Media Type	Most Common Word/Phrase and Frequency		2nd Most Common Word/Phrase and Frequency		3rd Most Common Word/Phrase and Frequency		Total Words
CAHSRA-Published	renewable energy	3.03e-2	feasible	2.64e-3	water have capacity abundance	1.32e-3 1.32e-3 1.32e-3	759
Negative	water	4.42e-6	land	2.25e-6	cost[s]	2.05e-6	6738
Neutral	cost[s]	2.83e-6	environment[al]	2.28e-6	land	1.65e-6	10385
Positive	water	5.23e-6	land	4.14e-6	drought	2.79e-6	2514
All Media	cost[s]	2.19e-6	water	2.17e-6	land	2.09e-6	20396

Table 11

7.1.3 Data Analysis

Data reduction was designed to identify trends in public perception over time as various groups lobbied for and against HSR's success. Section 7.1.2.1 begins this reduction by providing information regarding all articles over all time. The validity of the data range was determined by identifying the percentage of media pieces and the percentage of words corresponding to each media type, shown in Figures 5 and 6. While Figure 5 seems to indicate that there is inadequate representation across all media types, Figure 6 shows that when the total number of words of each media type is considered, the sample size is reasonably similar for each media type and can be considered representative of the Californian mindset as a whole.

The three most common words/phrases, their frequencies, and total word counts for each media type as well as for all media types are identified in Table 7 in Section 7.1.2.1. Appendix A contains a complete breakdown of frequencies of all key terms over all time. It comes as no surprise that the word 'cost[s]' occurs in the top frequencies for every category, as this word encompasses both monetary, land, and societal ramifications of actions. It is impossible to frame any dialogue regarding a megaproject without either justifying or condemning resulting costs. Environmental-type taglines such as 'renewable energy', 'sustainability', and 'environmental' make few appearances in this list, indicating that the prevailing concerns in voters' minds focus on economic considerations. This is somewhat surprising for a state known to focus on sustainability and environmentalism, but can be easily be explained by the economic and political factors during this time period. From approximately late 2007-mid 2009, the Great Recession caused panic throughout the world as food and oil prices soared in light of instability in major financial institutions. Consequently, even green-minded Californians cannot ignore even slightly unfavorable economics of megaprojects.

Section 7.1.2.2 analyzes data by time variance. Figure 7 summarizes how public perception has changed over time. Public perception suffered the most in the years 2010-11, corresponding to the point in time when funding for the project was nearly pulled. During this time, concerns over the validity of federal funding awards and increasing costs coupled with dramatic increases in the number of open lawsuits led to mistrust of the project's success. The most prevalent words publicized during this time period included 'cost[s]' and 'jobs', alluding to a deep distrust among California residents towards the state's ability to create an adequately beneficial HSR system to outweigh ever-increasing social and economic costs. Table 9 summarizes other words frequently used by media during this time period.

Perception improved from 2012-3, ultimately allowing contract awards and groundbreaking in early 2015. During this time period, the dialogue shifted to focus on ongoing lawsuits regarding land use and federal funding, leading to a more diverse set of common words and phrases. 'Environmental' was among the top three words/phrases in four out of five categories (shown in Table 10), suggesting that improvements in the economy were leading to a marginally greater public acceptance of high risk associated with mitigating environmental problems.

In the last two years, negativity dominated public perception as Californians demanded that taxpayer money be spent to address increasing implications of the drought, which began during the 2012-3 rainy season. As a result, dominating words and phrases during this time period centered on 'land', 'water', and 'costs'. Table 11 shows the exact breakdown of which media types focused on which issues. If public perception continues on this trend, CAHSRA runs the risk of losing public support, and consequently risks the project never becoming a reality.

7.2 Link to Ridership

To achieve the goals of providing an affordable environmentally-friendly alternative to driving or flying between destinations in the Los Angeles-San Francisco/Sacramento corridor, CAHSR must maintain an adequately high ridership as discussed in Sections 5.0 and 6.0. Public perception clearly plays a major role in determining ridership levels, which determines the success of CAHSR in meeting the objectives outlined in Prop 1A. Initially, public perception of CAHSR was reasonably positive, as indicated by the passage of Prop 1A - of 12.7 million voters, 52.7% voted 'yes' while 47.3% voted 'no.' As external factors stress economics and other challenges faced by the average resident in everyday life, it is clear that Californians will reprioritize the most important allocations of their taxpayer dollars, ultimately affecting the guarantee of future funding for this megaproject.

8.0 Conclusion

From our analysis of different factors affecting the success of CAHSR, we have concluded that many of changes from the initial conception of CAHSR required to practically develop a functional system have significantly impacted the HSR system's ability to meet the objectives outlined in Prop 1A. The segmentation of this megaproject may provide a sensible method of creating a statewide HSR system. Its flexibility provides a means for altering later construction packages and plans by learning from mistakes in earlier construction packages. The lack of definition in exact plans placed a major limitation on the validity of research conducted to track the viability of CAHSR to meet the goals of Prop 1A, indicating that results must be considered within this framework. Future work in reiterating these analyses as the details of the system develop may allow more sound conclusions in determining the viability of Prop1A goals

Limitations for each specific study type stemmed primarily from the loose bounds governing the structure of CAHSR, and consequently resulted in more general conclusions than desired. Studies critiquing implementation of other global megaprojects indicate that ridership projections will almost certainly exceed those published by the CAHSRA; however, due to lack of information and inability to rigorously relate the proposed HSR system to existing systems, ridership projections from CAHSRA were used in our analyses. Based on this uncertainty, we performed a sensitivity analysis to look at different ridership levels to identify how sensitive providing a subsidy-free system was to accuracy in ridership projections in each level. It was determined that for the lowest ridership scenario, deviations from expectations of as little as 5% would result in the need for subsidies, and that in the highest ridership scenario, deviations could be as large as 43% before operational subsidies were required.

Environmental analyses found that Prop 1A commitments generally sound. It was found that with respect energy consumption, global warming potential, and PM 2.5 emissions, CAHSR provides a better transportation option with ridership ratios as low as 0.04 and as high as 0.57. These ridership ratios are very feasible, indicating the CAHSR may have a potent role in reducing the environmental impacts of transportation in California . The development of the system details, especially with regards to electricity, will help elucidate these findings.

Finally, it was concluded that public perception cannot be detangled from ongoing world events, and consequently changes as a function of the public's ability to accept such a high risk project. Content analysis provided a relatively accurate means of tracking public perception over time. One major limitation of this analysis was the sample size - increasing the data set would have provided the ability to draw more exact conclusions, as well as a high enough confidence level to extrapolate data to produce meaningful predictions regarding public perception (to an extent as possible based on its inherent tie to current events).

Future work would aim to reiterate each of the studies conducted at various points in CAHSR completion to verify the validity of early findings. More information will allow ridership projection modeling to gain accuracy, therefore improving the ability of economic and environmental life cycle analyses to accurately describe the costs and benefits of implementing such a system, and will provide more diverse media to analyze public perception.

References

[1] Flyvbjerg, Bent, Nils Bruzelius, and Werner Rothengatter. Megaprojects and Risk: An Anatomy of Ambition. United Kingdom: Cambridge UP, 2003. Print.

[2] Ehrenfeucht, Renia. "Megaprojects and Risk: A Conversation with Bent Flyvbjerg R." Editorial. Critical Planning Summer 2004: 53-62. Print.

[3] International Union of Railways. N.p., n.d. Web. 30 Apr. 2015.

[4] Small, Kenneth A., and E. T. Verhoef. The Economics of Urban Transportation. New York: Routledge 2007. Print.

[5] Cambridge Systematics, Inc.. California High-Speed Rail 2014 Business Plan – Ridership and Revenue Forecasting – Technical Memorandum. California High Speed Rail Authority, 2014.

[6]Parsons Brinckerhoff. 2014 Business Plan - Technical Supporting Document - Operations and Maintenance Cost Model Documentation. California High Speed Rail Authority, 2014.

7 Parsons Brinckerhoff. 2014 Business Plan - Technical Supporting Document – 50-Year Lifecycle Capital Cost Model Documentation. California High Speed Rail Authority, 2014.

[8] Chester, Mikhail, and Arpad Horvath. "Life-cycle Assessment of California High-speed Rail." *Access* 37 (2010): 25-30. University of California Transportation Center. Web. 27 Apr. 2015. <http://www.uctc.net/access/37/access37_assessing_hsr.pdf>.

[9] Chester, Mikhail, and Arpad Horvath. "High-speed Rail with Emerging Automobiles and Aircraft Can Reduce Environmental Impacts in California's Future." *Environmental Research Letters* 7.3 (2012). *IOP Science*. Web. 19 Apr. 2015. <http://iopscience.iop.org/1748-9326/7/3/034012>.

[10] Chester, Mikhail. “Environmental Life-cycle Assessment of Passenger Transportation.” *tLCAdb: transportation LCA Database.* 2012. 22. Apr. 2015

[11] Thomas, Orville. “High-Speed Rail Authority Seeks Trainset Manufacturer”. 2 October 2014. Web. 22 Apr. 2015. <http://www.hsr.ca.gov/docs/Programs/trainsets/HSRA_Seeks_Trainset_Manufacturer100214.pdf>

[12] "Total System Load Factor." *Airline Data Project*. MIT Global Airline Industry Program, 1 June 2014. Web. 22 Apr. 2015. <http://web.mit.edu/airlinedata/www/2013 12 Month Documents/Traffic and Capacity/System Total/Total System Load Factor.htm>.

Figures 8-9 show the normalized frequency of each word or phrase chosen as an identifier in Section 7.1.1 - Methodology, broken down by media type and considering all time intervals.

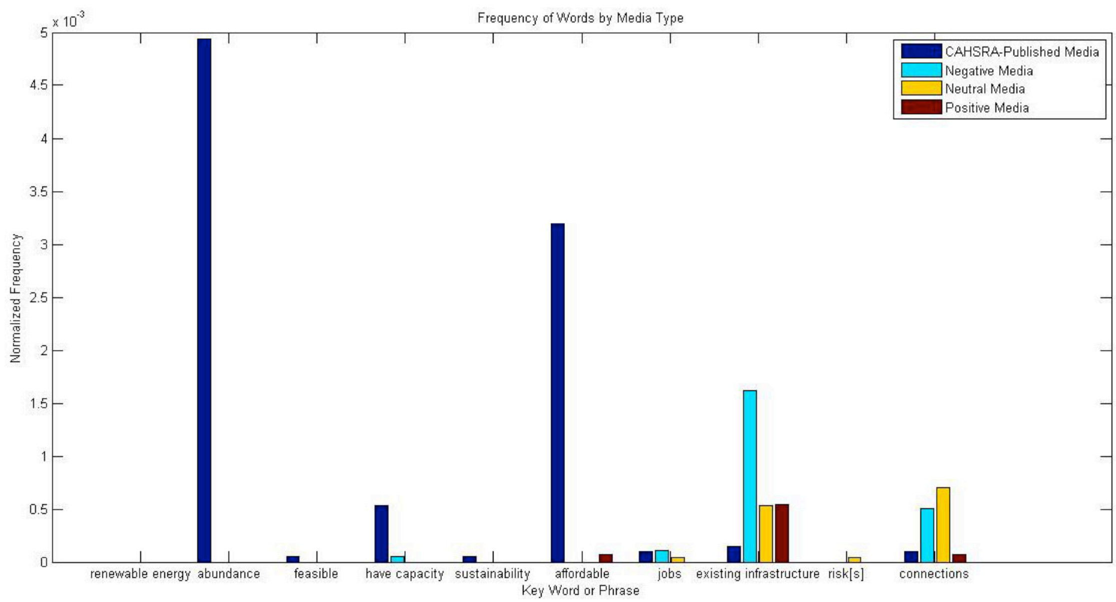

Figure 8

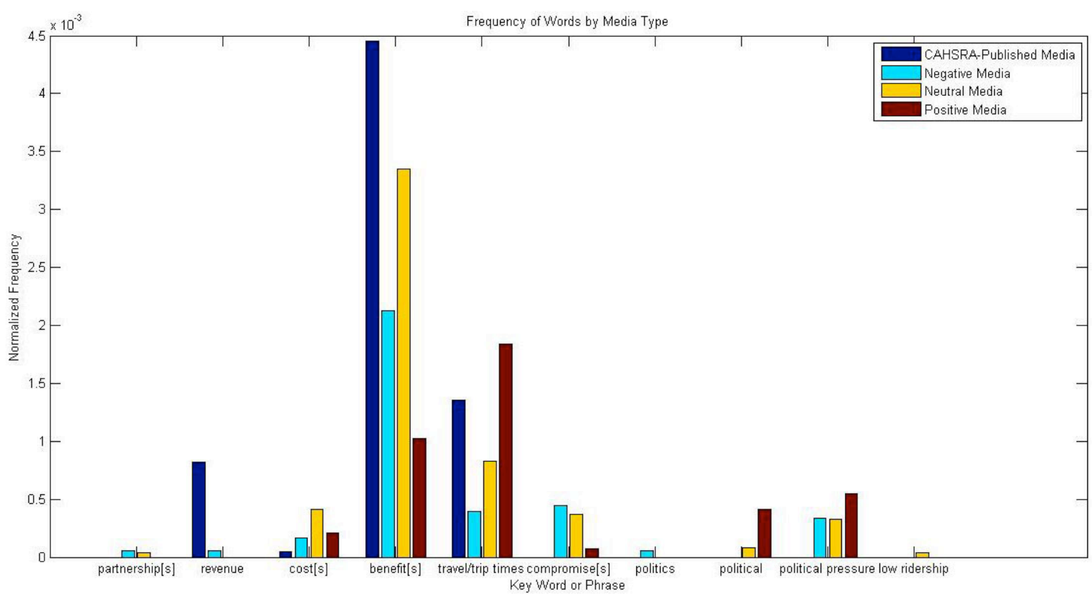

Figure 9

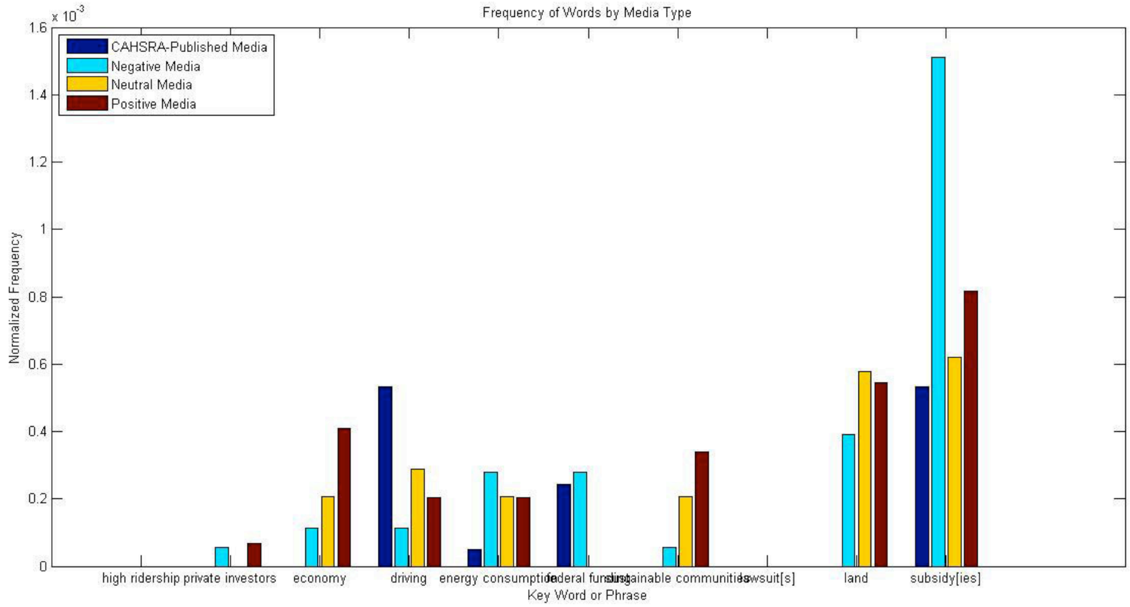

Figure 10

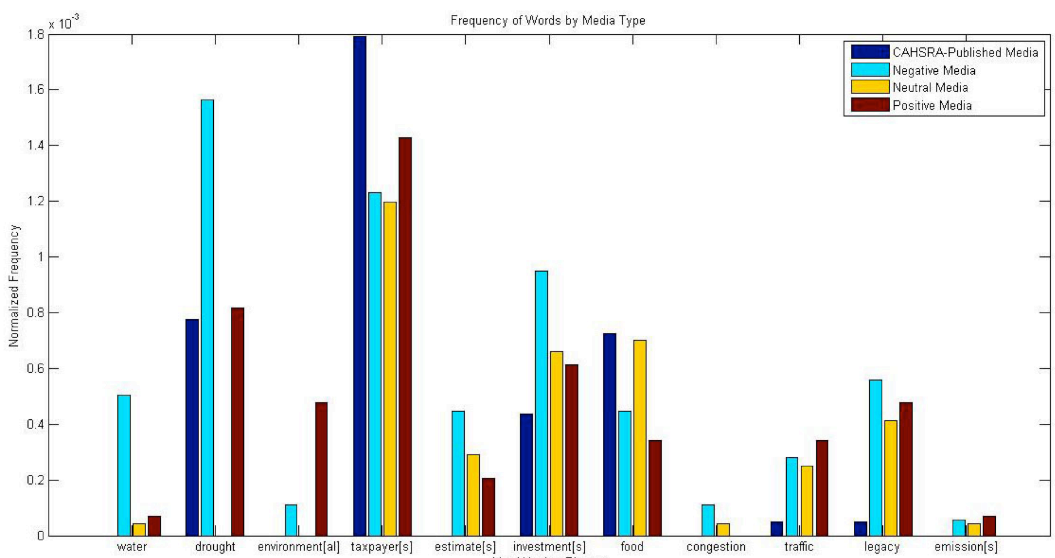

Figure 11