

Emerging High-Speed Rail Initiative in the Midwest
A Case Study of the St. Louis-Chicago Line

A Report by Energy Policy Group 8
Authors: Lauren Tarpey, Marie Donahue, Chad Joyce, Rachel Kenser, Katy Alberti

Professors Steve Berry and George Tolley
BPRO 29000
Wednesday, 12/8/2010

Table of Contents

I.	Introduction	3
II.	Overview of the Policy and Politics of U.S. Emerging High-Speed Rail Projects.....	4
A.	National political climate towards high-speed rail.....	4
B.	Regional political climate towards high-speed rail	8
C.	Specific State Information: Overview of Midwest Projects and Funding	9
D.	Take-home of Current Policy Considerations.....	11
III.	Energy Efficiency and Technology for Emerging High Speed Passenger Rail.....	12
A.	Background: Existing Rail Technology	12
B.	A Closer Look at Existing Technology: An Overview of the <i>Acela Express</i>	14
C.	Energy Efficiency Gains using Rail Technology.....	15
IV.	Economic Cost-Benefit Analysis of the Midwest High Speed Rail Proposal: A Detailed Study of the Chicago to St. Louis Corridor	18
V.	Environmental Impacts of Emerging High Speed Rail.....	22
A.	Environmental Effects of Current Train Technology	23
B.	A Comparison: Environmental Impacts of Other Modes of Transportation.....	25
C.	Additional Environmental Considerations of High Speed Rail	27
VI.	Consumer Behavior Analysis and Marketing Strategies: Increasing Ridership Equals Increasing Profitability Potential and Energy Efficiency	28
VII.	Conclusion	36
VIII.	Bibliography.....	39
IX.	Appendices.....	43
Appendix A:	Benefit Analysis Calculations	43
Appendix B:	Cost Analysis Calculations.....	44
Appendix C:	Supplemental Images, Graphs.....	46

I. Introduction

The United States currently lacks a well-defined philosophy on national transportation policy, and as such, it is unclear where passenger rail may or may not fit into future policies.

Despite overarching intentions of fuel efficiency, environmental improvements, and economic viability in the long term for the United States transportation system, there are few concrete efforts to map out what real changes are to be made to achieve these goals and priorities. One currently debated transportation initiative geared towards achieving these goals is the implementation of high speed rail across the United States.

The Federal Railroad Administration and Congress currently define high speed rail as an “intercity passenger rail service” that can be realistically expected to reach speeds of up to 110 miles per hour¹. It is important to note the distinction between emerging high-speed rail in the U.S. and the high-speed rail seen in other regions, especially Europe and Asia. Current alterations to U.S. rail are geared at updating the existing infrastructure to make the system more efficient, and will enable locomotives to reach speeds of up to 110 mph, unlike the 220 mph service provided in Europe and Asia.

There are few existing studies that present an unbiased, comprehensive policy, technological, economic, environmental, and behavioral analysis of emerging high speed passenger rail. Despite federal support for improving passenger rail systems, as evidenced in recent funding of such projects, the inconsistency and variability in regional rail networks is a barrier to establishing and fulfilling national goals for transportation efficiency. Examining attempts to build a high speed rail system in the Midwest reveals several important

¹ 49 USC §26105 (b)(4)

considerations within a region in terms of ridership, political concerns, and economic limitations. All of these factors present very convincing challenges to the federal goal of a high-speed passenger rail network, and must be considered and addressed during any planning or discussion stages of these projects.

The Midwest is a relevant area of study due to the large amount of funding it has received in recent federal grants. As single largest regional recipient of taxpayer dollars, it is important that the Midwest take a critical look at the proposed changes to the rail system and their consequences. Additionally, the area has historically been a hub of transportation in the nation, centered in Chicago, which has a great deal of existing rail infrastructure. Federal funding awarded in the Midwest is designated exclusively for emerging high speed rail and modernized service as opposed to an overhaul of the current system. We are limiting our study to the currently feasible alterations that have been proposed or are being implemented in the region. To this end, we will examine the policy considerations, technological improvements, economic benefits and costs, environment impacts, and marketing strategies relating to the implementation of emerging high speed rail in the Midwest.

II. Overview of the Policy and Politics of U.S. Emerging High-Speed Rail Projects

A. National political climate towards high-speed rail

Though the United States does not have a history of legislation of high-speed passenger rail at the national level, there are two recently enacted statutes that represent a first step towards a national high-speed rail program in the United States. These are the Passenger Rail Investment and Improvement Act (PRIIA) of 2008, and the American Recovery and Reinvestment Act

(ARRA) of 2009. While the PRIIA established new high-speed rail programs and identified potential corridors for rail, the ARRA provided funding for the implementation of these projects. These two statutes also required that the US Department of Transportation issue a policy blueprint regarding the national rail programs, which was entitled *Vision for High-Speed Rail in America*, published in April 2009. Based on this blueprint, the Federal Railroad Administration published guidelines for the nation's high-speed rail initiative, known as the High-Speed Intercity Passenger Rail Program (HSIPR). Under these guidelines, ARRA funds were to be distributed to intercity rail projects through PRIIA programs, and the eligible applicants for federal funding were states, interstate compacts, public agencies, and Amtrak. (Freshfields Bruckhaus Deringer US LLP, 2009).

The current debate over high-speed rail initiatives was spurred by federal funding provided for many of these projects across the nation. Funded by the American Recovery and Reinvestment Act (ARRA), the Federal Railroad Administration oversees discretionary rail grants to states. These funds are intended for use on intercity passenger rail projects, which include the development of high-speed rail lines as well as general issues of intercity passenger rail capacity or passenger rail congestion (Wisconsin DOT, 2010). The current round of funding through the ARRA involves \$8 billion to be used to on an FRA strategic plan for improving and establishing high-speed passenger rail systems. Grant applications for this funding were received during 2009, and in January 2010 President Obama announced the award recipients (Wisconsin DOT, 2010). In November of this year, the president awarded part of these funds, \$2.4 billion, in grants to passenger rail projects in 23 states (Mitchell, 2010). The federal rationale for this project includes environmental considerations and aspirations of establishing a more efficient

national transportation system. The environmental and economic considerations and effects of such initiatives will be addressed in this work.

With the exception of projects in Florida and California, the rail stimulus funds are designated for Amtrak modernization projects, including “smart and focused investments in new tracks, signals, and rolling stock” so that rail service can be upgraded to at least 90 miles an hour (MHSRA, 2010). The federal government refers to modernized Amtrak service as “emerging high speed rail,” to be distinguished from the “high speed” rail as seen in Europe and Japan, which operate at speeds of up to 220 mph (MHSRA, 2010). In many cases, proposed trains in the Midwest would reach only 79 mph at their maximum speeds, and on average would likely operate at slower speeds. The fastest trains in the country currently are the Acela trains seen in the Northeast, which can reach 150 mph, though their average speed is half that (Cooper, 2010).

One of the key hurdles in establishing a cohesive national rail policy is overcoming states’ varying stands on the initiative, as these projects are carried out at the state level. For this reason, even if a nationwide philosophy and policy is articulated, it is difficult to implement it at the state level. Prominent in recent news, several state officials around the country, and in the Midwest specifically, oppose the spending on high-speed rail in the current economic situation, arguing that these projects are too costly. While federal funding covers many initial costs of these projects, there are also high annual costs for the states to operate and maintain rail lines, which is drawing opposition from state leaders. Despite the federal government’s priorities and funding, states must carry out the actual construction, a fact that can be the downfall of this type of initiative. Additionally, with tax payer dollars going to these expensive projects, a key argument against high speed rail is that if these projects were truly viable they would be funded privately, rather than having to be subsidized (O’Toole, 17). In the recent midterm elections of

early November, the issue of high speed rail funding was, in many states, a contentious election issue. Several candidates used the subject as a political wedge and example of unnecessary governmental spending during a recession (Merrick, 2010).

States that have opposed rail projects in recent months include Wisconsin, Ohio, and Florida. Both the Wisconsin and Ohio governors have promised to return or redirect federal grants. According to the Republican Ohio governor-elect Kasich, “Passenger rail is not in Ohio’s future. That train is dead” (Rudolf, 2010). In Florida, governor-elect Rick Scott has expressed his objection to the use of state funds for the state’s proposed Tampa-Orlando line, previously thought to be the nation’s most likely line. Due to the cost of the project and limitations of the federal funds, this announcement effectively means that the project is unlikely to be completed (Plautz, 2010). Any state that returns the federal money would put it back in a pool for rail lines in other states, rather than allowing the funds to be used elsewhere in the state, as many governors have requested. The Department of Transportation has announced that rail funds will not be used for another purpose, including road repair (Plautz, 2010).

Mary Ellen Curto, executive director of the American High-Speed Rail Alliance, has acknowledged that different states have different data reflecting the potential effects of high-speed rail projects in their states. According to Curto, high-speed rail will be implemented in places where the metrics reflect that it will be a positive business model. “If these governors have data that show it’s not going to give a good return on investment, then they’re doing what’s best for their state” (Plautz, 2010).

In addition to the less-than positive response from several governors, the next head of the House Transportation and Infrastructure Committee, representative John Mica of Florida, has appeared to be less supportive of rail projects than many had originally believed. In an interview

with the Associated Press, Mica announced that he will review grants already distributed by the FRA, arguing that “the administration squandered the money, giving it to dozens and dozens of projects that were marginal at best to spend on slow-speed trains to nowhere.” (Mica, 2010). Though Mica has been a longtime advocate of high-speed rail, he has also been critical of the FRA grant project selection in the past. He has noted that the Northeast is the only region in the country with enough population density to justify a rail line. According to the congressman, “any high-speed rail initiative needs to be in a region that makes sense, can attract private-sector investment, and has a reasonable chance to be economically successful” (Plautz, 2010). Mica’s opposition to the grants provided in 2010 arises because, he argues, the federal grant selection process ignored several vital components, including private sector participation. The congressman also argues that the grant selections “focused on too many projects that will not provide true high-speed passenger rail systems” (Mica, 2010).

B. Regional political climate towards high-speed rail

In general, the attitude in Illinois and most of the Midwestern states awarded federal funds for rail projects is supportive of these endeavors. This fact is reflected by the recent creation of the Illinois and Midwest High Speed Rail Commission by an Illinois Senate Resolution. The Illinois Senate voted to create the commission in May, with the “intent of issuing a roadmap for the creation of bullet train lines in Illinois and neighboring states.” (MHSRA, 2010) The mission of the commission is defined as “recommending the best governmental structure for a public-private partnership to design, build, operate, maintain, and finance a high-speed rail system for Illinois and the Midwest” (MHSRA, 2010). Illinois is the third state to create such a commission, which is to be composed of 19 members, mostly members of the Illinois General Assembly or appointed by the governor (IL Senate, 2010).

The total funding for the Midwest from ARRA funding totaled \$2.6 billion, which was more than any other region in the nation (Landis, 2010). Specific projects which have received federal funding in the Midwest include rail service through Iowa city, Chicago, and the Quad Cities, which received \$230 million for upgrades; a route between Detroit and Chicago, which received \$161 million (Mitchell, 2010); Wisconsin routes which are collectively referred to as the Chicago-Twin cities corridor, including a route between the twin cities and Madison which received \$1 million, a route between Milwaukee and Madison which received \$810 million, and a route from Milwaukee to Chicago which received \$12 million (Nelson, 2010). In order to get a gauge on the costs and benefits of one of these Midwestern routes that might serve as a model for others, we are considering a route between St. Louis and Chicago, which has received \$1.1 billion in federal funding. This route, as seen in Figure 1 in Appendix C., provides insight into what a typical rail improvement project entails, as well as some of the difficulties and successes in implementing such a project.

C. Specific State Information: Overview of Midwest Projects and Funding

Within the Midwest, high-speed rail projects and proposals have experienced different levels of support and opposition, depending on the current political climates of the states. In an effort to understand the political reasons for supporting or opposing federal funding of high-speed rail initiatives, we can investigate these situations, as they may shed some light on the difficulties involved in securing political support for rail improvement projects of this type. Wisconsin's rail debate is a highly publicized case of opposition to the funding for passenger rail and to these projects overall, whereas the St. Louis line is an example of a mostly well-supported project, on which much progress has already been made. Despite the progress that has been made

on this line, there are still several points of contention, revealing the complexities of executing even a well-established and politically supported rail project.

Wisconsin's newly elected Republican governor has been staunchly opposed to the high-speed rail projects in the state, and has recently turned his campaign promises into a reality. In early November, soon after election results were announced, the Wisconsin Transportation Secretary announced that the state would suspend its work on the Milwaukee-Madison rail line, which received \$810 million in federal funding (Plautz, 2010). The state's new governor-elect cites concern regarding the project relating to state spending on maintaining passenger rail lines. The most recent round of federal funding requires that states cover 20% of the costs of a passenger rail project receiving funds (Plautz, 2010). States may be expected cover operating losses, as the government currently does for Amtrak, because few passenger-rail systems break even (Mitchell, 2010). In the case of Wisconsin's rail projects, current estimates of state spending are projected at \$7 to \$10 million, according to Walker. While this projected range of spending represents a small portion of the state's \$3.1 billion transportation budget, Walker and other opponents would rather see this money go to repairing roads and bridges (Merrick, 2010). One of Walker's campaign advertisements contained the slogan "if I'm elected as your next governor, we'll stop this train" (Cooper, 2010).

Unlike the proposed Wisconsin rail line, St. Louis's rail project has received a good deal of political support and its construction has begun. The federal stimulus money for this line included \$1.1 billion apportioned for high-speed rail between St. Louis and Chicago and \$31 million to upgrade passenger rail service between St. Louis and Kansas City (St. Louis Business Journal, 2010). Currently there are five daily round trips between Chicago and St. Louis and two daily round trips between St. Louis and Kansas City, but with updates to the system the hope is

for eight daily round trips between Chicago and St. Louis, at speeds of up to 110 mph (St Louis Business Journal, 2010). These changes would decrease travel time from Chicago to St. Louis to four hours, allowing customers to reach their destination 30 percent faster than they are able with current rail service, and 10 percent faster than driving between the two cities (St. Louis Business Journal, 2010). Some of the changes will include new trains, passenger cars, track work, warning devices and increased safety technology, according to Amtrak (Jonsson, 2010).

Work on the first part of the St. Louis project funded by the federal stimulus program began this year, involving the installation of new rail and concrete ties to support up to 110-mph passenger trains in the southern part of the state. One area of contention in the plan has been the increased number of trains passing through the capital city of Springfield. As a result of local concerns over increased rail congestion in the city, the current progress on the St. Louis- Chicago line has excluded the Springfield area, though a study is in progress to determine the best way to address this area (Landis, 2010).

D. Take-home of Current Policy Considerations

The current federal support indicates a commitment to updating the intercity rail infrastructure in the United States, though several states have shown that political support for these projects is not uniform. In the Midwest, there has been a demonstration of political support for high-speed rail of initiatives, as evidenced by the creation of the Illinois and Midwest High Speed Rail Commission. However, individual high speed rail projects in the region have run into varying degrees of political opposition due to perceived costs, including the contentious Wisconsin rail projects, while others are commencing with relatively smooth progress. The evidence of such variation in support of high-speed rail initiatives within one region in the country points to the difficulty in establishing a cohesive nation-wide program and initiative.

Analysts of the situation in the United States have pointed out that building a comprehensive high-speed rail network does not happen overnight, but is instead a highly complex and expensive endeavor. As a point of comparison, Spain spent two decades and \$35 billion developing its high-speed rail system (St. Louis Business Journal, 2010). While this system involves higher speed rail than the current initiatives in the United States, the sheer time and financial commitments necessary in Spain indicate the sort of timeline and expense the United States might expect for comprehensive changes.

III. Energy Efficiency and Technology for Emerging High Speed

Passenger Rail

Technological improvements to existing passenger rail in the Midwest can improve its speed and efficiency and help achieve a modernized, emerging high speed rail network in the region. In order to understand the direction that passenger train technology may take given increased funding and the goal of higher speed operation, this section will provide an overview of existing rail technology in the United States. In addition, this section will outline a comparison between the proposed Midwest network and Amtrak's *Acela Express*, the country's sole operating high speed rail line in the Northeast Corridor. This is an important case study to analyze in order to understand how the Midwest may be able to implement a similar initiative in the near future. Lastly, a discussion of technological alternatives that have the potential to increase the operational and energy efficiency of current passenger rail will be presented.

A. Background: Existing Rail Technology

Amtrak operates diesel locomotives for the majority of its fleet, which rely on the diesel combustion cycle or a direct-injection compression-ignition. In a study published by Argonne National Laboratory, diesel engines were cited as most efficient transportation engine available, able to operate at an average thermal efficiency (i.e. the ability to convert fuel into work, or the amount of energy output

over the amount of energy input) of 40% or higher (Stodolsky 2002, 15). For comparison, the internal combustion engines in standard gasoline-powered automobiles generally average a thermal efficiency of between 10 and 15% (Avallone and Baumeister 1995).

Because diesel engines are able to deliver power, reliability, and relatively low life-cycle costs, they have generally been the most attractive option for both freight and passenger service in the United States. For example, freight rail has a fuel consumption rate that is 11.5 times more energy efficient on a BTU per ton mile basis than trucks (U.S. D.O.E. 2007, 44). Furthermore, diesel locomotives have generally long productive lives, travelling up to one million miles before needing to be overhauled. These locomotives maintain the capacity to be updated and overhauled as needed given changes in technology, as outlined in the same Argonne study:

Locomotive engines are expected to last for at least 40 years, which places greater emphasis on durability. This low turnover rate also limits the penetration rate of new technologies; however, locomotives undergo many overhauls, providing opportunities for modifications throughout their lives. (Stodolsky 2002, 13)

The long life of current locomotive technology, as mentioned above, provides an indication for why incremental changes to existing service make more sense than a complete overhaul of the Midwest passenger rail system that would accompany any implementation of higher speed bullet trains (like those which exist in Europe and Asia). Because bullet trains rely entirely on electrification, such an overhaul would require replacing Amtrak's entire existing rolling stock. Instead, with locomotives that are able to last decades and be updated as needed, emerging high speed rail and modernization projects are less costly to state and federal governments than more ambitious bullet train projects would be.

Despite the advantages of existing locomotive technology, it is also important to consider the technology's limitations when evaluating its overall potential for energy efficiency. Although the engines of diesel locomotives achieve a high average thermal efficiency, this does not guarantee that passenger trains will always operate at this hypothetical, maximum efficiency. There are a number of factors that affect the performance of passenger trains including conditions such as signal delays, track congestion,

time spent idling, average and maximum speed, the number and occupancy of passenger cars, among others. Because of the number of factors involved and the potential variation in service, it is difficult to precisely determine an average energy efficiency measure for high speed passenger rail systems. Instead, it is important to realize this limitation and qualify any analysis of specific data with localized factors when possible.

B. A Closer Look at Existing Technology: An Overview of the *Acela Express*

Although many countries in Europe and Asia have prioritized high speed rail for decades, such systems have not historically been a priority in American transportation policy. For example, the U.S. has only one designated high speed rail corridor currently in service. Amtrak's *Acela Express* route complies with the FRA's high speed rail designation, connecting the Northeast population centers of Boston, New York City, and Washington D.C., while reaching top speeds of up to 150 miles per hour (Amtrak Government Affairs 2010). The service opened in December 2000 and has since grown in popularity with ridership reaching over 3 million during the 2009 fiscal year (Amtrak Government Affairs 2010). The *Acela Express* serves as a helpful model when analyzing proposals for future high speed rail corridors in the United States such as the proposals for the Midwest.

With the prioritization of its *Acela* line, Amtrak increased capital funding available to the Northeast corridor. Specifically, as result of a 73% increase in annual capital spending in FY 2003 through 2009, "infrastructure reliability [...] improved 50%" (Amtrak Government Affair 2010). This improvement had the effect of increasing the *Acela's* on-time performance and the Federal Railroad Administration's safety ratio. It also reduced operating man-hours and corresponding labor costs. This case demonstrates that the direct benefits of efficiency improvements often lead to indirect improvements elsewhere within a given rail system.

It is important to note that from a technological perspective, the *Acela Express* relies on electric locomotives, differing from the typical diesel or diesel-electric locomotives that power the majority of

Amtrak lines. The proposed Midwest system of emerging high speed rail would not rely on electrification but rather on a continued use of diesel engines. Despite this difference, certain characteristics of the *Acela*'s technology like regenerative braking (as discussed in the following section) can be utilized in the Midwest to increase the corridor's efficiency and satisfy its modernization goals.

C. Energy Efficiency Gains using Rail Technology

A number of empirically-tested technological upgrades have been developed that have the potential to substantially improve existing passenger rail service in the Midwest. For example, developments like “advanced materials (e.g., thermal barrier coatings, titanium), new enabling technologies, advanced combustion concepts (e.g., homogenous-charge compression ignition, cooled exhaust-gas recirculation), and advanced analytical tools for optimization” may contribute to substantial gains in rail's operational efficiency (Stodolsky 2002, 15). Several of these energy efficiency improvements are particularly well suited to be incorporated into the proposed modernization of Amtrak's Midwest service. These include energy recovery techniques like dynamic or regenerative braking, operational optimization, and modernized track and grade crossings.

First, one of the most significant technological updates to modern locomotive technology is the development of energy recovery capacity through dynamic or regenerative braking mechanisms. By harnessing a braking train's kinetic energy, diesel-electric locomotives harness energy from friction through traction motors that “retard the train by running as generators, producing excess electrical power that is dissipative in the locomotive as heat in the resistance grids” (Stodolsky 2002, 22). This harnessed energy can then be used to perform useful work in the train's onboard electrical system—improving its efficiency by utilizing otherwise lost energy and reducing the net energy required to run the locomotive's power systems. An example diagram of the mechanisms within a regenerative braking system are illustrated by Figure 2 found in Appendix C. The success of this braking mechanism depends on the grade (i.e. slope) of tracks, characteristics of the route, the average speed, and frequency of stops, among other variables. Furthermore, due to the nature of the energy generated, the majority of the dynamic

braking energy recovered must “be either stored during braking for later use [...] or sent off the locomotive for use elsewhere” on the grid (Stodolsky 2002, 22).

The storing capacity of these dynamic systems is perhaps the largest hurdle to current braking technology. There is a current lack of devices with the appropriate storage capacity (Stodolsky 2002, 22).

Similar to the problem encountered by producers of personal hybrid vehicles, the storage capacity of most existing batteries is not enough, although significant improvements to energy-storage technology are being made (see Balachandra et al. 2000 and INTELEC 1998).

Electrochemical batteries and electric flywheels are the two most promising alternatives for energy storage in hybrid braking systems on the market today. Storage batteries may be manufactured from lead acid, nickel-cadmium, nickel-metal hydride, lithium ion, or lithium polymer, and each composition has associated advantages and disadvantages. In general, current battery models, despite having high energy densities, fail to maintain their charge over large periods, are too heavy, do not regulate temperature well and are relatively expensive (Stodolsky 2002, 23). The other alternative for energy storage on board rail locomotives with dynamic braking systems is a commercially available flywheel energy storage system. This mechanism relies on an electric generator or motor to store energy during the braking process, releasing it later when the train decelerates and is in need of supplemental electricity (Vere 2007). An example diagram of a flywheel mechanism is illustrated by Figure 3 found in Appendix C. The barriers currently facing flywheel technology mainly include the mechanism’s limited energy density, high cost, and the reality that it is a relatively untested commercial technology in the rail sector (Stodolsky 2002, 23). In short, more research and empirical analysis of both battery and flywheel technology should be conducted to test whether they are effective energy storage solutions for the proposed emerging high speed rail initiative in the Midwest.

Additional gains in efficiency for passenger rail technology are often achieved through the streamlining of operations. So-called “operation optimization” has the potential to produce substantial gains in speed and efficiency of passenger rail. For example, track maintenance can dramatically reduce travel times, while better energy management and control strategies on board can reduce energy input

during rail operation (Midwest High Speed Rail Association n. dat.; Stodolsky 2002, 25). Also, having trains run with higher occupancy (i.e. maximizing the number of passengers per vehicle) allows trains to travel more efficiency—and increases the ratio of passenger-miles traveled to the train’s energy consumption, implying that each trip is made more efficiently. Reducing the amount of time that locomotives spend idling also has the potential to provide significant savings both in terms of energy and reduced operational fuel costs. Because most locomotives operating today are diesel-powered, these locomotive engines must be idled (i.e. remain running) to prevent engine coolant, which contains no antifreeze, from freezing (Stodolsky 2002, 21). The central goal of these gains in operational efficiency is to improve productivity by reducing the amount of time trains spend idling and in-transit as well as increasing ridership per trip, allowing more customers to reach their destination faster.

Finally, increased funding and attention that prioritizes updating existing track infrastructure and signaling systems has the potential to substantially impact the success of any high speed rail program. Technological improvements to tracks, signals, and crossing allow trains to travel at higher speeds with fewer stops and delays (Midwest High Speed Rail Association n. dat.). Additionally, these initiatives improve the safety and reliability of rail systems and allow better coordination between freight and passenger rail.

Although the railroad supply industry market is often considered “too small to independently fund technology development,” private and public interests stand to gain from technological and efficiency improvements in the passenger rail sector (FRA n. dat.). The technologies and strategies to update existing rail service as outlined above (in terms of regenerative braking, operational efficiency, and track improvements) have been tested commercially and are generally accepted as effective means for improving the performance of rail service. More research and development is needed in many areas to improve the reliability of modernized rail technology (for example, in regenerative braking and energy storage alternatives), but these advances in rail sector technology have applications elsewhere. Without funding priorities for technological improvements in passenger rail, it is unlikely that the Midwest and

more generally the U.S. will be able to achieve its goal of developing a successful, modern high speed rail network.

IV. Economic Cost-Benefit Analysis of the Midwest High Speed Rail Proposal: A Detailed Study of the Chicago to St. Louis Corridor

The benefits and costs of the St. Louis-Chicago corridor are being analyzed in order to model the general benefits and costs of investing in high-speed rail in the United States. In this analysis we will quantify the benefits of this policy by looking at the predicted growth in ridership of passengers based on the current growth of the passenger rail line. This increase in ridership is a necessary factor in calculating the benefits of the proposed high-speed initiative, though the uncertainties regarding the amount of this increase contribute to the inconsistencies in estimating the costs and benefits of such a system. In order to quantify the costs of the policy, it is necessary to find industry estimates for the factor and input of any new technology and construction, adjusting these estimates to the appropriate scale of this analysis. Additionally, the operating costs of a given rail line should be estimated based on expected train frequency and ridership, and inputs such as rents (Amtrak must pay rents to freight companies for using any existing track, which is owned and operated by those private entities), fuel, labor, and administrative costs.

After the benefits and costs for the St. Louis-Chicago corridor are quantified, the nominal values that are associated with the policy's time horizon—this report will use a period of ten years—must be adjusted by a discount factor (i.e. those benefits and costs that are not realized until after the start of the policy). This is done in order to quantify future values in terms of a standard present value unit and allow a basis for comparison of net benefits and costs. This

report will use a discount factor of 7% to adjust for future uncertainty associated with an untested policy such as Midwest high-speed rail.

System revenue is a primary benefit to the rail industry as well as the rail users.

According to a news release, total Amtrak ridership increased 7% to 1.969 million from September 30, 2009 to September 30, 2010 (Amtrak Illinois, 2010). The article also mentions the annual increase in ridership of 27% in the past five years. Based on estimates of an 80% increase in ridership from the implementation of a Midwest bullet train (a truly “high-speed” line), this analysis estimates that the implementation of emerging high-speed rail, with lower speeds, will result in a 50% increase in ridership (Trans Systems, 2010). This estimate is a very high bound, which means the resulting revenue calculations are extremely optimistic. Based on these estimates of increased ridership, the resulting revenue the following year is \$75 million (Appendix A).

The time savings to the passenger is determined by the time saved from using emerging high-speed rail over using automobile or conventional rail, which is approximately 1 hour and 31 minutes in the case of the St. Louis-Chicago trip (Midwest Regional Rail System Executive Report, 2004, Transportation Economics and Management Systems Inc., 2004). Using \$22 as the value of time for one hour, the total monetary consumer surplus of time savings gain is approximately \$61 million (Trans Systems, 2010). Food, beverage and other revenues also both add up to just over \$32 million.

Table 1. Summary of Benefit Findings

Description	Benefits
Increased Ridership Revenue	\$75,018,900
Food/Beverage Revenue	\$4,866,579
Other Revenue	\$27,340,332
Time Savings to Passenger	\$61,000,000
<u>Total</u>	<u>\$168,225,812</u>

The train equipment, infrastructure, and maintenance/operating costs were obtained from a study that used 2002 dollars. To make these costs up-to-date, these costs were converted into current dollars based on average inflation over the past 10 years, which was determined to be 2.7%. As a result, the train equipment and rolling stock costs were determined to be \$150 million; infrastructure costs of \$580 million; and maintenance/operating costs of \$61 million (Transportation and Economics Management Systems, Inc., 2004). Diesel fuel costs were calculated by taking the diesel per train mile ratio and multiplying it to the price per gallon of diesel, the additional daily round trips from HSR, the miles per train for one round trip, and 365 days out of the year. Therefore, this fuel cost was determined to be almost \$10 million.

Table 2. Summary of Cost Findings

Description	Costs
Rolling Stock	\$150,048,916
Infrastructure Costs	\$580,624,067
Operating/Maintenance	\$61,324,340
Diesel Costs	\$9,937,125
<u>Total</u>	<u>\$801,934,448</u>

Initially there will be a cost of \$801 million, but this value is composed of mostly start up costs.

After the first year, the primary costs to will be accounted for are operating/maintenance costs and diesel costs.

Table 3. Summary of Time Horizon Findings, Discounted Benefits and Costs

Net Benefit	\$168,225,812	Net Cost, t=0	\$801,934,448
		Net Cost, t>0	\$71,261,465
Time	<u>Discounted Benefits (\$)</u>	DR = 7%	<u>Discounted Costs (\$)</u>
0	\$168,225,812		\$801,934,448
1	\$157,220,385		\$66,599,500
2	\$146,934,939		\$62,242,523
3	\$137,322,373		\$58,170,582
4	\$128,338,666		\$54,365,030
5	\$119,942,679		\$50,808,439
6	\$112,095,961		\$47,484,523
7	\$104,762,581		\$44,378,059
8	\$97,908,954		\$41,474,821
9	\$91,503,695		\$38,761,515
10	\$85,517,472		\$36,225,715
NPB = ΣB	\$1,349,773,517	NPC = ΣC	\$1,302,445,155

Based on the results of this cost benefit analysis, it appears that the implementation of emerging high-speed rail in the Midwest, specifically between Chicago to St. Louis, would result in a marginally positive result. However, this analysis is limited in accuracy and certainty as a result of many variables that must be estimated or that are currently unknown, including ridership increases and diversions from other modes of transport. The estimates of ridership increases and diversion rates used in this analysis were likely very optimistic, so any resulting conclusions of

perceived benefits must also be understood as optimistic. Additionally, this analysis does not take into account environmental costs or benefits of the system, which, though contentious and the subject of much debate, are certainly neither clear cut nor easily quantifiable. These environmental factors will be discussed qualitatively in the following section. As a result of the very close margin between benefits and costs, more analysis and research should be conducted in this area in order to accurately portray and model the likely benefits and costs of an emerging high speed rail system in the Midwest as a whole.

V. Environmental Impacts of Emerging High Speed Rail

One of the primary talking points for the merits of implementing high speed rail in the Midwest is the perceived environmental benefits as passengers divert from other modes of travel, such as airplanes, automobiles and buses. In the Midwest Regional Rail Initiative's assessment of the impacts of the Midwest Regional Rail System policy proposal (MWRRS), they cite the major environmental benefits of the policy to include: decreased energy consumption, reduced air pollutant emissions and improved air quality, less land required compared to expanding existing highways and airports, and fewer environmental impacts on sensitive habitats and water resources (floodplains, streams, and wetlands) than highway and airport alternatives (Transportation Economics & Management Systems, Inc., 2004).

The most salient environmental benefit is an expected reduction in greenhouse gas emissions, which would be realized only as travel is diverted from other modes of transportation. The actual magnitude of this reduction is hotly debated, as at present only one percent of U.S. intercity trips are rail trips, while 90 percent are automobile trips, 7 percent are air trips, and 2 percent are bus trips (Center for Clean Air Policy, 2006, 4). Given this data, one must consider

whether a large enough portion of the population will divert travel modes in order for estimated environmental impacts to be realized. As consumer choice will be addressed in the next section of this paper, this section will use ridership growth and diversion rate information compiled by the Center for Clean Air Policy to predict emissions rates and environmental impacts. Because the CCAP has compiled estimates that are optimistic in nature, this paper will also acknowledge opposing arguments. Using current information and projections about the future of high speed rail and the environment, this section will seek to examine the energy efficiency of high speed rail in the Midwest, energy efficiency of other modes of transportation, and other environmental considerations associated with the construction and maintenance of rail infrastructure in the Midwest.

A. Environmental Effects of Current Train Technology

The ability of locomotive manufacturers to conduct research and development of fuel efficiency and emissions reduction is limited by the relatively small number of trains manufactured each year, with approximately 800 locomotives manufactured annually in the United States. Additionally, the largest demand for locomotives comes from freight companies that have different structural needs than passenger rail providers. As a result of this small unit sale over which research and development costs can be shared, locomotive fuel efficiency and emissions is relatively under-researched (Stodolsky, 2002, 3).

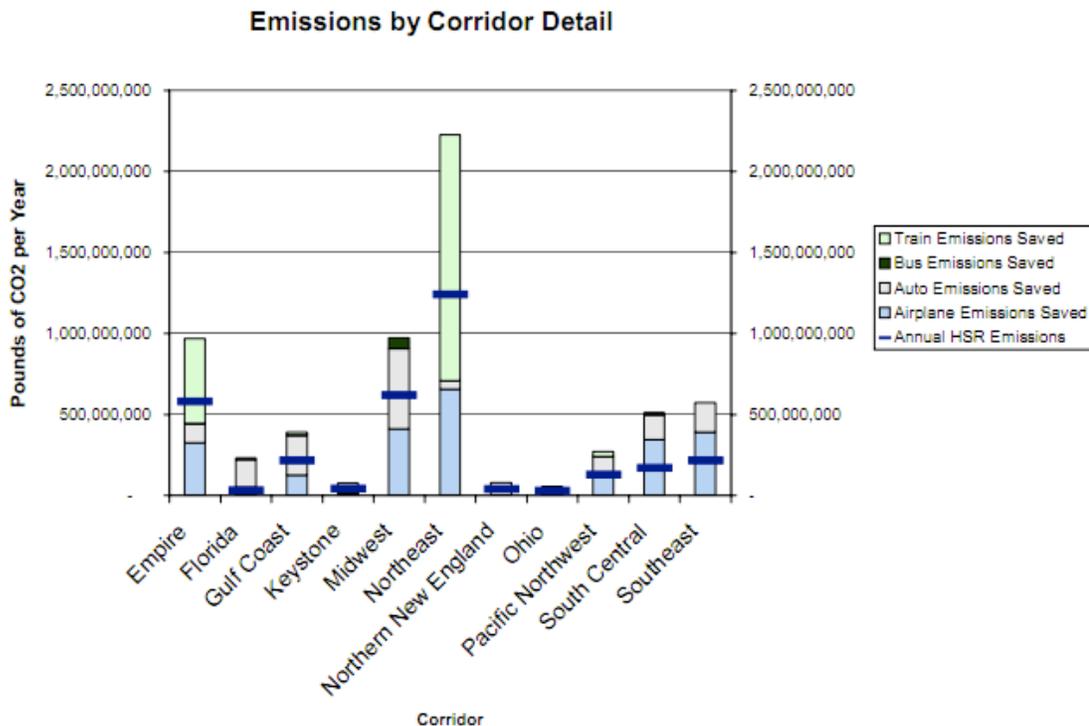
In a study of high speed rail emissions in the US, jointly prepared by the Center for Clean Air Policy and the Center for Neighborhood Technology, information on a variety of rail technologies was used to assess the emissions factors of high speed rail in the US. The CCAP and CNT indicate that high speed rail systems are typically diesel powered, MagLev or electrically powered. As discussed in the high speed rail technology section of this paper,

locomotive engines are expected to last for at least 40 years, placing greater emphasis on durability and limiting the penetration rate of new technologies (Stodolsky, 2002, 13). Current proposed legislation includes in its major plans the use of existing train tracks and rail infrastructure such that it can be assumed that diesel trains will largely be in use in the Midwest region (Transportation Economics & Management Systems, Inc., 2004). One such diesel powered train that will likely be used, the Danish IC-3, has a per passenger mile emissions factor of 0.26 pounds of CO₂ per passenger mile at an assumed 70 percent occupancy (Center for Clean Air Policy, 2006, pp). Lower passenger occupancies raise the emissions per passenger mile, grounding ridership, occupancy rates, and consumer choice as a key component in a holistic assessment of high speed rail in the Midwest.

In addition to greenhouse gas impacts, fossil fuel combustion in diesel powered trains can generate criteria pollutant emissions, such as particulate matter and nitrogen oxides. These can aggravate, and possibly cause, health problems such as asthma. When the full environmental impact of increased rail travel is considered, electricity may be a much more environmentally sound high speed rail fuel than diesel provided electricity generation is procured from green energy technology. The Shinkansen “Bullet Train” in Japan runs at a maximum speed of 300 km/hour (approx 180 miles/hour) using electricity as fuel and generating .22 pounds CO₂ per passenger mile at an assumed 70 percent occupancy. The TGV in France also runs at maximum speeds of 300 km/hour using electricity as fuel and can achieve 0.15 pounds of CO₂ per passenger mile at an assumed 70 percent occupancy (Center for Clean Air Policy, 2006, B-5). However, US safety regulations require that passenger trains in the US must be much heavier, increasing the CO₂ per passenger mile and reducing the overall environmental benefit.

B. A Comparison: Environmental Impacts of Other Modes of Transportation

Emissions reduction rates, whether high or low estimates, are all contingent upon diversion from other modes of transportation, specifically airplane, automobile and bus travel. In the Midwest, the impact of high speed rail on air travel is likely to be modest, with studies indicating just a 7 percent decrease in flights from 2006 levels based on projected diverted airline passengers in the Midwest (Center for Clean Air Policy, 2006, 1).



Center for Clean Air Policy & Center for Neighborhood Technology (2006) "High Speed Rail and Greenhouse Gas Emissions in the U.S."

As the chart above indicates, the primary benefit to the environment with respect to CO2 emissions in the Midwest will be realized in diversions from automobile and air travel, with only very small reductions in bus and existing train travel. The minor reduction contributed by diverting from these modes of travel is both a function of their low emission rates per passenger

mile and also their relatively low share of ridership in the Midwest. Conversely, even a small reduction in air travel confers a high emissions reduction. Using optimistic passenger diversion rate projections compiled by the CCAP in conjunction with the Transportation Economics and Management Systems, Inc. for the Midwest Regional Rail System., the calculated carbon dioxide emissions saved from passengers switching to high speed rail from other modes—air, conventional rail, automobile and bus—estimates high speed rail’s net emissions reduction due to diversion to be 972,300,492 lb CO₂ annually (Center for Clean Air Policy, 2006, A-7). The magnitude of this optimism, however, can best be seen in calculated auto emissions savings. The CCAP estimates an annual savings from reduced auto trips to be 497,727,461 lb CO₂, a large savings that assumes a very high 49% diversion rate (Center for Clean Air Policy, 2006, B-3).

Well constructed criticism of the actual benefits of high speed rail, such as that conducted by Randal O’Toole of the Cato Policy Institute, cite these high diversion rates as unrealistic indicators of actual emissions reductions. Calculating emissions reductions for lower diversion rates, though useful in informing policy decisions, are outside the scope of this paper. Further analysis of low and moderate diversion rates from air and auto travel in the Midwest is needed. An additional omission altering the validity of these bright projections that needs to be considered is the future advances in air and auto technology that will confer unknown emissions reductions.

Table 1. Summary Emissions Factors by Mode ²¹			
Mode	Emissions Per Passenger Mile (lbs CO ₂) ²²	Emissions Per Vehicle Mile (lbs CO ₂)	Passengers per Vehicle
Bus	0.14	4.87	35
Conventional Rail	0.21	66.96	322
High Speed Rail (IC-3)	0.26	25.10	97
Automobile	0.53	0.85	1.6
Airplane	0.62	48.04	77

Center for Clean Air Policy & Center for Neighborhood Technology (2006) "High Speed Rail and Greenhouse Gas Emissions in the U.S."

Estimates have indicated that a trip taken by bus generates about half the emissions of a trip taken by high speed rail that operates using a diesel engine (Center for Clean Air Policy, 2006, 10), though almost the same as electrically powered locomotives. As previously cited, bus travel still comprises a relatively low share of overall ridership in the US, and so diversion from bus travel in the Midwest will not have a significant impact on the environment. Causes of relatively low ridership in intercity bus travel should be thoroughly investigated when estimating actual high speed rail ridership.

C. Additional Environmental Considerations of High Speed Rail

Midwest high speed rail plans are not accompanied by the same detailed environmental analysis included in Florida and California plans. Though as in all regions of the US, when assessing the environmental impacts of increased high speed rail in the Midwest, the environmental impacts of rail and other modes of transport are not the only considerations. The energy and pollution cost of updating existing lines and constructing new rail lines will require

huge amounts of fossil fuels in construction, manufacturing, and maintenance (O'Toole, 2008, 1).

Finally, concerns have been raised that high speed rail is not auto-competitive when journey times to and from the station are considered. The additional transport required to complete a door to door trip contributes an additional environmental impact to high speed rail that is not factored into emissions estimates for high speed rail (though the same factors are excluded for bus and airplane emission rates). Population density of regions served may change in the near future, making this additional factor of greater or lesser significance in a holistic analysis of high speed rail and the environment.

VI. Consumer Behavior Analysis and Marketing Strategies: Increasing Ridership Equals Increasing Profitability Potential and Energy Efficiency

As stated in the policy review above, the implementation of high speed rail continues to be highly controversial across impacted state governments and the federal government. Despite this debate, the federal government ultimately supports investing in this endeavor as demonstrated by the massive subsidy they have awarded. They have done so regardless of the expressed financial risks and political concerns. The multifariousness of the variables and uncertainties influencing costs and benefits of high speed rail hinders a comprehensive and definitively conclusive cost-benefit analysis. The question now is do we build the infrastructure and then hope for the potential benefits to manifest? Or do we wait for the feasibility of high-speed rail to come to fruition before we begin building? Currently, a large sum of taxpayer dollars has been allocated to this initiative, so for the purposes of this consumer behavior

analysis, we assume that high-speed rail will ultimately be implemented, whether those improvements are ultimately made to the Midwest rail or money is redistributed to other regions.

With this mentality of national determinism, the main goal for all parties involved- state and federal governments, industry, and consumers- will necessarily be to retain current passengers and increase ridership. By growing market share, the project boosts its profitability potential as well as maximizes energy efficiency. Subsequently, a successful program will produce incentive for greater private ownership of the system, alleviating some of the burden on taxpayers. In turn, this encourages continued governmental support of incremental improvements, which will foster additional market growth. To this end, the government and Amtrak should not assume that once the improvements to the trains are implemented people will become aware of the advantages and automatically change their behaviors. Consumers will need to be persuaded that taking the high-speed train provides more personal benefits than cars, buses, or planes. To start, this section presents trends in the market that might have implications for the success of this initiative. Next, this section expounds the most salient of the multitudinous factors contributing to a consumer's transportation mode decisions. Finally, this section reviews various consumer behavior psychologies pertaining to environmental consumption and transportation preferences, as well as how these can translate to a successful marketing campaign for high-speed rail.

The rate of ridership growth is one of the biggest uncertainties influencing the feasibility of this project. However, the current atmosphere of the transportation market in the Midwest indicates an upward trend in ridership that, if continued, might provide incentive to make improvements in the system now. First off, Amtrak reports ridership increases nationwide for fiscal year 2010, especially in the Midwest. The Chicago-St. Louis line stands out with the

largest increase of all, up 11% from last fiscal year. Even more remarkably, this line shows a five-year growth of 27% annually over the past five years (Amtrak Illinois, 2010). Concurrently, intercity bus companies also report massive growth over the past three years. Annual growth from 2006-2007 increased 8.1% and then 9.8% in the following year (Schwieterman, Fischer, & Smith, 2008) and five new bus companies have been established since 2007 (Washington Post, 2009). This trend is contrary to airplanes where the Great Lakes region has seen some major decreases in passenger numbers on flights over the past year as well as the past ten years overall (Brookings, 2009, 2). Three of the region's hubs, Chicago, Detroit, and St. Louis, face declining numbers while the nation is experiencing increases. St. Louis in particular shows one of the steepest declines, -6.8% from 2008 to 2009 and -54.1% last ten years. Specifically, the domestic route from Chicago to St. Louis has seen a 21.6% drop in total passengers (5). Although it's nearly impossible to project the magnitude of diversion to trains from other modes of transport, some assumptions might be made in light of the above trends. Most likely people who are avid bus riders won't choose to take the train because of the large price differential. However, people are obviously looking for alternatives to plane and car travel, so high-speed rail could take advantage of this trend by utilizing targeted messaging.

A number of multidimensional factors influence consumers' transportation decisions. Intuitively, the list could get pretty long: accessibility, reliability, ticket prices, gas prices, cleanliness, traffic, weather, privacy, productiveness, on and on. However, not all can be taken into account or considered equal when developing the marketing plan for high-speed rail promotion. Research on the most important considerations in regards to travel judgments, in particular on high-speed rail, is limited. As a start, the Chicago Transit Authority's (2010, 28) report on attitudes will be presented for a reference point. According to this account, getting

there on time is the number one priority. The next highest priorities are location, speed, safety, and schedule. Surprisingly, value for the price is ranked in importance after these five aforementioned needs. It could probably be assumed that price value would be ranked higher for an intercity rail survey since the differentials between modes are much higher. Relevant to the present study, good for the environment comes in at 15 out of 20 choices. Future research is needed to broaden the scope to intercity rail in order to be highly focused on the priorities of intercity travelers.

By understanding how people behave and make decisions in the transportation market, businesses can be more effective in their messaging. However, consumers' attitudes tend to be more multidimensional in regard to social dilemma situations, or scenarios where personal goals conflict with collective goals. Attitudes in these scenarios can also be counterintuitive or surprising (Griskevicius, Van den Bergh, & Tybur, 2010; Reno, Cialdini, Kallgren, 1993; Schultz, et al., 2007), which can make effectively marketing energy-efficient products difficult. Generally, given a social dilemma, such as choosing between cars and trains, people fall into two categories: pro-self and pro-social. Pro-self follows the rational choice pattern in which an individual is motivated by maximizing personal gains and minimizing personal losses. On the other hand, pro-social individuals are concerned for the well-being of the larger group, an obviously important personality trait as it pertains to environmental decision-making. Remarkably, when messaging states high impact versus minimal impact of cars on the environment, pro-self individuals meet preference levels for public transportation similar to those of pro-socials who consistently prefer the train (Van Vugt, Van Lange, and Meertens, 1996, 385). In this case, high speed trains would benefit from increasing awareness of the critical damage to the environment caused by cars.

Van Vugt, et al. (1996, 384) also demonstrate that people are more likely to prefer public transportation versus a car when two obstacles (i.e. longer travel time and reliability) are eliminated simultaneously than when those two influences are separately aggregated. Therefore, high speed rail messaging would most likely induce greater persuasion by promoting two of its perceived advantages, such as decreased travel time and environmental benefits, concurrently rather than separately.

Another social orientation of which marketers should be aware is promotion vs. prevention motivations (Krishen, A., Raschke, R., & Mejza, M., 2010). Promotional people tend to be more engaged in messaging that highlights the positive benefits of a product or policy. Prevention-skewed people engage more in messaging that promotes qualities that help avoid negative occurrences. As it pertains to encouraging ridership of high-speed rail, focused messaging is encouraged in order to induce greater persuasion for a broader range of people. One recommendation for a campaign would combine these three findings (high environmental impact, dual obstacles, positive/negative skew). After identifying the promotional and prevention car commuters, one message could cater to the promotional type by promoting how the train will get you there faster and is more environmentally friendly, while the other could cater to the prevention set by claiming the avoidance of traffic and immense reduction of carbon emissions.

Marketers should be cautious when developing messaging about the advantages of the train when social norms are salient because consumers have some tricky idiosyncrasies when it comes to making judgments in these situations. One study shows that a person who already behaves in a socially responsible way (i.e. energy conservation) will actually engage in more damaging behavior if marketing campaigns induce a perception of being below the norm (Schultz, et al., 2007, 432). However, when the message is qualified with an approval or

disapproval depending on the individual's perception of their current behavior being above or below the norm (*injunctive norm*), respectively, the behavior boomerang is avoided. Another interesting study shows people are significantly more likely to follow a social norm when the reference group is close in proximity (i.e. same neighborhood) than when the reference group is similar in social identity (i.e. car commuter) (Goldstein, Cialdini, & Griskevicius, 2008).

With the last two findings in mind, train marketing could combine the effects (injunctive norm and proximity norm) by customizing messaging for current Amtrak riders and car commuters. To be more specific, one strategy could be to target Amtrak riders on the Chicago-St. Louis line with a message like “a total of 136% more people have chosen to take the train from Chicago to St. Louis over the past five years (Amtrak Press Release, 2010). Thanks for your support!”. Contrast that with a targeted message toward car commuters driving that same route saying “a total of 136% more people have chosen to take the train from Chicago to St. Louis over the past five years. Jump on the train!”. By targeting the receivers with tailored messages qualified with relevant location specification and nodding to the individual's position in reference to the norm, persuasion rates could potentially be amplified resulting in increased ridership. This would be a novel approach to marketing that is empirically founded; however, additional consumer research would be recommended to further support this hypothesis.

A highly controversial aspect of the high-speed rail system is the pricing of tickets. Elasticities should be calculated to determine the most appropriate ticket price range to ensure maximum profitability and, simultaneously, the least impact on the taxpayers. This is a convoluted problem with too many extant variables and uncertainties for the scope of this paper. Instead, presented here are comparative ticket pricing of other running high-speed rails for reference. Following this comparison are alternative pricing options and strategies that might

encourage traveling consumers to consider the train as a viable mode of transportation and potentially compete with cars and planes.

The three graphs as illustrated by Figures 4, 5, and 6, in Appendix C., show comparative costs of travel between well-established high-speed rail systems in Europe and Japan with the relatively newer Northeastern corridor rail (Freemark, 2009). From this pricing picture, one can see that the only existing US high-speed rail ranks on the high end whether comparing cost per distance, speed, or time. The longevity of the European and Japanese rails probably allows them to better calculate precise fair and competitive pricing by utilizing extensive historical ridership data. In contrast, Acela's high fare prices deter many potential riders, where the relatively less affluent would probably consider driving or busing before the train and the remainder who can afford it would probably prefer to fly for an incrementally higher cost. When producing a pricing equation one should also consider the consumers' subjective pricing on personal time, productivity, comfort, and convenience. This is where the marketing campaign could contribute to changing the public perception of the fairness of Amtrak's pricing by promoting the train's advantages (i.e. roominess, wi-fi for productivity, shorter travel time).

As of now, Amtrak offers one base rate no matter the time of day, year, or popularity. This fixed system deters a rider who has previously considered Amtrak and subsequently rejected it based on price. By varying prices based on timing (i.e. off-hours, advance purchase) and popularity, behaviors such as price shopping are reinforced and Amtrak remains in the consideration set during travel decisions (think of the similar reinforcement of gambling behaviors). This pricing system is supported by the data in Figure 1 above which shows that the majority of rail systems not in the US implement this variable pricing schedule. Air carriers and

Megabus also employ this type of pricing schedule where riders tend to shop around hoping to catch the cheapest prices offered which could be as low as \$1 on Megabus.

Griskevicius, Van den Bergh, & Tybur (2010) demonstrate that when status is indicated in purchases, people tend to find the self-sacrificing option more appealing versus the self-indulgent option as long as it is noticeable to the public. Similarly, people who buy the Prius are attracted to it because it projects their financial capability as well as their environmental care. As for Amtrak, they could offer business class and coach class cars in order to appeal to typical flyers who might be attracted to the status symbol, except this has the added benefit of demonstrating their concern for the earth.

Other marketing strategies could include partnering with Metra and CTA to offer deal packages on travel passes so when the traveler arrives in the city via high speed rail they are able to get around the city. Another program such as a frequent rider program would induce loyalty and consistency, similar to air carriers. A similar incentive such as corporate discounts could encourage train travel among professionals and businesses. From the get go, a hurdle that any new product coming into the market faces is not just awareness, but consumer inertia. Therefore, Amtrak should consider an initial push to get new users to experience the trains at which point consumers would potentially transform their perceptions of the train.

The strategies presented here cover a wide range of options for Amtrak to consider when improvements to the current infrastructure are made. Deeper investigation would be needed to support the viability of these proposals. However, a strong marketing campaign is essential in order to maximize success of the project to increase incentive for further improvements.

VII. Conclusion

Because a large degree of uncertainty still remains in terms of ridership growth, rates of substitution, longevity of federal funding and other factors, it is difficult to draw any single, overarching conclusion about the viability of emerging high-speed rail in the Midwest. There are considerable costs to be examined for these projects, including initial funding in taxpayer dollars, maintenance and operation costs likely covered by states, and unaccounted-for environmental costs from initial construction. While there are certainly benefits that might ostensibly be obtained from the implementation of high-speed rail in the Midwest, these are contingent upon high ridership of the rail and high diversion levels from other modes of transport. While these levels are difficult to predict and estimate because they are based on so many factors, they are vital in determining the cost-effectiveness of emerging high-speed rail. Significant levels of ridership and diversion would need to be proven in order to justify the investments and costs of these initiatives.

Having considered these costs, and with an understanding of the limitations of the benefits, our study concludes that high speed rail projects merit a critical eye in order to truthfully determine and weigh their benefits and costs. The uncertainties and great number of variables of such projects point to the challenge that is articulating and implementing a clear and comprehensive transportation policy in the United States. Still, the federal government would stand to benefit from developing a clear and well-defined transportation doctrine in order to align goals with its states and constituents. The current political discord between several states receiving but refusing high-speed rail funding reveals the need for the federal government to realign its goals and methods with those of the states. Modeled after our analysis of proposed emerging high-speed rail service between Chicago and St. Louis , more analyses should be

undertaken to quantify the costs and benefits associated with other lines within the proposed Midwest corridor and in the United States in general.

Furthermore, a significant amount of uncertainty exists with regard to the future political climate and whether or not federal and state funding for high speed passenger rail may continue. However, some concrete conclusions may still be drawn from each section individually.

First, current federal support indicates a commitment to updating the intercity rail infrastructure in the United States, though several states have shown that political support for these projects is not uniform. In the Midwest, individual high speed rail projects have run into varying degrees of political opposition due to perceived costs, including the contentious Wisconsin rail projects, while others are commencing with relatively smooth progress. The evidence of such variation in support of high speed rail initiatives within one region in the country points to the difficulty in establishing a cohesive nation-wide program and initiative.

Second, successful alternative technologies and efficiency strategies have been developed that have the potential to be implemented in the Midwest's emerging high speed rail system to increase average speeds and improve diesel locomotive energy consumption. These technologies have been proven successful in their applications to freight service and existing passenger rail (e.g. in the *Acela Express* and other countries' high speed rail systems). However, there are limitations to implementing these alternatives in the Midwest including the need for additional research and the cost of current retrofits and improvements.

Third, the economic cost and benefit analysis resulted in higher benefits than costs, but these results are based on many assumptions and estimates that are certainly not accepted as fact by many analysts. Many assumptions used for this analysis were optimistic, especially including calculations of increased ridership, which are vital components of the analysis. As a result of the

uncertainties in such an analysis, and due to the very close margin between the net present value of calculated costs and benefits, we must conclude that this project, while promising, requires much more study and analysis to thoroughly understand its true costs and benefits.

Fourth, high speed rail in the Midwest may prove to have a positive environmental effect, with respect to CO2 emission reduction, but only if intercity travel is diverted from automobiles and airplanes at very high rates, and moreover will be more significant if trains are run on clean sourced-electricity rather than diesel. . It is likely that diversion rates will be low to moderate, especially in the early phases of emerging high speed rail, and this factor should be taken to account. Also, while it is helpful to consider the environmental impacts of implementing hybrid or electric locomotive technologies eventually, it is also important to note the current scenario in Midwest high speed rail initiatives, which involve diesel engines.

Finally, a if high speed rail initiatives are to have any chance at increasing ridership and diversion levels, a successful marketing campaign will be critical. It is important to note that a typical marketing campaign is prompted by a marketable and profitable product, but in this case, it cannot be conclusively determined if high speed rail is economically feasible considering the enumerated uncertainties. However, provided that the funding has been allocated to the high speed rail initiative, a successful marketing campaign will be essential for generating ridership numbers that will maximize profitability and energy efficiency.

Ultimately, there are many components to be considered in a project on the scale of a high speed rail network in the Midwest. As such, it is vital that all areas be examined and researched if the federal funding is to be used wisely and appropriately.

VIII. Bibliography

- Amtrak Government Affairs. (2010). "Amtrak's Northeast Corridor Facts and Background Information FY 2009." <http://www.amtrak.com/servlet/ContentServer?c=Page&pagename=am%2FLayout&cid=1246041980246>. Accessed 16 Nov. 2010.
- Amtrak Illinois. (November, 2010). "Annual Ridership on Illinois Amtrak Routes Nears Two Million Passengers." News Release.
- Avallone, E. and T. Baumeister, eds. (1995) Marks' Standard Handbook for Mechanical Engineers. 10th ed. New York: McGraw-Hill Professional.
- Balchandra, J.C., T. Bialek, M. Gravely, and E. Weaver, 2000, "Test Site and Methodologies for Testing and Comparing Energy Storage Systems for UPS, Load Management and Power Quality Applications," International Conference on Electric Utility Deregulation and Restructuring and Power Technologies, London, April 4-7.
- Center for Clean Air Policy & Center for Neighborhood Technology (2006) "High Speed Rail and Greenhouse Gas Emissions in the U.S." <http://www.cnt.org/repository/HighSpeedRailEmissions.pdf> Accessed 2 Dec. 2010.
- Chicago Transit Authority. (March, 2010). "Rider/Non-Rider Behavior and Attitudes Survey." CTA #C09FC100801152. Prepared by: Abt SRBI.
- Cooper, Michael. (October 4, 2010). Rail Service Expansion Imperiled at State Level. http://www.nytimes.com/2010/10/05/us/05rail.html?_r=1
- Federal Railroad Administration (FRA). (n. dat.) "Next Generation High-Speed Rail Technology Demonstration Program." U.S. Department of Transportation. <http://www.fra.dot.gov/Pages/566.shtml>. Accessed 4 Dec. 2010.
- Freemark, Y. (September, 2009). "Getting the Price Right: How much should high-speed fares cost?" The Transport Politic. <http://www.thetransportpolitic.com/2009/09/08/getting-the-price-right-how-much-should-high-speed-fares-cost/>, Accessed November 26, 2010.
- Freshfields Bruckhaus Deringer US LLP. (Dec 16, 2009). "US High-Speed Rail Update." <http://www.freshfields.com/locations/us/briefings/>
- Goldstein, N. J., Cialdini, R. B., & Griskevicius, V. (2008). A Room with a Viewpoint: Using Social Norms to Motivate Environmental Conservation in Hotels. *Journal of Consumer Research*, 35.

Griskevicius, V., Van den Bergh, B., & Tybur, J. M. (2010). Going Green to Be Seen: Status, Reputation, and Conspicuous Conservation. *Journal of Personality and Social Psychology*, 98, 392-404.

IL D.O.T. (September 17, 2010). "Government Quinn Announces Illinois as First State to Begin High-Speed Rail Construction." *Track Improvements on Chicago-St. Louis Corridor Will Create Thousands of Jobs, Economic Boost for Illinois Communities*.
<http://www.dot.state.il.us/press/r091710.html>

INTELEC, 1998, INTELEC '98 20th International Telecommunications Energy Conference, Sessions 21, 28, and 31, San Francisco CA, Oct. 4-8.

Jonsson, Greg. (August 30, 2010). "Track work will disrupt St. Louis-Chicago Amtrak service." www.STLtoday.com

Krishen, A., Raschke, R., & Mejza, M. (2010). Guidelines for Shaping Perceptions of Fairness of Transportation Infrastructure Policies: The Case of a Vehicle Mileage Tax. *Transportation Journal*, 49 (3), 24-38.

Landis, Tim. (November 20, 2010). "High-speed rail progress hit-and-miss across the U.S." *The State Journal-Register*. <http://www.dot.state.il.us/press/r091710.html>

Merrick, Amy. (October 28, 2010). "Racing to Build Midwest Rail Line." *The Wall Street Journal*. <http://online.wsj.com/article/SB10001424052702304248704575574633862261608.html>

MHSRA. (2010). "Amtrak Modernization." Midwest High Speed Rail Association. <http://www.midwestsr.org/amtrak-modernization>

MHSRA. (May 7, 2010). "Illinois Senate creates Illinois and Midwest High-Speed Rail Commission." Midwest High Speed Rail Association. <http://www.midwestsr.org/illinois-senate-creates-illinois-and-midwest-high-speed-rail-commission>

Mica, John L. (January 12, 2009). "High-Speed Passenger Rail." House Transportation and Infrastructure Committee. <http://republicans.transportation.house.gov/News/PRArticle.aspx?NewsID=339>

Midwest High Speed Rail Association. (n. dat.) "Building Blocks." <http://www.midwestsr.org/building-blocks>. Accessed 6 Dec. 2010.

Mitchell, Josh. (October 28, 2010). "US Awards \$2.4 Billion for Passenger-Rail Projects." *The Wall Street Journal*.
http://online.wsj.com/article/SB10001424052702304316404575580644010770322.html?mod=WSJ_WSJ_US_News_5.

Mitchell, Josh. (October 28, 2010). "US Awards \$2.4 Billion for Passenger-Rail Projects." The Wall Street Journal.

Nelson, Shannon. (2010). "WISPIRG: Wisconsin continues to benefit from federal rail investments". <http://www.wispolitics.com/>

O'Toole, R. (2008) "High-Speed Rail The Wrong Road for America"
<<http://www.cato.org/pubs/pas/pa-625.pdf>> Accessed 2 Dec. 2010.

Plautz, Jason. (November 8, 2010) "Wisconsin Halts Rail Project as Election Fallout Begins." Greenwire. <http://www.nytimes.com/gwire/2010/11/08/08greenwire-wis-halts-rail-project-as-election-fallout-beg-32870.html?scp=3&sq=wisconsin%20high%20speed%20rail&st=cse>

Reno, R. R., Cialdini, R. B., & Kallgren, C. A. (1993). The Transsituational Influence of Social Norms. *Journal of Personality and Social Psychology*, 64, 104-112.
Schultz, P. W., Nolan, J. M., Cialdini, R. B., Goldstein, N. J., & Giskevicius, V. (2007). The Constructive, Destructive, and Reconstructive Power of Social Norms. *Psychological Science*, 18, 429-434.

Rudolf, John Collins. (November 4, 2010). "A High-Speed Derailment."
<http://green.blogs.nytimes.com/2010/11/04/a-high-speed-derailment/?scp=2&sq=wisconsin%20high%20speed%20rail&st=cse>

Stodolsky, F. (2002). "Railroad and Locomotive Technology Roadmap." Center for Transportation Research, Energy Systems Division. Argonne National Laboratory.

St. Louis Business Journal. (January 28, 2010). "St. Louis- Chicago high-speed rail gets \$1.1 B in stimulus." <http://www.bizjournals.com/stlouis/stories/2010/01/25/daily48.html>

Transportation Economics & Management Systems, Inc. (2004) "Economic Impacts of the Midwest Regional Rail System" <<http://www.dot.state.wi.us/projects/state/docs/mwrri-regional-brochure.pdf>> Accessed 2 Dec. 2010.

U.S. Department of Energy (U.S. D.O.E.). (2007). "Issues in Focus." *Annual Energy Outlook*. U.S. Department of Energy, Energy Information Administration.

U.S. Department of Energy's Energy Efficiency and Renewable Energy (EERE). (2007). "Multi-Year Research, Development and Demonstration Plan: Planned Program Activities for 2005-2015" <<http://www1.eere.energy.gov/hydrogenandfuelcells/mypp/pdfs/production.pdf>>. Accessed Nov. 30, 2010.

Van Vugt, M., Van Lange, P. A. M., & Meertens, R. M. (1996). Commuting by car or public transportation: A social dilemma analysis of travel mode judgments." *European Journal of Social Psychology*, 26, 373-395.

Washington Post. (August, 2009). "Back on the Bus."
<<http://www.buses.org/files/WAPO%20back%20on%20bus.pdf>>. Accessed Dec 8, 2010.

Wisconsin Department of Transportation. (2010). "Railroad projects."
<http://www.dot.wisconsin.gov/projects/recovery/railroad.htm>

http://online.wsj.com/article/SB10001424052702304316404575580644010770322.html?mod=WSJ_WSJ_US_News_5.

IX. Appendices

Appendix A: Benefit Analysis Calculations

System Revenue

1.969 million riders this past year was increased by its annual average 27%, then multiplied by 50% in order to determine the increased ridership from the implementation of high speed rail.

This number was multiplied by \$45, which was the average ticket price, in order to determine the increased system revenue due to high speed rail (Transportation and Economics Management Systems, Inc., 2004).

$(1.969 \text{ mil})(127\%)(50\%)(\$45) = \text{additional } \$56.3 \text{ million revenue from increased ridership due to HSR}$

Consumer Surplus of Time Savings (Value of Time Benefits)

Assuming three round trips and \$22 value of time per hour, the additional ridership from the previous calculation in system revenue was use to determine the consumer surplus of time savings.

$(\$22/\text{per trip})(1.5 \text{ hours saved time})(1.969 \text{ mil})(127\%)(50\%) = \61 million

Food and Beverage Revenue

The purchase of food and beverage also provides additional revenue. The food and beverage is determined by taking the actual revenue from sales of these products and using total ridership.

By using these two elements we are able to determine the food and beverage revenue per rider

and multiply this by increased riders from the addition of the high speed rail. Let's assume that each rider eats a proportional amount of food so that the food is evenly distributed between all riders, and assuming that 1,250,000 is accurate increase in ridership, than the overall revenue totals from food and beverage would be \$4.8 million per year.

$$(\$8.9 \text{ million}/2.286)(1.25 \text{ million new HSR riders}) = \$4.8 \text{ million}$$

Other Revenue

In addition to ticket and food and beverage revenue, riders contribute revenue in additional miscellaneous ways. This category of 'other' revenue uses the total revenue divided by the totally number of passengers. This amount it then multiplied by our 1.25 million new riders resulting in \$27.3million in additional revenue. This revenue accounts for additional, unexpected spending done by the riders and therefore is a smaller amount and harder to accurately quantify.

$$(\$50 \text{ million}/2.286)(1.25 \text{ million new HSR riders}) = \$27.3 \text{ million}$$

Appendix B: Cost Analysis Calculations

Train Equipment and Rolling Stock

This value was estimated by using the estimated cost in 2002 dollars and converting them into 2011 dollars. The inflation rate used was 3%, which was approximately the ten year inflation rate average (Transportation and Economics Management Systems, Inc., 2004).

$$(\$115 \text{ million})(1.03^9) = \$150,048,916$$

Infrastructure

This value was also estimated by using the estimated cost in 2002 dollars and converting them

into 2011 dollars. The inflation rate used was 3%, which was approximately the ten year inflation rate average (Transportation and Economics Management Systems, Inc., 2004).

$$(\$445 \text{ million})(1.03^9) = \$580,624,067$$

Operation/Maintenance

This value was again estimated by using the estimated cost in 2002 dollars and converting them into 2011 dollars. The inflation rate used was 3%, which was approximately the ten year inflation rate average (Transportation and Economics Management Systems, Inc., 2004)

$$(\$47 \text{ million})(1.03^9) = \$61,324,340$$

Appendix C: Supplemental Images, Graphs

I. B. Figure 1: Map of proposed St. Louis-Chicago Route



In this image, the “emerging high speed line” (i.e. the passenger rail line that would run on existing track at 110mph top speeds) is indicated in green by the “Western Routing.” The “Eastern Routing” will not be considered as it indicates a proposal for a higher speed, 220mph proposal that we do not feel is feasible at this time.

Image Source: <http://www.thetransportpolitic.com/2009/06/30/major-study-advocates-220-mph-operation-on-chicago-st-louis-run/>

III.C. Figure 2 : Regenerative Braking Technology in a Diesel Electric Locomotive

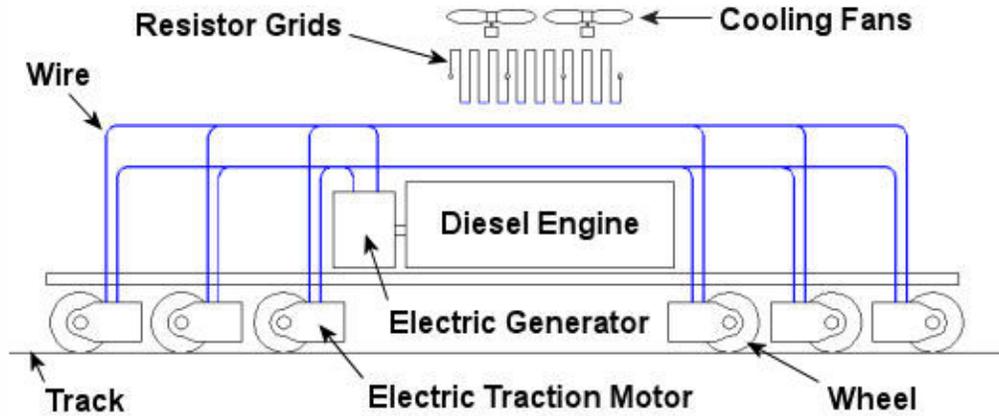


Figure 2 – The Propulsion System In A Six-Axle Diesel-Electric Locomotive

You probably noticed in Figure 2 that there are resistor grids and cooling fans. As long as you're powering a locomotive's traction motors to move a train, these grids and fans won't come into play. It's when you want to *stop* the train that they become important. That's when the locomotive's controls will act to disconnect the traction motor wires running from the electrical generator and reconnect them to the resistor grids as shown in Figure 3 below.

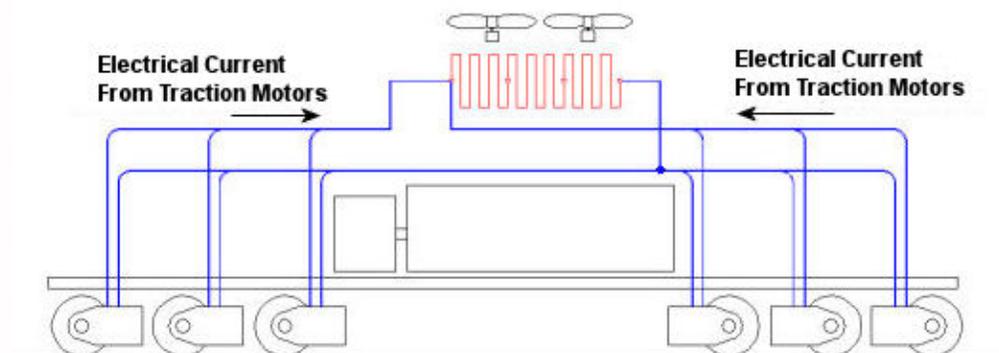


Figure 3 – The Dynamic Braking System In A Six-Axle Diesel Electric Locomotive

Image Source: <http://www.engineeringexpert.net/Engineering-Expert-Witness-Blog/?tag=traction-motor> [accessed 7 Dec. 2010]

III.C Figure3

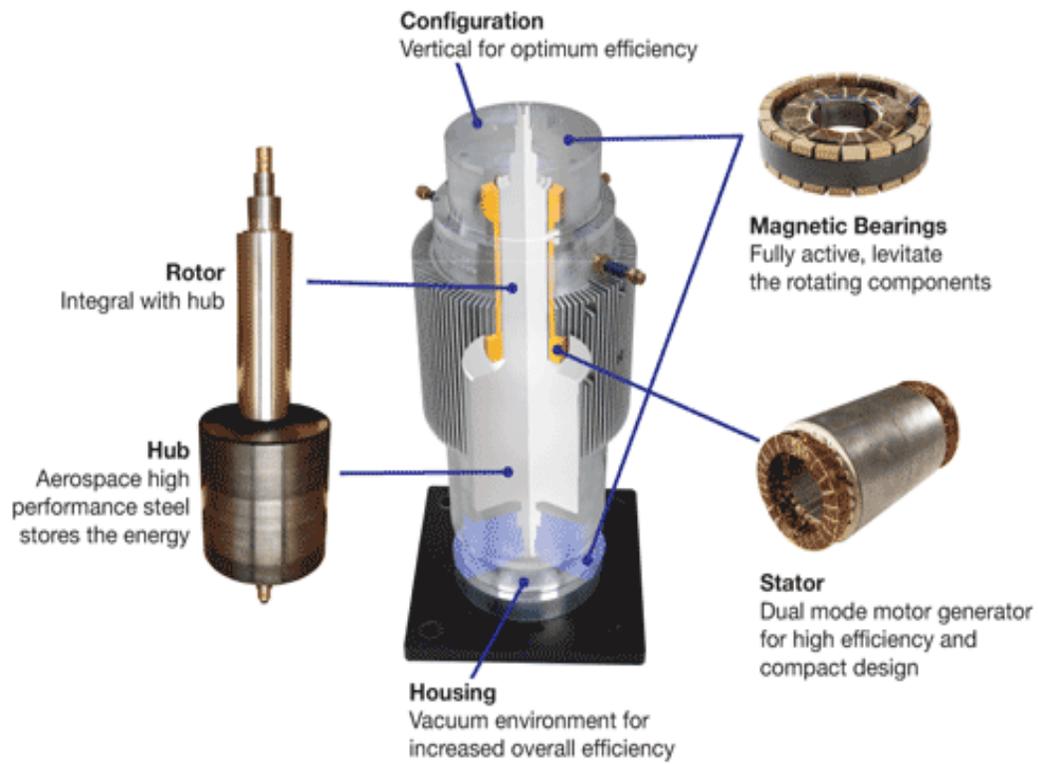
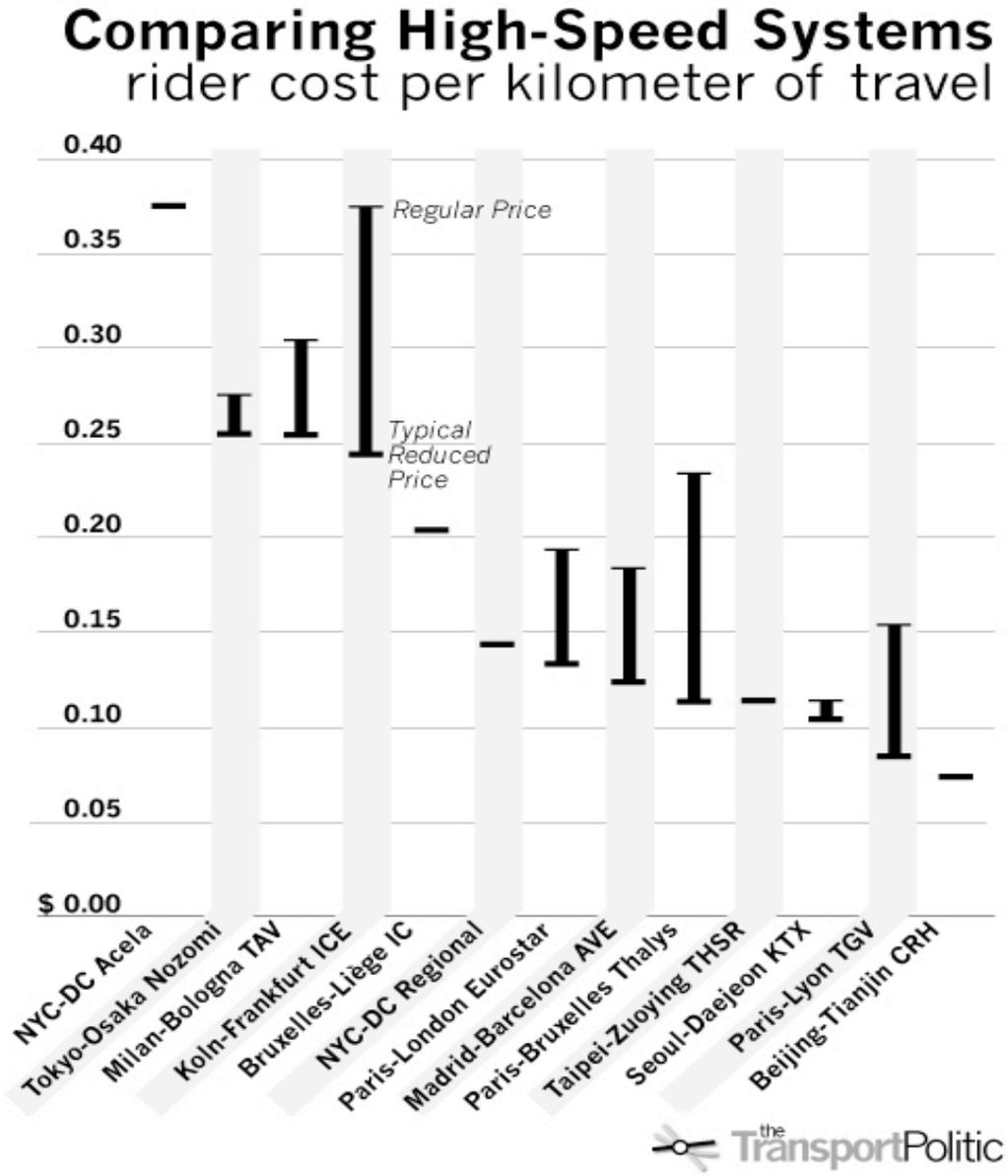


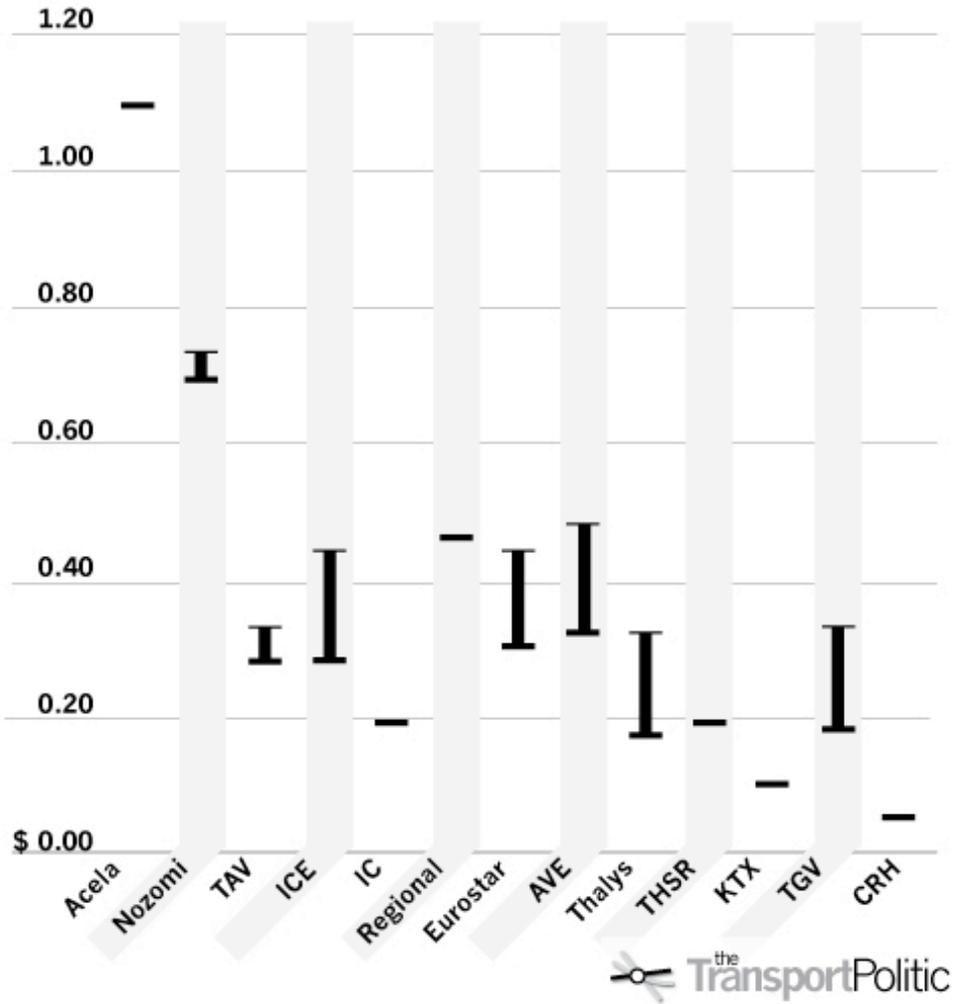
Image source: <http://www.vyconenergy.com/pages/flywheeltech.htm>

VI. Figure 4
 Cost per distance



VI. Figure 5
Cost per speed

Comparing High-Speed Systems rider cost per average km/h



VI. Figure 6
Cost per time

Comparing High-Speed Systems rider cost per hour of travel

