MTI Report MSTM 00-4

Japan's High-Speed Rail System Between Osaka and Tokyo and Commitment to Maglev Technology: A Comparative Analysis with California's High Speed Rail Proposal Between San Jose/San Francisco Bay Area and Los Angeles Metropolitan Area

March 2000

Robert Kagiyama

a publication of the
**Norman Y. Mineta
International Institute for
Surface Transportation Policy Studies**
IISTPS
Created by Congress in 1991

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipients Catalog No.
4. Title and Subtitle Japan's High-Speed Rail System between Osaka and Tokyo and Commitment to Maglev Technology: A Comparative Analysis with California's High-Speed Rail Proposal between San Jose/San Francisco bay Area and Los Angeles Metropolitan Area		5. Report Date March 2000
		6. Performing Organization Code
7. Author Robert Kagiyama		8. Performing Organization Report No. MSTM 00-4
9. Performing Organization Name and Address Norman Y. Mineta International Institute for Surface Transportation Policy Studies College of Business—BT550 San José State University San Jose, CA 95192-0219		10. Work Unit No.
		11. Contract or Grant No. 65W136
12. Sponsoring Agency Name and Address California Department of Transportation Office of Research—MS42 P.O. Box 942873 Sacramento, CA 94273-0001	U.S. Department of Transportation Research & Special Programs Administration 400 7th Street, SW Washington, D.C. 20590-0001	13. Type of Report and Period Covered MTM 290 March 2000
		14. Sponsoring Agency Code
15. Supplementary Notes This capstone project was submitted to San José State University, College of Business, Master of Science Transportation Management Program as partially fulfillment for graduation.		

16. Abstract

The Norman Y. Mineta International Institute for Surface Transportation Policy Studies (IISTPS) at San José State University conducted this study to examine the 36 years of the first high-speed rail in the world, the Tokaido Shinkansen between Osaka and Tokyo. The report evaluates the JR Central Company's historical financial and operating data and compares it with the California High-Speed Rail Authority's proposal to develop a 700 mile high-speed rail network between San Diego, Los Angeles, Central Valley, San Jose, San Francisco, and Sacramento. The report also evaluates the history of maglev technology, progress made in Japan, and whether the technology is suitable for California.

17. Key Words Shinkansen, Bullet train, high-speed rail, maglev, transportation policy, privatization, Japan Railway,	18. Distribution Statement No restrictions. This document is available to the public through The National Technical Information Service, Springfield, VA 22161		
19. Security Classif. (of this report) Unclassified	Security Classifi. (of this page) Unclassified	21. No. of Pages 88	22. Price $15.00

Form DOT F 1700.7 (8-72)

To order this publication, please contact the following:

Mineta Transportation Institute
College of Business—BT550
San José State University
San Jose, CA 95192-0219
Tel (408) 924-7560
Fax (408) 924-7565
Email: iistps@iistps.cob.sjsu.edu

http://transweb.sjsu.edu

http://transweb.sjsu.edu

ACKNOWLEDGEMENTS

This capstone paper was prepared as partial fulfillment of the Master of Science in Transportation Management (MSTM) Program, at the College of Business, San José State University, San Jose, California. The author wishes to thank

- the staff of the Office of Japan Railway & Transport Review (JRTR) for providing back issues of *Japan Railway & Transport Review* monthly magazine;
- my sister-in-law in Kyoto, Atsuho Miki, a staff member at Kyoto University, and cousin in Tokyo, Hiroshi Yamamoto, for their personal time on weekends at libraries and bookstores to provide transportation and commuting data used in the report;
- Joan Freidman, Metropolitan Transportation Commission/ABAG Head Librarian, for providing reference material;
- John Barna, Assistant Director of the California High-Speed Rail Authority for providing background reports and information on the California High-Speed rail proposal;
- Barney Burke, Assistant Economic Development Manager and Michael Percy, Principal Planner for the City of Mountain View for reviewing the draft and providing input; and
- Rod Diridon, Executive Director of the Mineta International Institute for Surface Transportation Policy Studies and MSTM academic advisor, for his support, vision and leadership.

Special appreciation is also due to my wife Chiari and our two children, Sean and Lane, who patiently traveled on the Shinkansen with me on numerous high-speed trains on the Tokaido Shinkansen Line between Osaka and Tokyo during our two-week adventure crisscrossing the Honshu region with a Japan Rail Pass. The highlight of the research trip was visiting the Maglev Research Center and witnessing several manned runs of a maglev train going about 300 mph, with only the noise coming from the train's aerodynamic drag. It is an amazing technology and future. I would not have had the opportunity to visit the many stations and maglev test center without Chiari's assistance in coordinating train transfers from the Shinkansen, express trains, subways, and taxis.

I would also like to thank the Mineta Transportation Institute staff and Editorial Associate for editing and publishing assistance.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

THE VIABILITY OF A CALIFORNIA SHINKANSEN

In 1959, Japan embarked on a national project that forever changed the physical landscape, national economy, and mobility of people between two of the most populated metropolitan areas in the world. In 1964, the Tokaido Shinkansen (Bullet Train) became the first high-speed railway line between Osaka and Tokyo opened to the public. It was an instant success and continues today to be a vital link and an extremely profitable route for the operator, Central Japanese Railway (JR) Company. In the Shinkansen's 36 years of operation, the high-speed rail system has not experienced any loss of life or had any major accidents largely because the line is grade separated from motor vehicles and constructed on right-of-way dedicated solely for the Shinkansen high-speed rail operation. The average delay per train is 24 seconds. Currently the Shinkansen high-speed network comprises over 1,200 miles of track and there are approved plans to construct an additional 680 miles of high-speed tracks.

In January 2000, the California High-Speed Rail Authority (CHSRA) received the final draft engineering and ridership reports for a proposed 700 mile-long high-speed rail network, and will shortly be forwarding a business plan recommendation to Sacramento. The timetable to develop and deliver a 700 mile-long high-speed train network into revenue service is 16 years (2017) with the possibility of completing the San Jose-to-Los Angeles segment by 2012.

In the United States, there has yet to be a serious investment in the high-speed rail transportation market. The Japanese Shinkansen as well as France's TGV and Germany's Intercity Express (ICE) system demonstrates that high-speed rail linking heavily concentrated metropolitan regions is quite successful and heavily in demand by the public, who generally prefer to travel on the ground for medium distances.

The financial and operating records of the Tokaido Shinkansen in the post JNR privatization era demonstrates that a high-speed line can be quite successful. The Tokaido line is equal in length and has high population centers like the California segment between San Jose and Los Angeles. A California version of high-speed rail can be successful and will likely possess a significant market share for medium-distance travel.

Comparison between Shinkansen and California Proposal

The success of the Tokaido Shinkansen between Osaka and Tokyo is simply due to the highly dense population in the metropolitan regions and in between the endpoints. Although regional population figures do not compare well, California's population continues to grow and is expected to increase by 44% at the same time a high-speed rail network could be in full revenue service. High population in metropolitan regions and medium distance links are the key to a high-speed rail system.

The California High-Speed Rail Authority estimates that the cost of a 700-mile high-speed rail network will be about $25 billion.[1] Of that amount, it will cost $13.7 billion (Table 1-1) to construct the main segment or backbone between Los Angeles and San Jose/San Francisco.

Table 1-1: CHSRA's Cost Estimate between LA and San Jose[2]

Construction Segment	Distance per segment (miles)	Construction Cost ($ billion)
Los Angeles - Bakersfield	110	4.4
Bakersfield - Merced	160	2.3
Merced - San Jose	129	4.5
San Jose - San Francisco	43	2.5
Total Distance and Cost	442	$13.70

This is the most crucial segment as it will deliver passengers from southern to northern California in approximately two hours time and influence the economy and prosperity of cities in between the major destination points. The historical construction costs of various JNR and JR Company Shinkansen lines are less than the projected cost-per-mile for the California high-speed network. In comparing the difficult mountainous and geologic terrain along the Shinkansen lines with the CHSRA alignment and physical terrain, the cost to construct the network should be less than the CHSRA's estimate of $25 billion. Once in construction, the timetable to complete the segment between San Jose and Los Angeles should be less than the CHSRA business plan's schedule of seven years. The Tokaido line was constructed in five years and in much more difficult terrain.

Transport Market Share

A CHSRA ridership report predicts that a high-speed rail system between Los Angeles and San Jose will have about 45%[3] of the transport market share. Although the Tokyo to Osaka transport market has an extremely high population density and its market share in 1965 was initially high primarily because of heavy reliance of rail transport, it appears from comparative analysis of the Tokaido line that the CHSRA 2020 projection is achievable. It is not unusual for ridership projections to be overstated, but in the CHSRA report, the projections might be understated and the California high-speed line could gain substantial market shares shortly after introducing a high-speed train to the public (see Table 1-2).

Table 1-2. Market Share between Air and Rail vs. Distance/Time[4]

Area Market	Distance (miles)	Travel Time	One-way Fare	Market Share
Tokyo – Osaka[5]	325	HSR: 2 hr 30min Air: 2 hr 30min	HSR:$129 Air: $149	HSR: 88% Air: 12%
San Jose – Los Angeles	(Proposed) 340	HSR: 2 hr 2 min Air: 1 hr 45 min	HSR: $22 Air: $60	HSR: 66% Air: 34%

Source: Central Japan Railway Company, SJ/Los HSR Fares from CHSRA Report

Comparison of HSR Fare Structure

A ridership projection report prepared for the California High-Speed Rail Authority[6] indicates that if California HSR fares are set between 70% to 80% of the cost of an airline ticket between SJ/SF Bay area and Los Angeles, operating revenues could be maximized. However, ridership could increase by 31% if fares are reduced from 80 to 50% of the cost of airfare.

The cost of flying on Japan Airline or ANA Airline between the Osaka and Tokyo airports costs about $149, or 16,250 yen (see table 1-3). The cost of riding the Hikari Shinkansen between downtown Osaka and the Tokyo Train Station is 13,750 yen, or about $126 dollars at today's exchange rate of $1=109 yen. The Hikari Shinkansen train service is characterized by having three intermediate station stops between Osaka and Tokyo. Riding the fastest

Shinkansen train or the Super Nozomi train service is characterized by no intermediate stops, and the shortest transport time costs 14,720 yen or $149.

Table 1-3. Fare Comparison

Shinkansen	Market	Fare (one-way)	Percentage Of airfare
Hikari	Tokyo-Osaka	13,750 yen ($126)	85%
Nozomi	Tokyo-Osaka	14,720 yen ($135)	91%
CHSRA[7]	San Jose-LA	$22 to $40	50 to 70%

Because the Shinkansen dominates the market between Osaka and Tokyo, the operator of the line, JR Central Company, is able to charge rail fares that are between 85% to 91% of the cost of airfare. Once Shinkansen passengers realized the benefit and convenience of high-speed ground transportation, they literally abandoned air travel for medium distances.

FUTURE OF U.S. MAGLEV

In 1999, a manned Japanese maglev train broke a speed record by going 344 mph on a 27 mile-long test track. Speed is an important factor in medium distance travel, and as maglev testing reaches speeds closer to airline speeds, it could someday be a viable alternative form of mass surface transportation.

Although maglev is an amazing technology that could become energy and cost effective in the future, it is an unproven and vastly expensive technology. While Japan and Germany have expended billions of dollars developing maglev technology for the purposes of passenger revenue service, the United States is not in a position to expend the same level of effort and funding. To maintain the public's trust in rebuilding and improving the nation's transportation infrastructure and developing new modes of mass transportation, the public's perception of transportation funding cannot be jeopardized by leapfrogging to a high-speed maglev train that has yet to be in commercial use. This does not mean abandoning the technology altogether; while the high-speed rail is under planning stage or construction, California companies, such as Lockheed Martin, Boeing, or an international airline could commit to advancing the maglev technology to a useable form. However, to provide the necessary incentives that could encourage formation of joint ventures with Japan and Germany to further maglev development and deployment, sizable grant funding programs from Washington and Sacramento are crucial to an operational breakthrough.

CONCLUSION

In the United States, the automobile has been recognized as the primary mode of transportation and will continue to play a significant role as the most flexible means of providing mobility. However, the promotion of other transportation modes will need to be further developed to balance out capacity and environmental constraints, and provide options that are limited or unavailable today. A long-term commitment to mass transportation, principally in the development of a statewide passenger-rail network connecting the major metropolitan regions, could change the public's attitude and limited experience with alternative transportation sources.

The promotion of mass transportation will benefit all modes of transportation and ease the congestion being felt on the freeways and airports. A comprehensive, well-balanced and technically sound transportation system could make California more productive. A statewide railway network could make a long term difference in the stability of the economy and will allow greater flexibility in the movement of people, goods and services.

The Tokaido Shinkansen has been an extremely profitable line for the Central Japan Railway Company, and a high-speed line between Los Angeles and San Jose could be quite profitable if properly financed and managed. California and other states or regions potentially seeking high speed links between major metropolitan cities simply cannot afford to put all surface transportation eggs into one basket as diverse mass transportation systems can provide competitive options for consumers and businesses.

The California High Speed Rail Authority's Business Plan provides in-depth detail on the practicality of constructing a high-speed train system for California. It appears that the plan could be a smart investment if properly approached to complement existing transport infrastructure and can adequately and openly address the issue of public subsidy. The enormity and importance of the HSR plan can be compared to the California Water Project as both are considered to be extremely vital to the state's economic well-being.

California has historically been recognized for its vision and leadership in infrastructure. The state had the vision and wisdom to invest in the development of the University of California (UC) and California State University (CSU) system to handle the anticipated educational demand and employment projections. Its water supply infrastructure has transformed a desert into one of the world's most productive agricultural regions, and the Silicon Valley between Palo Alto and San Jose is known today for its cutting-edge technology.

The California High-Speed Rail Authority concluded their business plan to the public that California's future contains a high-speed train system. Based on an evaluation and historical review of the first high-speed rail system in the world, it appears that if California chooses to construct a high-speed rail system, it could become successful and set the lead for other states to follow.

CALIFORNIA'S TRANSPORTATION FUTURE

BACKGROUND AND PURPOSE

The purpose of this capstone paper is to evaluate the Tokaido Shinkansen between Osaka and Tokyo and develop comparisons with the proposed high-speed rail line between Los Angeles and San Jose. In addition, the paper will examine Japan's commitment to developing magnetic levitation trains for commercial use and whether this amazing technology is appropriate for California.

CALIFORNIA TRANSPORTATION MARKET

Californians report that congestion, airport delays and transportation issues in general are highest on their list of concerns. The productive time lost by non-movement of private automobiles on highways and local streets unable to handle existing capacity, and the frustrating delays at airports are gradually taking a toll on the economy and contributing to public demand for alternative solutions. A dynamic economy relying on just-in-time concepts can quickly go sour when the freeways and airports can no longer handle the demand, and material goods cannot be moved efficiently by truck or airline. Over-dependence on a single transport source is detrimental to businesses, tourism, and the individual commuter.

According to the 1998 Transportation Statistics Annual Report on Long Distance Travel and Freight, a report by the Bureau of Transportation Statistics, of the top 10 medium-distance travel markets in the United States, five are in California and most of the person-trips are made by private automobile (Table 2-1).

Table 2-1. Top 5 Medium-Distance Travel Markets in California

Travel Market Between			Travel Distance (miles)	Person-Trips (1,000)
Los Angeles	**-**	**San Diego**	130	10.5
Las Vegas	**-**	**Los Angeles**	180	9.1
Los Angeles	**-**	**Los Angeles**	60	7.6
Los Angeles	**-**	**SF/San Jose**	325	7.1
Sacramento	**-**	**San Francisco**	125	5.3

Source: U.S. Department of Transportation, Bureau of Transportation Statistics

With existing freeways at built-out capacity and extensive delays routinely occurring at airports, an alternative transport system is needed to relieve the congestion and balance capacity constraints.

In January 2000, a draft final report "California High-Speed Corridor Evaluation"[8] was submitted to the California High-Speed Rail Authority (CHSRA). Along with the engineering studies, a separate draft ridership study entitled "Independent Ridership and Passenger Revenue Projections for High Speed Rail Alternatives in California"[9] was submitted to the CHSRA.

The proposed high-speed network (Figure 2-1) consists of 700 miles of high-speed track between San Diego, Los Angeles, San Jose, and Sacramento. (Figure 2-1) According to the current CHSRA project timeline, the complete high-speed train network could start operations as early as the year 2017.

If the backbone or central system between San Jose-San Francisco and Los Angeles goes into revenue service by 2012 or seven years after environmental clearance and construction completion, it will occur at the same that the first baby boomers will reach the age of 65. Retired baby boomers are expected to have more disposable income to spend on leisure travel and they will be looking for convenience and stress-free travel modes.

To analyze the CHSRA proposal, a comparison between the Osaka-Tokyo regions and SJ-SF Bay–LA Basin regions was chosen because of numerous similarities including the distance between the major metropolitan regions, large population base, and their economic importance to each nation. According to a Southern California Association of Governments (SCAG) annual report, the four metropolitan regions in this study report are on a list of the world's top six metropolitan economies as shown on Table 2-2.

The Tokyo-Yokohama Region has the highest gross regional product (GRP) output and has the world's highest concentration of population for a metropolitan area. The economies of the Los Angeles Basin, the San Jose-San Francisco Bay region, and the Osaka Region are third, fifth, and sixth, respectively. The combined GDP-GRP person for the Los Angeles Basin and SF-SJ Bay region is 42% higher than the combined GDP-GRP per person of the Tokyo-Yokohama and Osaka-Kyoto regions.

Table 2-2. The World's Top Six Metropolitan Economies

	Metropolitan Area	GDP/GRP (billion dollars)	Population (per million)	GDP/GRP per person ($/person)
1	Tokyo-Yokohama Region	$757	27,276	$27,753
2	New York City-New Jersey	$740	n/a[10]	n/a
3	Los Angeles Basin	$453	16,262	$27,856
4	Chicago	$296	n/a	n/a
5	SJ-SF Bay Region	$265	6,814	$38,891
6	Osaka, Kyoto Region	$227	11,800	$19,237[11]

Source: Ranking & GDP/GRP data by Arthur J. Shaw, Consulting Economist, SCAG 1999 State of Region Report, Population: SCAG, ABAG, Japan Almanac

After the Tokaido Shinkansen between Osaka and Tokyo was completed in 1964 (Figure 2-1), there was a period of intense economic expansion that was not directly due to the Shinkansen. However, its presence had a particularly large impact and assisted in promoting the nation's economic boom particularly in the large metropolitan regions along the Shinkansen line. The medium distance of 325 miles between the two major Japanese cities makes routine exchange of goods and services readily accessible by air, high-speed rail, and roadway.

The travel distance between San Jose-San Francisco Bay area and the Los Angeles Basin is about 340 miles. Multiple international airports, conventional railway, and a freeway system link the two metropolitan regions. With traffic congestion worsening and transport capacity reaching its limitation, alternative transport systems will need to be considered to sustain the two major metropolitan regions' economies.

Source: Central JR Company Web Site

Source: California High Speed Rail

Figure 2-1. High Speed Route Maps (not to Scale)

JAPAN'S METROPOLITAN LANDSCAPE AND TRANSPORTATION SYSTEM

GEOGRAPHY OF JAPAN

Japan is a long and slender chain of four main islands (archipelago) consisting of Honshu, Hokkaido, Kyushu, and Shikoku. Honshu is the largest and most habitable island. Japan geographically is largely a mountainous terrain with most of the nation's population centers of industry and commercial development located in the coastal regions.

Although Japan is much longer than California, its total land area is 145,000 square miles or about 93% of California's land area. This comparison can be quite deceiving since only about 29% of Japan's total land area is habitable. The magnitude of the disparities between habitable land and the high population density can be best viewed by taking half of the United States' population and concentrating the population with numerous large cities along the California coastline between San Francisco and Los Angeles.

POPULATION

Japan is the seventh most populated nation in the world with 126,900,000 people. Japan's developable land area concentrates the population in the major coastal cities. Most of the population is concentrated in the three largest cities of Osaka, Nagoya and Tokyo, where 50% of the nation's total population resides. The Tokyo region possesses 25% of the country's total population. The distance between Tokyo and Osaka is about 325 miles with Nagoya in between. The dense population base and the medium to long distance between the three cities make an ideal setting for a high-speed rail network. The data shown on Table 3-1 suggests that the population density is much higher in Japan, both overall and locally, making mass transit more usable and necessary.

Table 3-1. Population[12]

Region	Land Area (sq. miles)	Population (million)	Density (person per sq. mi.)
Japan	145,000	126.0	869
Tokyo Region	1,089	27.0	24,793
Osaka Region	495	14.2	28,687

Source: World Almanac, Japan Almanac, ABAG

Japan currently has a total population of 126 million people. As shown on Figure 2-2, Japan's population is expected to peak to 127.6 million in 2010 and by the year 2050, the population is projected to decline to 100 million or decrease by 20%.

When the Shinkansen bullet train started operation between Osaka and Tokyo in October 1964, Japan had a population of about 98 million people, or slightly less than what is projected in the year 2050. The population projections are based on the fact that fewer couples are having children. This could be a result of a highly dense population base that offers an average of 1,000 square feet of living space for a typical household of 2.8 people in the major metropolitan areas, as well as the high level of education, and that Japan as a nation has one of the highest levels of median income. Although Japan statistically has the greatest number of people living the longest in the world, this country is balanced by the low birth rates, which leads to a long-term decline in population.

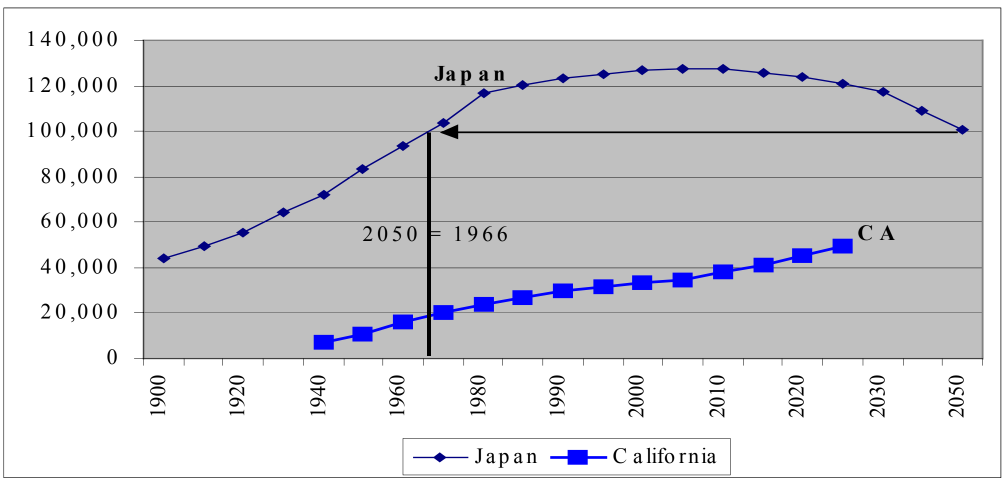


Figure 3-1. Population of Japan & California (in 1,000s)

Impact of Population Density in Tokyo and Osaka on JR Shinkansen's Success

To provide an idea of the magnitude of the population and its impact on Shinkansen ridership between Osaka and Tokyo, the following are some very astonishing statistics:[13]

- The two busiest JR Shinkansen stations in Tokyo are the JR Tokyo and JR Shinjuku Station. The Shinjuku Station is the busiest with about 750,000 passengers per day going in and out of the station. This is nearly equal to having 90% of the city of San Jose's population using the Downtown San Jose Diridon Train Station on any given weekday.

- The JR Tokyo Station has a total of 4,047 trains that pull in and out each weekday; of these, 640 are special express trains.
- Over 57% of commuters in the Tokyo Prefecture use rail to commute daily to work.
- On an average day, 14,000 lunch boxes are sold at the JR Tokyo Station. Lunch boxes are usually purchased by passengers going a long distance on the JR Shinkansen and eaten on-board.
- The JR Tokyo Station consists of 25 platforms and 800 station staff members.
- During the peak periods, train headway in Tokyo and Osaka is two to three minutes, and on non-peak weekdays, the headway is about five to six minutes. The high concentration of population requires frequent trains even during the low or non-peak periods.

THE TOKAIDO SHINKANSEN BETWEEN OSAKA AND TOKYO

TOKAIDO SHINKANSEN

In 1959, the JNR (Japanese National Railway) began construction of the Tokaido Shinkansen line from Tokyo to about 18 miles beyond Osaka, for a total distance of 344 miles. The project was completed in advance of the 1964 Summer Olympics in Tokyo to showcase the first high-speed rail technology to the world.

In Japan, the high-speed trains known as bullet trains, or the Shinkansen, have been efficiently providing transportation for Japanese commuters for about 36 years without recording any major accidents or fatalities, largely due to dedicated right-of-way and grade separation requirements.

A typical Shinkansen train consists of 16 cars linked together to make a total train length of over 1,300 feet or about one-quarter of a mile. Each train can carry as many as 1,300 passengers (Photo 4-1), has eight telephones and restrooms in alternating cars, two cars to accommodate passengers upgrading to first class seats (these seats are similar to an airline’s first-class seat) and there are ten stewardesses assigned to each train.

Photos 4-1 and 4-2. Nozomi Train heading for Tokyo

Tokaido Shinkansen Background

The Tokaido rail line originated over 120 years ago. In 1930, an express train on the Tokaido Line (which has since been extensively modified and realigned for high-speed rail), took an average of eight hours and 20 minutes between Tokyo and Osaka. The line reached capacity limitations in the early

1950's, which lead to the government's decision to construct a high-speed replacement. The Tokaido Line was electrified in 1956. The Japanese probably embraced electric trains shortly after WWII because the nation is highly dependent on imports for oil and other natural resources. In 1958, the JNR budgeted 195 billion yen ($537 million in 1964 U.S. dollars) to construct the Tokaido Shinkansen line. Prior to the construction, the president of the JNR, Shinji Sogo, made the decision to upgrade the Tokaido line from narrow gauge to standard gauge (1435 mm). After the Tokaido Shinkansen opening in 1964, the public was pessimistic about a high-speed rail system competing with road and air transport. The public's perception quickly changed, as the success of the line between Osaka and Tokyo prompted national demand for the construction of a nationwide system.

The initial construction of the Tokaido Shinkansen began with the assumption by JNR officials that the entire cost would be recovered by passenger fares and high demand for the service. The financial burden of the new line was immediately felt after revenue service began, and the long-term debt services still exist today. In the California plan, the CHSRA is not necessarily proposing to recover construction costs by fares.

The over-commitments by politicians that led to over extending the initial Tokaido high-speed line terminus end points, and the overestimating of the ridership projections were the primary reasons for the financial difficulties of the JNR and taxpayers. Political pressure and influences allowed the basic track line and station infrastructure to grow with additional embellishments. The political pressure to extend the line beyond Osaka, to a low demand area, seems to pinpoint most of the financial problems. Had the JNR limited the construction between Tokyo and Osaka, where the high ridership and profit exists, it could have avoided the financial disaster that led to the reformation and privatization.

Once the public enjoyed the high-speed, convenience, and comfort offered by the Tokaido Shinkansen, they demanded even more lines to be constructed. Consequentially, the JNR and the national government extended the network to other highly populated cities and low demand areas.

Privatization of Japanese National Railway (JNR)

In 1982, a government ad hoc commission made a recommendation to privatize the JNR, and in 1985 a final report with the recommendation was submitted to the Japanese Prime Minister. In that same year, the JNR's long-term debt was 23,500 billion yen or about $99 billion in 1985 dollars. In 1987, Japan made a bold move to deal with the financial problems of the JNR—

government officials decided to breakup the national railway into six private companies to handle passenger volume and one freight company.

A former president of the Japan Transportation Economics Research Center, was one of several individuals who originally proposed reforming JNR into several regional networks.[14]Eventually, the JNR was broken into the six regional passenger railways and one freight service company that exists today as listed below:

- JR East
- JR Central
- JR West
- JR Hokkaido
- JR Shikoku
- JR Kyushu
- JR Freight

To ensure a smooth and financially successful transition, the government created the Japanese National Railway Settlement Corporation to handle the JNR's long-term debt and assets. In addition, a holding corporation now known today as the Railway Development Fund was set up to manage the leasing of the Shinkansen lines, to collect leasing fares, and to maintain profitability of each JR company. In April 1987, the seven JR-created companies began life as private companies. Two years after privatization, the JR companies in the aggregate, achieved a record high 134 billion passenger-miles, and revenues were far greater than predicted by the government.

After the Creation of JR Companies

After the first year of operation as a private entity, the JR companies had a combined operating profit of 340 billion yen or about $2.4 billion in 1987 dollars. In 1992, or five years after privatization, the operating profits soared to 900 billion yen or $7.1 billion in 1992 dollars. Over the years, as profits continued for the JR Central, JR East, and JR West, the companies were able to purchase the lines instead of leasing the infrastructure from the government. This posed a financial burden, but in the long run the companies felt it would be in a better financial position to the stockholders by combining infrastructure ownership with the operations. See Table 4-1 for a comparison of JR company revenues.

Table 4-1. Comparison of JR Companies (1998) [15]

JR Company	Commuter and Shinkansen Line (miles)	No of Passengers per Year (millions)	Annual Operating Revenues (Billions of Dollars)[16]
JR Central	1,233	519	10.0
JR East	4,684	5,978	16.9
JR West	3,156	1,867	8.2
JR Hokkaido	1,553	125	.9
JR Shikoku	532	62	.4
JR Kyushu	1,306	315	1.5

It appears that the benefits of privatization and breakup of the Japanese National Railway far exceeds the historical success of the former JNR Corporation, and opened up more business opportunities which indirectly created more jobs and provided a truly competitive regional marketplace.

Current JR Central System

Since the opening of the Tokaido Shinkansen line 36 years ago, several billion passengers have ridden on the line between Osaka and Tokyo. Today, the line carries over 350,000 passengers in an 18 hour day[17] with 285 trains per day operating between Tokyo and Osaka (Table 4-2). The JR Central Company provides three train services. The Nozomi service provides the fastest train and the shortest travel time between Osaka and Tokyo with a maximum of two station stops at only the major stations at Nagoya and Kyoto. The Hikari train service makes three to four intermediate stops and the Kodama train service stops at all 14 stations between Tokyo and Osaka. Of the 285 trains per day, 51 trains are Nozomi service, 147 are Hikari service, and 87 are Kodama train service (see Appendix D for service schedule). There are 8,600 employees involved in the operations of the Tokaido Shinkansen line between Tokyo and Osaka.

Table 4-2. Ridership on Tokaido Shinkansen Line[18]

Tokaido Line	1964	1999
Travel time	4 hours	2 hr 30 min
Trains per hour from Tokyo	2	11
Trains per day	60	285
Passengers per day	61,000	357,000

COMPREHENSIVE MASS TRANSPORTATION SYSTEM

In addition to the Tokaido Shinkansen, the JR group as a whole provides about 1,346 miles of high-speed Shinkansen lines as shown on Table 4-3. The entire country has about 16,800 miles of rail line, of which the privately owned JR Companies operate about 12,600 miles of rail service including the Shinkansen, commuter rail and local lines.

Table 4-3. Current JR Shinkansen Lines

Shinkansen Line	Operator of Shinkansen Line	Year completed	Length of high speed track (miles)	Construction Cost per mile ($ million) [19]
Tokaido	JR Central	1964	343	2.84
Sanyo[20]	JR West	1975	344	8.91
Joetsu	JR East	1982	168	39.10
Tohoku	JR East	1991	309	64.10
Yamagata	JR East	1992	54	n/a
Akita	JR East	1997	79	n/a
Hokuriku	JR East	1997	73	n/a

Source: Central JR Company, JR East, Japan Railway & Transport Review[21]

Today, the entire Shinkansen system runs flawlessly with average time schedule delays of only about 24 seconds per train.[22]With traffic congestion, concerns for the environment, and the high price of gasoline and parking, commuters seek favorable alternatives. It is the operating efficiency, comfort, and convenience of the Shinkansen that aid in attracting a high number of rail passengers.

At major station stops along the Shinkansen line, particularly in Tokyo and Osaka, Shinkansen passengers have plentiful commute options once they depart a station. In Osaka and Tokyo, subways, express trains, monorail, and Automatic Guideway Transit (AGT) are some of the transportation alternatives available throughout each city. In Tokyo, there is an extensive underground network of subways totaling 148 miles, which carry 7.3 million passengers per day with a headway of two minutes during the peak periods. The success of transporting people between major metropolitan areas could not occur without the metropolitan regional government's plan for an expansive and reliable transportation network to disperse incoming and outgoing traffic. The columns in Figure 4-1 reflect the different modes of transportation available to connect with the proposed high-speed train service in the different areas.

San Jose/Bay Area				**Los Angeles Basin**
Amtrak	↔		↔	Amtrak
Caltrain	↔		↔	Commuter Rail
BART	↔		↔	LRT
LRT	↔	Proposed	↔	Subway
Bus	↔	High Speed Train ◄──►	↔	Bus
Taxi/Shuttle Service	↔	340 miles apart	↔	Taxi/Shuttle Service
International Airport	↔		↔	International Airport
Roadway System	↔		↔	Roadway System
Walking, Biking	↔		↔	Walking, Biking

Osaka Prefecture				**Tokyo Prefecture**
Shinkansen	↔		↔	Shinkansen
Express trains	↔		↔	Express trains
Commuter Rail	↔		↔	Commuter Rail
Subway	↔	(Proposed Chuo Maglev)	↔	Subway
Monorail	↔	Tokaido Shinkansen ◄──►	↔	Monorail
AGT	↔	325 miles apart	↔	AGT
Bus	↔		↔	Bus
International Airport	↔		↔	International Airport
Taxi/Shuttle Service	↔		↔	Taxi/Shuttle Service
Roadway System	↔		↔	Roadway System
Walking, Biking	↔		↔	Walking, Biking

Figure 4-1: Availability of Mass Transit Connectivity to Other Modes

Japan's Transportation Network Improvements

In addition to continuous rail and station improvements throughout the Shinkansen corridor, Japan is moving aggressively to improve and expand its roadway system at staggering costs. The 5.8-mile long Seto Ohashi Bridge (Photo 4-3 and 4-4) was completed in 1987 at a cost of 1 trillion yen, or about 7.7 billion dollars.

Photo 4-3. Seto Ohashi Bridge[23] **Photo 4-4. Rail Service on second deck**

The bridge structure consists of a four-lane highway to accommodate vehicular traffic on the upper deck, and a double track for commuter rail and two tracks for a Shinkansen line on the lower deck.

In April 1998, the Akashi Kaikyo Bridge (Photo 4 and 5) opened to the public after ten years of construction and 500 billion yen or 4.6 billion U.S. dollars.[24] As the world's longest suspension bridge with a total length of 3,911 meters or 12,828 feet, the Akashi Kaikyo Bridge, unlike many other major bridges in Japan, cannot accommodate both motor vehicles and rail. This is due to the fact that the bridge connects to a small island where there is low demand for rail, and other islands are linked by lengthy underwater tunnels. The Akashi Kaikyo Bridge, however, was constructed to provide an important roadway link and improve the nation's overall surface transportation system. Most bridge sightseers come by Shinkansen to get a view of the structure and visit the Bridge Exhibition Center from the nearby JR Maiko Station.

Also in 1998, the Ministry of Transport approved construction for three new Shinkansen lines with a budget of one trillion yen or 9.2 billion U.S. dollars. These three lines are expected to be completed by the year 2018 and incrementally go online along major sector points. In addition, the government is spending billions of dollars each year to improve the overall transportation network with expressway upgrades, new bridges, and rail extensions. While Shinkansen lines continue to be constructed and line extended, the debate continues over the cost and need for high-speed rail system improvements into lower demand areas.

Japan is spending massive amounts to improve their overall transport system for both the auto and rail. The Seto Ohashi Bridge included provisions for a future Shinkansen bullet train to deal with the anticipated capacity. In addition, the development of a new airport at Kobe Bay is underway as a possible replacement to the Osaka domestic airport. With a highly dense population, a comprehensive mass transportation system and integrated network is a crucial element to a livable community and to international businesses that are relying on timely deliver of goods and services.

Photo 4-5. Akashi Kaikyo Bridge

CENTRAL JR COMMITMENT TO HIGH QUALITY STANDARDS AND PROFITABILITY

Customer Service

Japan is an extremely clean and modern country with over 2,000 years of history allowing castle and temples to coexist with skyscrapers and high-speed rail. While its largest cities are quite modern, the Japanese take pride in preserving their historical treasures. Along with the famous gardens and castles, the Shinkansen is a national delight and workhorse that functions well because of the dedication of the JR employees. On average, a train is delayed no more than an average of 24 seconds.

One of the many reasons passengers are attracted to the Shinkansen is the high quality of service. The inside of a Shinkansen train cabin is comparable to riding in the business class of an airline. A passenger entering a Shinkansen train will find ample walkway space as well as plentiful overhead luggage compartments (Photo 4-6), and comfortable, fully reclining seats (Photo 4-7), all in an extremely clean environment. At top speed, passengers still enjoy a remarkably quiet ride while traveling at speeds as high as 168 miles per hour.

It is not unusual for JR staff to make prompt repairs while the train is in service. For instance, if a conductor happens to notice a burned out bulb on the overhead ceiling, the conductor will call in the defect, and by the next station stop maintenance staff will board the train and, with little notice, will promptly make the repairs and exit at the next station. If a passenger using a pay telephone on the train should happen to get their telephone card jammed in the telephone, the conductor will call ahead and by the next station stop a telephone company representative will board to assist the passenger.[25] At the end of each Shinkansen trip and prior to the train's return trip, the inside of all the cabins are thoroughly cleaned by JR employees and the seats are automatically repositioned to face the forward direction.

Photo 4-6. Interior of Shinkansen Train

Photo 4-7. Reclining Seats

Overall Business Activities and Practices of JR Central

After the privatization and break-up of JNR and the creation of JR Central to manage and operate the Tokaido Shinkansen Line and a dozen commuter lines, there became a need for business diversification to deal with mounting debt services from the JNR. Today, JR Companies own and operate a variety of businesses including:

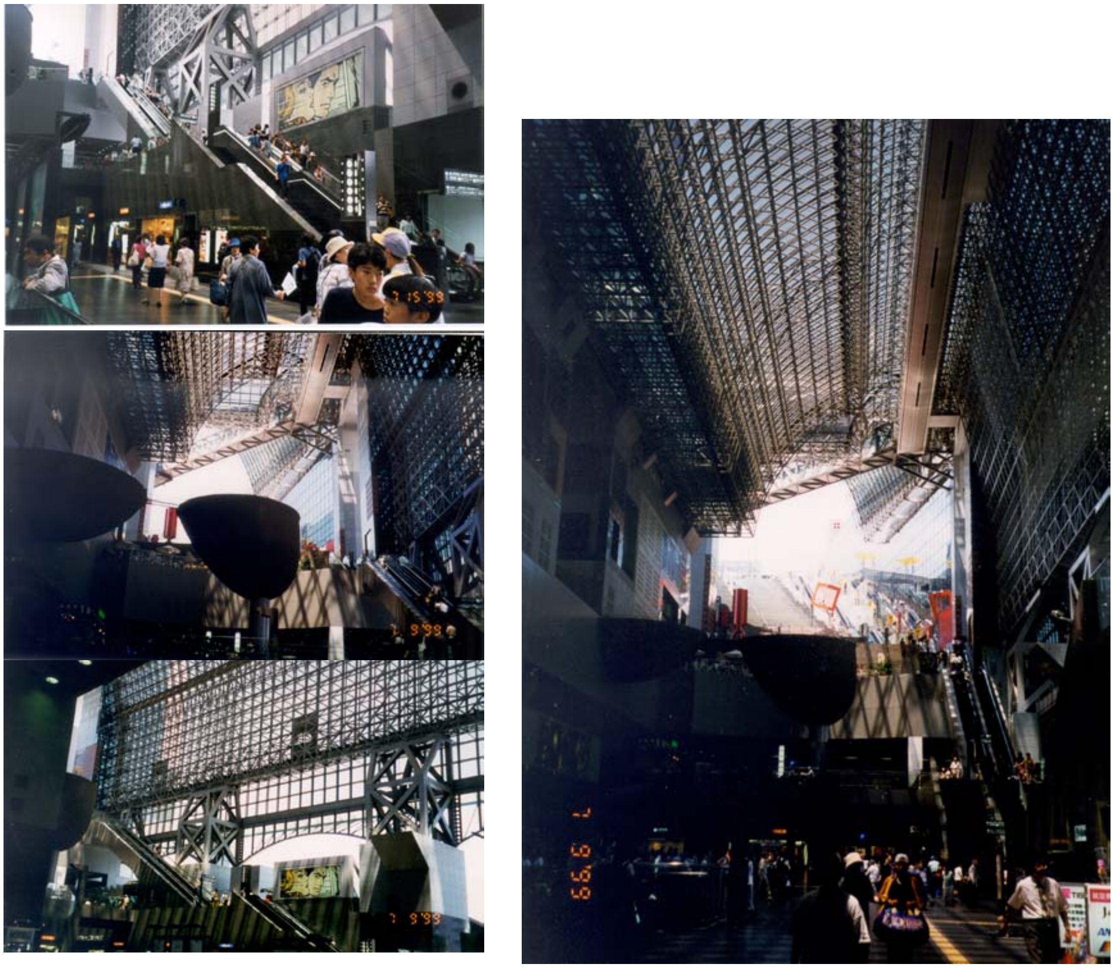
- Restaurants
- Tour companies
- A car rental business
- Hotels
- Travel agencies
- A real estate development
- Shopping centers
- Department stores
- Kiosks
- A trucking company
- Construction companies
- Ski resorts
- Power generation plants
- A professional sports team

Architecturally appealing train stations—A New Era

The connecting point to each of the major cities is at a major train station. Each of the private JR companies have undertaken substantial station projects and continue to this day to improve the image of each their stations. New
station drug stores,
librarie n Station is a
marvel are taking in
the de gh 4-14. The
station . The station
include drug stores,
bakerie s. Within the
12-sto r find plenty
of fast es a stimulus
for a g

At the ng a massive
project hotel and the
other t

Photos 4-9 and 4-10. Kyoto Station.
More photos on next page



Photos 4-11 through 4-14. Kyoto Station [26]

COMPARISON OF THE SHINKANSEN TO THE CALIFORNIA PROPOSAL

In spring 2000, California state legislators and the governor will make a decision on the CHSRA's business plan for a $25 billion high-speed rail system. The high speed network would run between Sacramento, San Jose, Central Valley, Los Angeles, and San Diego at speeds as high as 200 miles per hour. Once completed, a private company such as an airline would likely operate the system. It is unknown, though, how the capital costs would be financed—whether an airline would operate or instead sue to prevent the HSR proposal from going any further. The real test will be paying for the $25 billion price tag and unknown profit margins.

Population Comparisons

To effectively provide mass transportation within a metropolitan region and link it to another medium distance metropolitan region, high population density is a necessity. The success of the Tokaido Shinkansen is primarily due to the high concentration of population in the Osaka, Tokyo, and Nagoya regions. Between 2000 and 2050, Japan's population will decrease substantially from 127 million to 100 million while California's population is expected to increase 44%—from 32 million to 46 million people. See Table 5-1 for a comparison of regional populations.

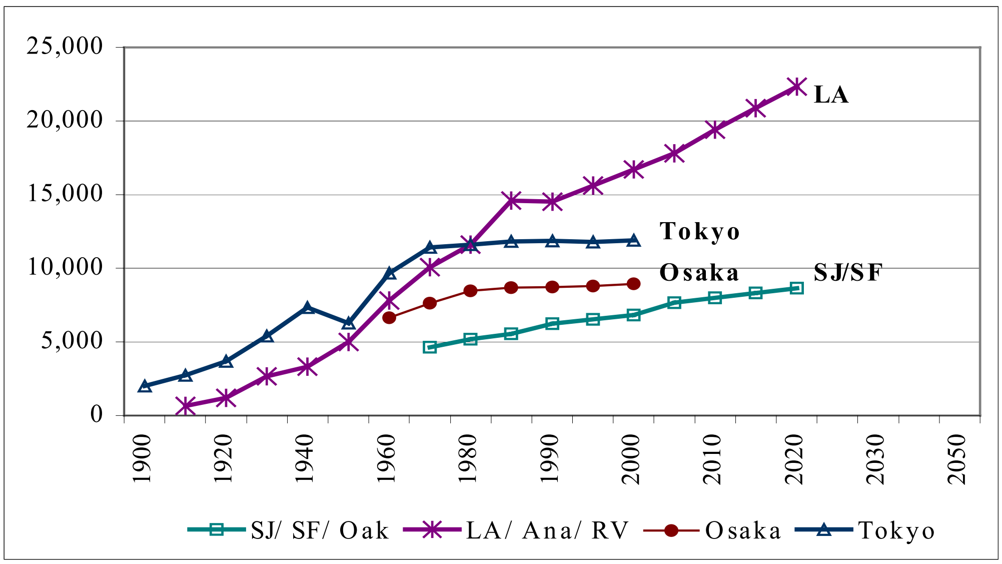
Table 5-1. Population Comparison

Region	Land Area (sq. miles)	Population (million)	Density (person per sq. mi.)
California	156,000	32.5	208
Japan	145,000	126.0	869
SJ/SF Bay Region	6,923	7.0	1,011
Bay Area 2025	6,923	8.7	1,257
Los Angeles County	1,110	10.7	9,640
Tokyo Region	1,089	27.0	24,793
Osaka Region	495	14.2	28,687

Source: World Almanac, Japan Almanac, ABAG

In Figure 5-1, the population growth of the Bay Area and Los Angeles metropolitan region is compared to the Tokyo and Osaka Prefectures. The Los Angeles Metropolitan Service Area (U.S. Census term) includes Los Angeles, Orange, Riverside, and San Bernardino Counties. The population data collected for the San Jose/San Francisco Bay Area includes the nine counties of Santa Clara, San Mateo, San Francisco, Alameda, Contra Costa, Sonoma, Napa, Marin, and Solano. The data points collected for Tokyo and Osaka Prefectures are similar to a county boundary. Historical data for the Tokyo and Osaka Regions were not available.

In the latest *World Almanac*, the Tokyo and Osaka metropolitan regions are ranked number one and six respectively as the most populated metropolitan regions in the world. New York City is ranked five and Los Angeles is the thirteenth largest metropolitan city in the world. The Tokyo or Kanto Region has a population of about 27 million and consists of the Tokyo, Chiba, Saitama, and Kanagawa Prefectures. The Osaka or Kansai region has a population of about 15 million and consists of the Osaka, Kobe, and Kyoto Prefecture. Collectively, these two metropolitan regions have a larger population than the State of California (Figure 5-2).



Note: Tokyo and Osaka population data for Prefecture. Population in 1,000s

Figure 5-1. California Metropolitan Region vs. Tokyo & Osaka Population

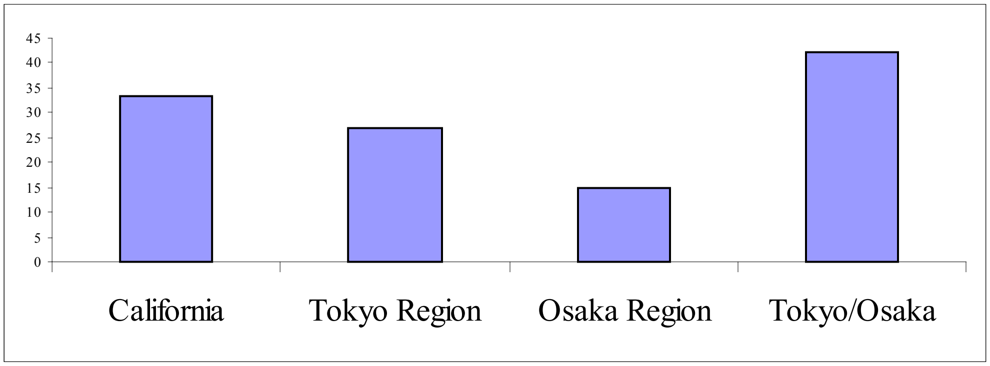


Figure 5-2. Regional Population to California

Construction Comparisons

The Tokaido Shinkansen project cost about 380 billion yen, or about 1 billion U.S. dollars in 1964,[27] and took five years to complete. By inflating 1964 construction costs using the Japanese Construction Price Index for Public Works projects, and converting from yen to 2000 dollars, the initial $2.8 million per mile construction cost in 1964 dollars would cost about $45 million per mile in 2000. In today's prices, the average construction unit cost per mile of $45 million in Japan is quite a value when considering the fact that Japan consists of rough terrain, requires numerous tunnels and grade separations along the Tokaido Line. The Tokaido Shinkansen Line consists of 66 tunnels, of which the longest is about five miles long and the shortest is about 100 feet.

The California high-speed rail proposal of $25 billion for a 700-mile network equates to an average cost per mile of $35.7 million. Considering the fact that tunneling costs can easily double the cost of construction, the $35.7 million estimate compared to the Tokaido Shinkansen inflated 2000 cost of $45 million, appears to be more than adequate, particularly since California's terrain is not nearly as difficult and mountainous as the Tokaido line.

The Need

In 1996, a Japanese University economic professor questioned the need to expand the Shinkansen system and communicated the following comment to the JR companies and the government: "The Tokaido Shinkansen Line was built to absorb the increasing traffic demand of the Tokaido line, which at that time was already operating at full capacity, but there is no clear demand at places where the projects are currently planned." In California, the CHSRA proposal comes at a time when freeway and airport congestion continues to worsen. In 20 years, with population projections indicating a 36% increase in the number of people in California, a high-speed train system will be able to absorb traffic demand between the northern and southern California metropolitan regions.

JR Company Operating Debts vs. California Proposal

The total debt remaining from the former JNR remains at about 28 trillion yen, or about $257 billion in today's dollars. The debt amounts to about 6% of Japan's national debt, or represents about 4.5% of the United States' National Debt of $5.7 trillion. Today, the JR as a private company is no longer affected by the political interference that undermined the JNR. Governmental interference was the major cause of JNR's demise as a public corporation and will not be an issue for the California proposal.

The lack of government control and regulation is what permits the JR companies to perform well and provide competition amongst the other transportation companies. However, the long-term debts will likely have to bepaid by the taxpayers who have been saddled with long-term governmental public expenditures. In the California proposal, the construction costs will be fronted by California taxpayers, but a private entity is expected to operate the system and return revenue to the state. Outstanding debt services for a California high-speed line will be far more manageable financially than what was left by the former JNR Corporation for Japanese taxpayers.

The Tokaido Shinkansen Line comprises 25% of the JR Central Company's total track line, but makes up 85% of the company's total income. Because of the high population concentration in and between the Tokyo and Osaka regions, the Tokaido Shinkansen is very profitable. The aftermath of privatization led to leasing payments and debt services based on profitability of each line. A similar scheme may need to be employed in the California proposal, although it was not addressed in the CHSRA report.

High-Speed Rail Fares

A recent study[28] for the California High Speed Rail Commission showed that if HSR fares are between 70% to 80% of airfare, the HSR operator will be able to maximize revenue. Ridership could increase by 31%, however, if fares are reduced from 80% to 50% of airfare (See Tables 5-2 and 5-3). The cost of riding the Shinkansen between downtown Osaka and the Tokyo Train Station is 13,750 yen, or about $126 dollars at today's exchange rate of $1=109 yen. Riding the Super Nozomi (intermediate stops only at major stations and the fastest train on the line) costs 14,720 yen, or $149. The cost of flying on Japan Airline or ANA Airline between the two cities' major airports would cost $149 or 16,250 yen.

Table 5-2. Fare Comparison

Shinkansen	Market	Fare (one-way)	Percentage of airfare
Hikari	Tokyo-Osaka	13,750 yen ($126)	85%
Nozomi	Tokyo-Osaka	14,720 yen ($135)	91%
CHSRA[29]	San Jose-LA	$22 to $40	50 to 70%

Table 5-3. Comparing HSR and Airline Travel

Area Market	Distance (miles)	Airfare (one-way)	HSR Fare (one-way)
Tokyo – Osaka	320	$149	$129
San Jose – Los Angeles	350	$60	$22-40

Transport Market Share

Based on the actual data collected from the Central JR Company annual report, medium-range travel distance is ideal for a high-speed train market. By penetrating the market with lower fares, it can easily overtake the airline market share. As distance increases, however, the high-speed market share decreases substantially, as travel time becomes the major factor in choosing air travel over high-speed rail.

Table 5-4. Market Share vs. Distance/Time

Area Market	Distance (miles)	Travel Time	One-way Fare	Market Share
Tokyo – Osaka	325	HSR: 2 hr 30min Air: 2 hr 30min	HSR:$129 Air: $149	HSR: 88% Air: 12%
San Jose – Los Angeles	(Proposed) 340	HSR: 2 hr 2 min Air: 2 hr 35 m[30]	HSR: $22 Air: $60	HSR: 66% Air: 34%

Source: Central Japan Railway Company, SJ/Los HSR Fares from CHSRA Report

As shown on Table 5-5, operating revenue for the Tokaido Shinkansen has steadily increased, and due to the high population density along the Tokaido

Line, it is reaching maximum capacity, which is why Central JR is leading efforts for a separate line between Osaka and Tokyo to run an ultra high-speed maglev system. In California, the CHSRA ridership projections indicate that operating revenue for the Los Angeles-SF-SJ Bay market could bring in about $347 million in the first year of service based on 11.2 million passengers per year. Based on the success of the Shinkansen and French TGV, ridership could be higher than anticipated if the economy at that time lends itself to favor high-speed transport.

Table 5-5. Tokaido Shinkansen Ridership and Revenue

Year	Passengers (million)	Revenue (billion yen)	Revenue (million dollar)[31]
1965	11.0	55	151
1969	60.9	165	461
1974	113.9	326	1,116
1979	91.4	699	3,185
1984	93.2	894	3,763
1989	112.2	968.6	7,014
1994	131.8	1,113.8	10,898
1999	130.0		

Source: Central JR Company, dollar conversion based on exchange rate in that year

Business Diversity

In addition to operating the high-speed rail system, the operator of the California high-speed rail system will receive additional non-operating revenues from station-related businesses. In Japan, the development of JR Company real estate holdings is especially interesting around the JR Train Station, where most of their business activities are concentrated, and has a positive effect on their high revenue streambed. In the CHSRA proposal, it assumes the possibility of an airline company operating the California High Speed Rail line. By adding the high-speed rail operations to its air travel business, the airlines are not only further diversifying their product line, but also allowing greater focus on their high-distance air market and providing far more flexibility and convenience in travel linkage.

VIABILITY OF MAGLEV TECHNOLOGY

In 1966, two U.S. scientists at the Brookhaven Lab, James Powell and George Danby, proposed using superconducting magnets to levitate and propel trains. In 1968, they developed a technique and had it patented. The High Speed Ground Transportation Act of 1965 led to the development of the first maglev vehicle by the Massachusetts Institute of Technology (MIT) and the National Science Foundation. In 1975, all federal funding for high-speed transportation was terminated. Thereafter, Germany and Japan took over research and development of the maglev technology to where it is today.

The first maglev track was constructed in 1975 and was used to verify and develop the maglev concepts. After testing at the experimental track, the government approved construction of a 27-mile long track in the Yamanashi Prefecture. The track today follows the same alignment of the proposed maglev route between Tokyo and Osaka. In December 1997, an unmanned maglev train set a world speed record by going 341 mph on the Yamanashi test track.

PROGRESS OF MAGLEV TECHNOLGY IN JAPAN

In 1999, a Japanese Maglev experimental train set a new world record when it reached a top speed of 344 miles per hour. Each year, new speed records are being set in Japan and Europe. The Japanese Railway (JR) has had reliable high-speed rail for about 36 years and continues to advance the maglev technology because engineers feel they have essentially tapped out the top speed of high-speed rail when confronted with noise restrictions. The United States, however, continues to take a slow and cautious stance to high-speed rail and maglev development.

In Japan, there are two experimental magnetic levitation test centers. The main test track is located in the Yamanashi Prefecture south of Tokyo. The track system consists of a 27-mile long track that is located within easy view of Mount Fuji. Although one might expect, for testing purposes, that the experimental tracks might be on relatively flat terrain—for example, in California, a straight stretch of Interstate 5 in the Central Valley of California would be ideal to conduct tests—the Japanese instead chose to construct a 27-mile-long test track in a fairly mountainous region where the tracks are mostly in tunnels (Photo 6-1). The double track system consists of 21.5 miles of tunnels and only a few miles of outside track visible to visitors (Photo 6-2). Test runs are routinely performed at the Yamanashi Prefectural Maglev Exhibition Center and after three years of testing, the year 2000 will be used to confirm the practicality of using maglev technology for revenue service.

Photo 6-1. Maglev Test Line

Photo 6-2. Test Run of 3-Car Maglev Train

Japanese commitment to maglev technology

In a recent survey conducted by the Japanese government, 71% of the respondents stated that they expect the maglev system to play a major role in the Japanese economy and society (Figure 6-1). When asked about being able to ride on a train going 500 kilometers per hour (315 miles per hour), 53% found the speed to be especially appealing, 19% indicated it would be appealing but were concerned about noise, and 21% did not feel that such high speed was necessary (Figure 6-2).

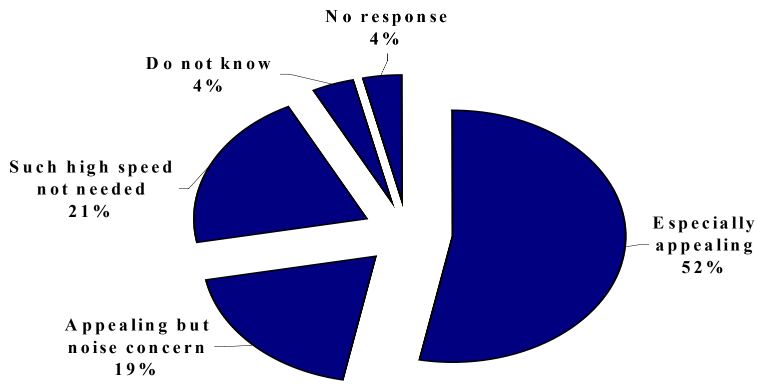


Figure 6-1. Japanese Opinion of the Maglev's High Speed

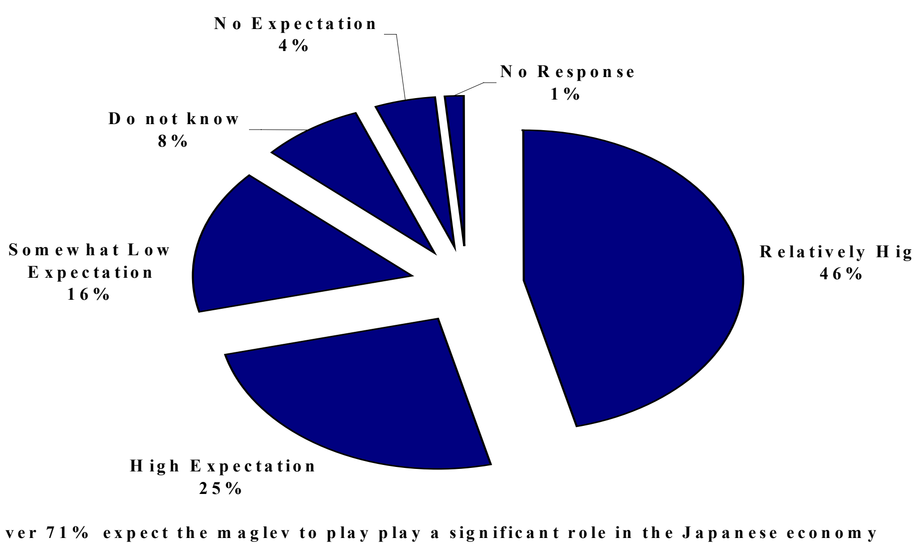


Figure 6-2. Japanese Citizen's expectation of Maglev on economy

Magnetic levitation trains continue to be tested in Japan and Germany. The German government was scheduled to begin operation of their 181 mile-long Transrapid maglev system between Hamburg and Berlin by late 2006, but the formation of a new government will likely delay or cancel the project. The uncertainties are due to environmental standards, rising costs, and governmental opposition to fund the project. The line is currently estimated to cost about $5.5 billion to construct or about $30 million per mile.

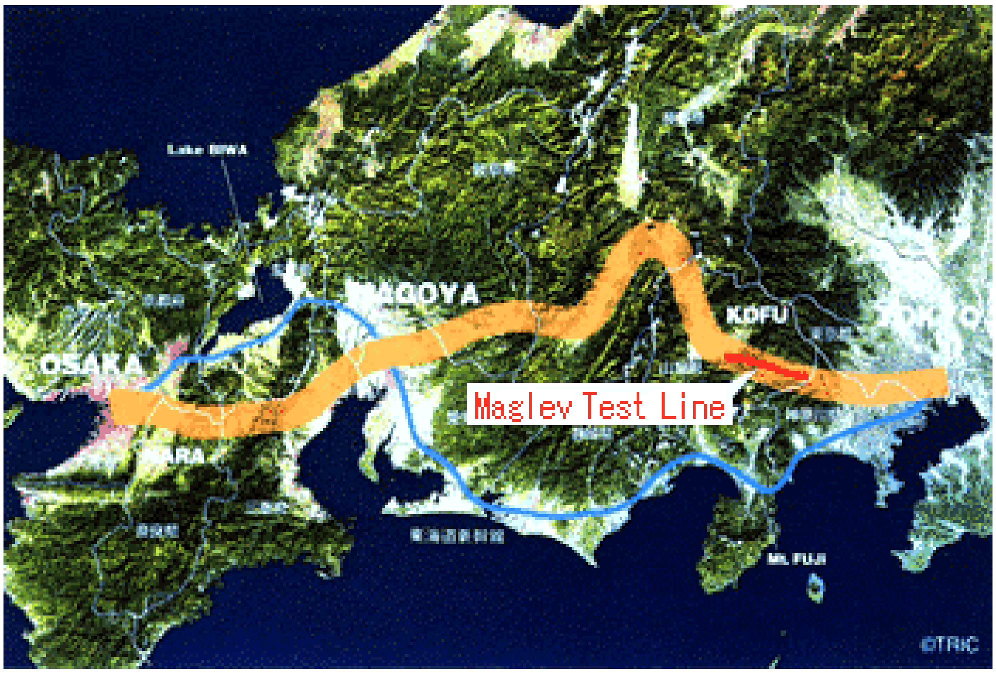


Figure 6-3: Route of Chuo Maglev Shinkansen

Source: JR Central Company

Status of the Chuo Maglev Shinkansen Line

In the year 2000, JR Central will continue performing test runs for a final analysis and decision to construct the Chuo Maglev Shinkansen line between Osaka and Tokyo (Figure 6-3).

One of the greatest obstacles that Japanese engineers and scientists are attempting to overcome is controlling the maglev train is stability during an earthquake event, as Japan has frequent earthquakes. It is likely that they will succeed in overcoming all the stability problems in the near future, and be able to develop practical solutions to make the Chuo Shinkansen line a reality. Despite over 20 years of research and development, however, Japan does not have a firm timeline to commercialize maglev into revenue service, and based on the latest news to the public, the performance results are not very encouraging and the testing costs are far greater than originally anticipated.

Redeployment of Maglev Technology Back to the United States

It was two U.S. scientists, Powell and Danby, who were awarded the patent that led to the development of maglev trains in Germany and Japan. The Transportation Equity Act for the 21st Century (TEA-21) includes a developmental program entitled "Magnetic Levitation Transportation Technology Deployment Program." The funding authorizes \$60 million for research and preliminary engineering and an additional \$950 million that Congress could appropriate for a construction project. To date, the U.S. Department of Transportation has authorized \$12 million in planning and research funds to seven separate maglev proposals, including one between Las Vegas and Los Angeles. These concept studies hope to justify obtaining \$950 million in federal funds to construct a maglev line.

With TEA-21 legislation and funding in place, the United States and individual states benefit with roadway and transit funding. Given historic and political factors, it seems unlikely that the federal transportation funding program will approve any viable maglev proposals.

The interest in developing maglev technology should continue as the advantages are numerous, including:

- Ultra high speed
- Environmentally sensitive technology
- Frictionless and vibration free
- Dedicated Guideway system—no conflicts with other modes
- Smooth and quiet ride (noise consists of only aerodynamic drag)
- Low maintenance

Since the U.S. transportation infrastructure funding is heavily biased toward cars, and change is difficult to overcome, seeking mass transportation alternatives will likely hit many bumps in the road for the next several decades. Until there is an incentive for private businesses to develop the technology in the United States, maglev technology will remain overseas in Japan and Germany. The existing TEA 21 maglev-funding provisions will need to be amended to funnel remaining unallocated funds for the sole purpose of developing the technology to a practical level if the United States is to reenter maglev research.

HISTORICAL EFFECT OF U.S. TRANSPORTATION POLICIES ON HIGH-SPEED RAIL

U.S. INTERSTATE HIGHWAY SYSTEM

The building of the Interstate Highway System was an essential and remarkable achievement, which occurred at a crucial time in U.S. history, significantly affecting the economy and land use patterns ever since. It now needs to be followed and complimented with the delivery of high speed rail corridors along the major metropolitan regions with the greatest population and transport alternatives.

In the 1940s, the pressure from highway lobbyists changed the transportation system landscaping. Automotive companies producing and promoting their goods and services dictated U.S. transportation policy, which led to the demise of the railway and its infrastructure. Today, the auto continues to be the primary transportation mode, for better and for worse.

In 1974, Bradford C. Snell, Senate Antitrust Committee counsel, noted that "highly monopolized, powerful automobile firms and their diversification into various areas of transportation manufacturing may have retarded the development of mass transportation, and, as a consequence, may have generated a reliance on motor vehicles incompatible with metropolitan needs."[32]

Had metropolitan areas kept mass transit systems in place to compliment the automobile, the urban settings in the largest U.S. cities would likely be designed quite differently to accommodate mass commuting patterns instead of individual commuting and parking needs.

Economic development and a coordinated regional transportation plan requires a central agency to oversee the master plan. Also, zoning, parking regulations, and appropriate land use will require greater attention and vision.

As disposable income increases for all income brackets, automobile purchases will continue. However, it will level off as the number of vehicles per household is reaching a saturation point. The number of new automobiles will not make a significant impact to an already congested roadway system. The only positive impact automakers can have on the U.S. market is the development of low emission vehicles and voluntary compliance in meeting stringent requirements. The predominance of the automobile as the preferred transportation within metropolitan areas is not likely to change given the land use patterns within these areas and our highly mobile society. Travel between metropolitan areas, however, is subject to change. It is not necessary for the most mobile society to change its appetite for automobile ownership. Large metropolitan areas that have medium-distance linkage capability to other nearby metropolitan service areas, however, will need to eliminate the transport fragmentation, by favoring a mass transportation policy to meet 21st century mobility needs and capacity demands.

While the U.S. can take pride in the Interstate Highway System, it also needs to strategically develop passenger railway service to handle and balance the overall transport capacity demands. Japan is far behind in developing its national and regional roadway system to be on par with U.S. standards, which is not necessarily a detriment to its system-wide network. With land value and right-of-way constraints, modernizing their expressways, major arterials, collector, and local roads will be a nearly impossible task or require decades of planning and redevelopment effort.

With the exception of Tokyo, which is relatively young as a modern city and able to meet roadway geometric standards, narrow roads elsewhere in Japan—particularly cities with thousands of years of history such as Kyoto—tend to suppress roadway traffic with its extremely narrow roadway and thus encourage alternative forms of transport. In Kyoto for example, there are many narrow streets that are geared for two-way traffic that have no curb but have concrete utility poles along the side of the road. These narrow roads compare in width to many of the bicycle/pedestrian trails found in the San Jose-San Francisco Bay region.

GASOLINE PRICES AND TAX

In the U.S., the combined federal and state fuel tax is quite low in comparison to other industrial countries in Europe (Figure 7-1). In 1932, the federal government began to levy federal gasoline taxes occurring after individual states first introduced a gasoline tax. Japan began to charge a fuel tax in 1954 and used the revenue to finance their public works infrastructure.

In Europe and Japan, gas tax is significantly higher than in the United States (Figure 7-1) and has had a strong influence on the type of vehicle motorists purchase and how they commute. Even with recent surges in gasoline prices in California and across the nation, the price for a gallon a gasoline is quite inexpensive compared to the rest of the industrialized nations.

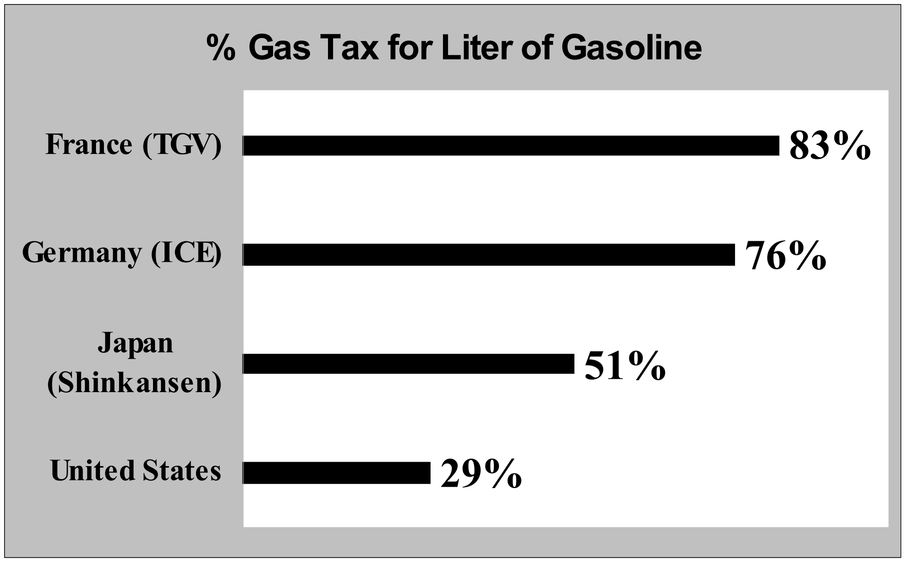


Figure 7-1. International Comparison of Gas Tax[33]

California Consumers

According to a recent *San Jose Mercury News* article, although gasoline prices continue to go into new retail price levels, consumers are purchasing Sport Utility Vehicles (SUVs) at astonishing quantities. While one cannot criticize SUV owners for their buying habits and SUV owners cannot moan about the cost of filling up at the gas station, the United States needs to reexamine the long-term implications of historically low gas taxes. A steadily increasing gasoline tax could allow the automakers to react to the market change by re-introducing fuel efficient cars. Given the sudden spike of gasoline,however—now averaging $2 per gallon—the American consumer will not tolerate any mention of a gas tax increase.

In Washington D.C., there is no effort to increase gas taxes to the same scale as in Japan and Europe. The American consumer enjoys relatively low gas prices compared to other nations and the freedom that the automobile offers. Powerful oil and automobile lobbies have historically ensured that their interests are met without any opposition. While there was talk decades ago in Washington for a federal gas tax increase as high as 50 cents, politicians generally do not favor increasing gas taxes because they consider it to be regressive to lower income people who would pay a higher share of their spending income on taxes, and because most Americans want to drive for free, not recognizing many subsidies given to the automobile mode. Some politicians and economists fear that a gas tax increase would slow down the economy and lead to inflation. Gasoline prices paid by U.S. consumers are some of the lowest in the world. High fuel taxes and the unit price of retail gasoline in Europe and Japan have had a strong effect on the type of vehicle a motorist will purchase and how they commute during the weekday.

The United States has enjoyed low prices of gasoline at the pump and there is nationwide anger over OPEC's production cutback and price increase of a barrel of oil. In the San Jose-San Francisco Bay area, gasoline pump prices in a March 2000 *San Jose Mercury News* article reported prices as high as $2.10 per gallon for premium gasoline.

Before there are any serious decisions to increase the gasoline tax, particularly a regional gas tax, the public should have greater convenient choices with mass transit that has extensive connectivity with multiple mass transportation facilities, and any gas tax proposals should include provisions to exempt commercial truckers and agriculture.

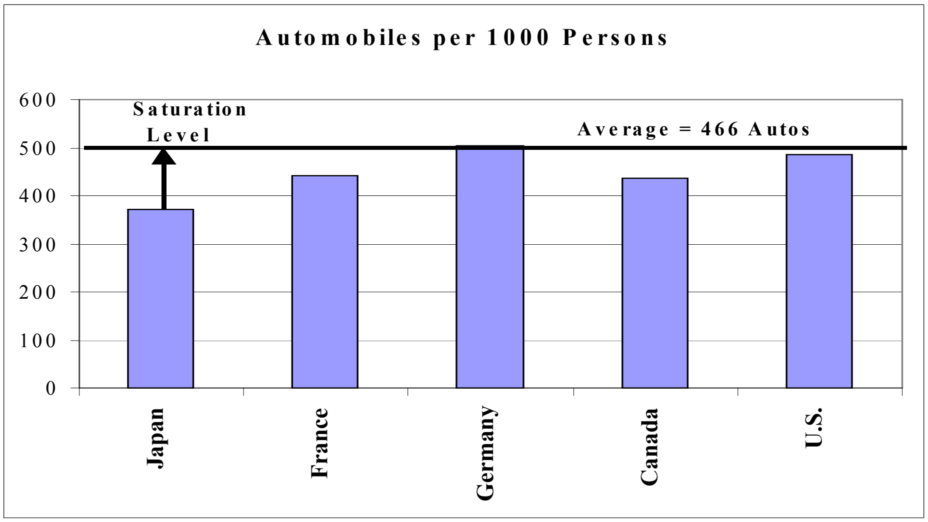
Any proposal to pay for transportation improvements by raising gasoline or sales tax increases would require a two-thirds majority vote as required in California. This is a virtually impossible task and waiting for the existing transportation system to completely break down is an irresponsible position and politically unavoidable position.

Automobile Ownership

The top industrialized countries in the world enjoy the benefits of modern amenities. The countries with the highest disposable incomes have an extensive roadway network that goes hand in hand with the high rate of automobile ownership (Figure 7-2).

The trend of purchasing and driving high gas-consumption vehicles will continue for the time being, particularly in California where the economy is advancing at a sizzling rate and disposable income is at its highest. The fear that someday the world's petroleum reserves will run dry does not concern consumers, as they believe that the present natural resources available will serve well into the next century. The primary concern is dependence on foreign oil cartels that control the world's oil supply and the need to increase fuel efficiencies and emission compliance of automobiles.

Artificial gasoline shortages make the United States vulnerable to external factors such as political changes. Greater diversification of oil purchases and setting goals to reduce foreign oil dependence will require the United States to rethink energy and transportation policies.



Source: U.S. Department of Transportation, Japan Almanac

Figure 7-2. International Comparison of Auto Ownership

Although individual drivers will continue to purchase new cars, especially when disposable income rises, introducing new private automobiles will not necessarily have an impact on an already saturated market in major metropolitan areas. As shown in Figure 7-3, the ownership curve (in 1,000s) is leveling off for Japan, California, and the San Jose-San Francisco Bay area. In addition, the proportion of SUVs and other gas-guzzling vehicles will change over time. When gasoline is plentiful and inexpensive, consumers tend to disregard fuel efficiency and environmental concerns. Automobile owners with high incomes especially tend not to consider fuel efficiency when purchasing a vehicle.

In Japan, the country is highly dependent on the importation of oil, but could continue movement of people and goods with their vast network of railroad trackage. The country has been striving for the last 20 years to reduce their oil dependency on OPEC by developing more fuel-efficient technology, developing other energy sources, and purchasing crude oil from non-OPEC nations. Japan has one of the highest median incomes in the world and they, like the rest of the industrialized nations, enjoy the benefits of automobile ownership. However, it comes at a high price. The average price of gasoline is about \$3.60 per gallon[34] and the high cost of monthly parking fees encourage the vast majority of commuters in metropolitan regions to use the passenger rail system, which is extensive and quite convenient. In the large metropolitan areas of Osaka, Nagoya, and Tokyo, employers encourage mass transportation by providing stipends which pay for monthly rail passes. This is similar to the Bay Area where employers can provide monthly transit passes (EcoPass or Commuter Check Program) to their employees as an incentive to not drive their automobiles.

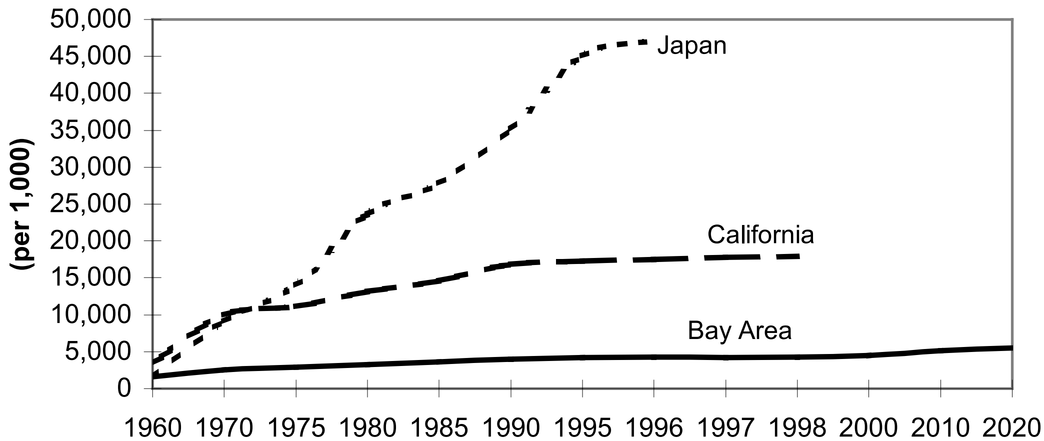
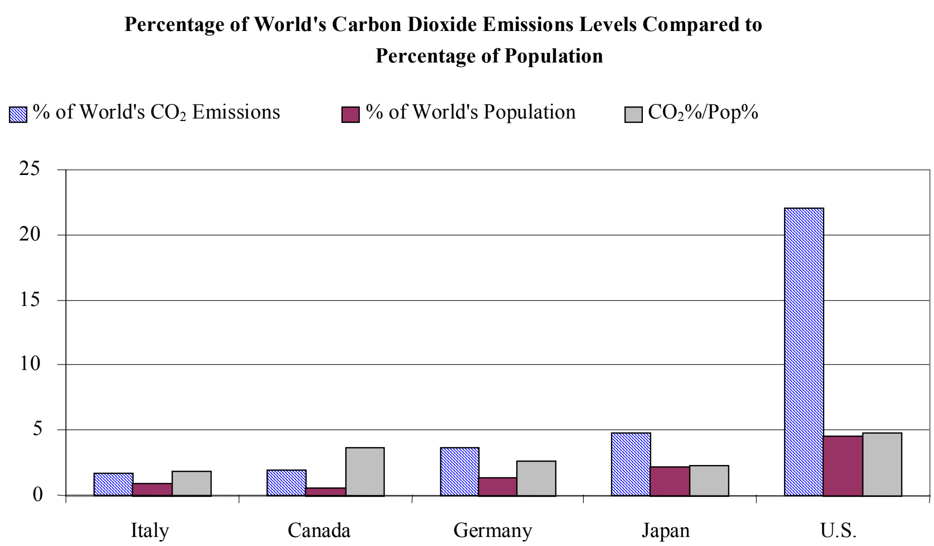


Figure 7-3. Automobile Ownership

The Japanese, however, still enjoy their private automobile—especially on weekends. After the completion of the Tokaido Shinkansen, rail market share decreased over the next two decades, while automobile ownership skyrocketed—largely because of the booming economy and the continuous construction and expansion of Japan's Expressway system. Their expressway system is somewhat comparable to the United States' Interstate Freeway, but has only a very small fraction of freeway capacity compared to what the U.S. enjoys.

Global warming and the environment

It seems a day does not go by without reading in the newspapers or a magazine about the worldwide concern for global warming. There are many knowledgeable experts and laypersons who are critical of those who perceive global warming, or the unknown long term effects of gas emission into the atmosphere, as not being a serious issue. As the debate continues, it is, however, troubling that the United States contributes almost 25% of the world's global warming effluent each year while it represents only 4.6% of the world's population (Figure 7-4). These statistics will not likely have any profound implications on U.S. consumers, but should be a wake up call for gradual change to modernize our facilities and develop new energy resources. As undeveloped countries attempt to achieve higher levels of development, it becomes apparent that the U.S. level of pollution is not a sustainable model.



Source: Japan Almanac, 1999, World Almanac

Figure 7-4. International Comparison of Carbon Dioxide Emissions

In December 1997, the UN Framework Convention on Climate Change was held in Kyoto, Japan. Japan has recognized the problems with global warming by agreeing to formal reduction goals. It has agreed to reduce greenhouse gas emissions by 6% from the 1990 output level between the years 2008 and 2012 and the U.S., if committed to setting the same goals, would have to achieve a 7% reduction. Whether these two nations actually work toward reduction of greenhouse gases or opt to use loopholes to defer their commitment remains to seen, but the general public is becoming more aware of the issue and making individual decisions.

How will mass transportation help the cause? Although a HSR or Maglev system could result in automobile and air travel reduction, and thus less air polluting emissions, a high-speed train requires burning of fossil fuels to generate the electricity for the electrified system. However, there is sufficient information and verifiable data to show that the incremental savings of carbon

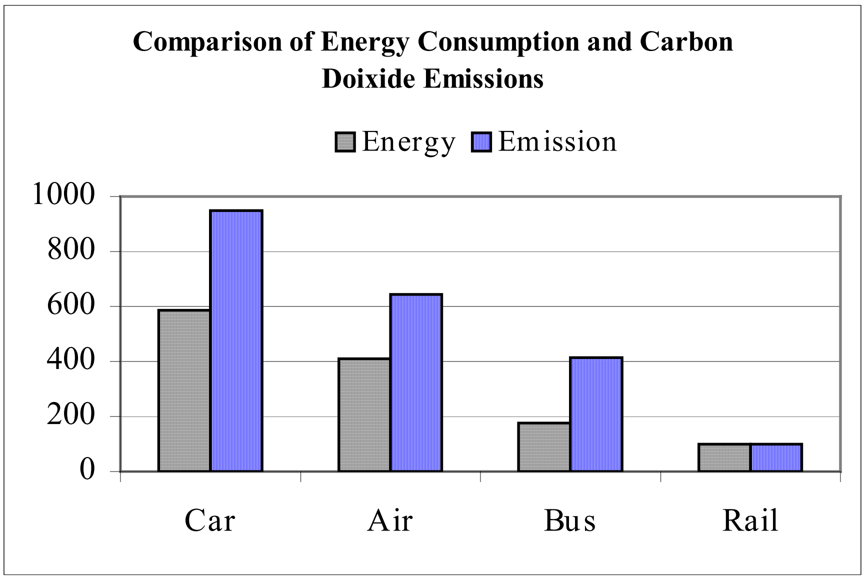


Figure 7-5. Comparison of Energy Consumption and Emission by Mode

dioxide emissions are substantial as illustrated in Figure 7-5. Using 100 as the base for rail mode, the automobile consumes 5.9 times as much energy as rail and displaces 9.5 times as much carbon dioxide or greenhouse gas into the air. Independently, the JR companies are continually finding ways to save energy in the operation of high-speed rail to reduce energy operating expenses while promoting a green campaign to the public. Since the introduction of the first series of trains, the latest trains have been found to use 37% less energy and the JR companies are seeking to further reduce the energy requirements by setting reduction targets.

THE NEXT STEP: HIGH SPEED TRAINS FOR CALIFORNIA

CALIFORNIA'S FUTURE HIGH-SPEED RAIL NETWORK

In January 2000, the California High-Speed Rail Authority received the final draft report on the proposed route for the statewide high-speed rail network. A total of 700 miles of tracks are proposed with the metropolitan regions of San Diego, Los Angeles, San Jose, San Francisco, and Sacramento as the major destination points. The CHSRA is projecting it will take 16 years to complete the high speed network.

36 years ago, once the JNR and the Japanese government made a decision to construct the Tokaido Shinkansen line, it took about five years to complete the 344 mile-long route. This route extended beyond two of the largest populated cities in Japan and is nearly equivalent to the distance that separates Los Angeles and the Bay Area.

California voter approval to fund the CHSRA's $25 billion proposal is going to be a financial challenge. If approved by California voters, the plan could ultimately lead to timely completion of the backbone system between Los Angeles and San Jose, which could possibly set the state's economic bar to a higher level by introducing another form of passenger and commercial ground transportation.

Transportation leadership

It is said that one is not a leader if one does not have followers. To change the medium distance transport habits of auto-loving Californians, the CHSRA will need to take the lead to change the individual mind set by educating the public with practical reasons for developing a high speed rail corridor and carefully market their product. Independently, metropolitan regions will need to further develop their basic mass transportation infrastructure and slowly encourage change to occur by providing incentive programs such as the EcoPass (monthly transit ticket) Program, but more importantly provide convenient and reliable service as the demand grows. Amtrak's Acela may be a start of what could eventually lead to high-speed trains to serve the most populated metropolitan areas on the East and West Coast.

This will require strong leadership in the transportation and political arena. In the United States, there is too much of a tendency to think short-term and dismiss long-term objectives for others to contend with when it then becomes an urgent or desperate matter. In Florida, plans for a $6 billion high-speed rail project that would have linked Miami, Orlando, and Tampa was canceled by the state's governor. Instead, the Florida governor proposed $4 billion for improving the Florida Interstate Highway System over the next 10 years. While this proposal may do a great deal of good for surface transportation, once again, it prevents the development of a comprehensive mass transportation system. In California, the push to revise the two-thirds voter requirement for increasing taxes for transportation funding is not gaining support from the governor. The lack of support and roadblocks in Sacramento could hinder California's ability to maintain its base as a leader in high technology and quality of life.

California should be doing what it is best at doing and that is embracing technological changes. Without leadership from Sacramento, the current and future transportation system will likely suffer from massive overload and ultimately lead to complete breakdown of a constrained network, with commensurate damage to the state's economy.

Sustaining California's Economy

California continues to prosper and its current population of 33 million is expected to grow to 42 million in the next 20 years. One of the most critical elements to prepare for the expanding economy and population growth is having a well balanced and comprehensive transportation system in place. Managing the movement of people and goods will require a cooperative effort from automobile, highway, airline, and railroad interests. Moreover, changing individual attitudes and land use patterns will be interesting to follow over the next 20 years.

At the 1991 Regional Forum on Maglev Planning and Implementation in Sacramento, California, Dr. Tim Lynch of the Florida High Speed Rail Transportation Commission stated that the "Europeans are expanding their (high speed) rail system from 1,200 miles to 27,000 miles… to integrate, unite, make a more competitive economy…while the United States will further lose ground in a world of shrinking global economies." Nearly ten years after the forum, little has been done in the United States other than feasibility reports. This while France, Germany, Spain, the Scandinavian nations, Switzerland, and Great Britain continue with their transport plans to improve, and eventually integrate, a high-speed rail network throughout Europe, and Japan continues to expand their high speed rail network to the outermost regions. This lack of action does not necessarily mean the United States is well behind the rest of the world in developing rail transportation. Over the last decades, the automobile and airlines have provided the type of transportation modes suited for the U.S. market. The delays in entering the high speed rail market was not only political but a business decision based on population density, ridership and revenue projections that did not pan out. However, over the next 20 years, there will be a business opportunity to introduce high-speed rail into the transport market for medium-distance between major metropolitan regions such as the Los Angeles–San Jose market. The progress and high ridership success of the Japanese Shinkansen and the French TGV will eventually change the public's attitude about mass transportation in suitable areas.

Environmental Constraints

The National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA) pose administrative, political, and legal challenges. Mitigation measures to deal with the noise issue will be a hot debate along the California High-Speed Rail Corridor and have costly consequences. In Japan, environmental concerns and lawsuits led to operational changes and further development in acoustical design. In residential areas along the Shinkansen routes, noise is limited to 75 dba. This upper noise limit generally would not be acceptable in California urban areas, and the placement of masonry block concrete soundwalls may not be the ideal solution since one of the nice features of train travel is being able to enjoy the scenery.

Throughout California, construction of new freeway lanes requires massive soundwalls to isolate noise transmission and gives one an impression of being isolated and unable to see beyond the solid mass of masonry blocks. The development of high-speed trains and mitigating noise should not include the construction of high wall barriers. Efforts should be made to install the best available technology while creating an enjoyable atmosphere for the rider.

OBSERVATIONS AND RECOMMENDATIONS

OBSERVATIONS

Comparing historical and present high population density in Tokyo and Osaka metropolitan areas with California is a challenge; however, the rail market and population of Europe offers a glimpse of what could happen in California. Correspondingly, the Tokyo-Osaka and San Jose-Los Angeles travel market have similarities such as distance, congestion problems, airport delays, and proportionally high population at each destination point that cannot be ignored and are quite compelling. Based on analysis of the Tokaido Shinkansen Line and the Central JR Company annual reports, it is clear that market penetration of auto, rail, and air is highly dependent on the extent of the transportation mode's infrastructure, cost of travel or fare price, convenience, and travel distance and time.

Observations based on my research and case studies are as follows:

- The privatization of the JNR into six JR companies promoted price competition, leaner and more effective management to run the individual lines, and created more jobs by each company's ability to diversify their product and business line.
- When gasoline prices and taxes rise substantially to force commuters to look for cost-effective alternatives, transit ridership not only increases but also becomes extremely competitive with airfare.
- By converting the cost-per-kilometer of previously constructed Shinkansen lines to present day dollars-per-mile—by using the construction index factor as shown on Table 9-1 and that year's exchange rate—the unit cost per mile of the Shinkansen, as compared to the California High-Speed Rail Authority's average construction cost per mile of $35 million, is much higher. Because Japan is such a mountainous nation, which requires its transportation system to be fitted with many tunnels and bridges, the unit cost is much higher, and on some projects, double the cost of the project. Although the Japanese have nearly perfected the technique of boring large-diameter tunnels with advances in tunneling equipment, it is still quite expensive. Based on the adjusted cost figures, it appears that the California High-Speed Rail Authority's average cost per mile of $35 million appears to be more than adequate, particularly since construction costs in Japan tend to much higher than the norm because of difficult terrain and long lengths of tunneling. Based on current construction technology and methods in California, the overall

construction cost and economy of scale factored in the overall cost, the unit cost should be lower than the projected cost estimate.

Table 9-1. Shinkansen Cost per Mile

Shinkansen Line	Construction Cost ($ million/mile)	Construction Cost Index Factor	Construction Cost in 2000 dollars ($million/mile)
Tokaido	2.84	4.76	45.0
Sanyo	8.91	1.88	45.6
Joetsu	39.1	1.21	108.1
Tohoku	64.1	1.02	80.7

Note: Construction cost in year completed

- In major Japanese cities, particularly in Tokyo and Osaka, commuter rail, express trains, subways, monorail, AGT, and transit buses provide extensive and extremely convenient means of traveling from point to point. In the Tokyo Prefecture, 57% use rail and only 8% use their car to commute.
- Traveling by auto in Japan does not compare well to the California experience due to high fuel and parking costs and extremely limited road capacity.
- The Japanese take pride in their high-speed system, JR Shinkansen, largely because of its high reliability, on-time service, abundant number of trains leaving every few minutes from any given station, and its overall convenience.
- The Central JR is able to charge competitive fares that closely match the fare of the airline for medium-distance travel. Regular rail travelers found the Shinkansen a more convenient and relaxing mode of travel compared to dealing with airport delays and the tight confinement of airline travel. As shown on Table 9-2, the California High-Speed Rail Authority initial fare estimate of 50% of airfare is much lower than the established Tokyo-Osaka travel market. Although the origin/designation distances between Tokyo-Osaka and San Jose-Los Angeles are nearly identical, it will take some time before HSR will be able to match fare percentages equal to Central JR because California will not have the population density and

demand until 2020. However, France's TGV and Germany's ICE are exceeding expectations and continue to break ridership records.

Table 9-2. Market Share vs. Distance-Time[35]

Area Market	Distance (miles)	Travel Time	One-way Fare	Market Share
Tokyo – Osaka[36]	325	HSR: 2 hr 30min Air: 2 hr 30min	HSR:$129 Air: $149	HSR: 88% Air: 12%
San Jose – Los Angeles	(Proposed) 340	HSR: 2 hr 2 min Air: 1 hr 45 min	HSR: $22 Air: $60	HSR: 66% Air: 34%

Source: Central Japan Railway Company, SJ/Los HSR Fares from CHSRA Report

- The financial problem of the initial construction of the Tokaido Shinkansen line beyond Osaka may be akin to constructing a high-speed rail system between Los Angeles and the San Jose-San Francisco Bay Area and allowing Sacramento politicians to pencil in a line extension to Napa Valley or San Bernardino into the initial CHSRA construction proposal. If a high-speed train is to be constructed, it is extremely important to construct only the segment where the demand is the greatest and keep to the basics. That must include grade separations instead of station betterments.

- The current Shinkansen fare between Tokyo and Osaka as shown on Table 9-3 is between 85% and 91% of the cost of airfare. The JR Central operates three daily train services between Osaka and Tokyo. The Kodama Shinkansen train makes a stop at every station between Osaka and Tokyo. The Hikari Shinkansen train departs daily and makes four to five intermediate stops before reaching Tokyo or Osaka. The Nozomi Shinkansen train makes either no intermediate stops or at most only two immediate stops before it arrives at the endpoint. Because speed and travel time savings is important to business travelers, the Central JR Company is able to charge a slightly higher fare for the Nozomi train because of its average high speed of 170 mph and shorter travel time.

Table 9-3. Fare Comparison

Shinkansen	Market	Fare (one-way)	Percentage Of airfare
Hikari	Tokyo-Osaka	13,750 yen ($125)	85%
Nozomi	Tokyo-Osaka	14,720 yen ($134)	91%
CHSRA[37]	San Jose-LA	$22 to $40	50 to 70%

The travel market between Tokyo and Osaka is extremely profitable for the Central JR Company. The Shinkansen service and arrival time allows the fares to be closer to what the airline charges. The travel time from downtown Tokyo to central Osaka actually takes less time and effort because the airports are some distance from the inner city core and require longer transport time from the airport to the destination point.

- The high-speed rail corridor dominates the Japanese medium-distance market (Figure 9-1). The Osaka–Tokyo route is dominated by the Central JR Company and has all but wiped out air competition for distances less than 200 miles. As rail distance and time increases, the high speed market loses substantial market shares to airlines because of the speed differential.

  Introducing faster technology such as maglev could recapture the market share for longer distances. Until maglev becomes a feasible solution to high speed land transportation, it appears that the likely market to focus attention upon is distances between 200 and 350 miles, which is the range of the San Jose – Los Angeles route and market. Once the California High Speed Rail Authority completes construction of the backbone system, private operators could quickly take a stronghold and divert most of the air passengers between the Bay Area and Los Angeles with the low fares suggested in the Charles River Associates ridership report. Once the HSR operator has captured the market, it will be able to increase fares to 80 to 90% of the price of airfare. The potential loss of market share is not necessarily bad news for the airlines, since an airline company could operate the high-speed rail system. This business approach could then allow airlines to focus on the longer distance air market where there is no competition from other transportation sources.

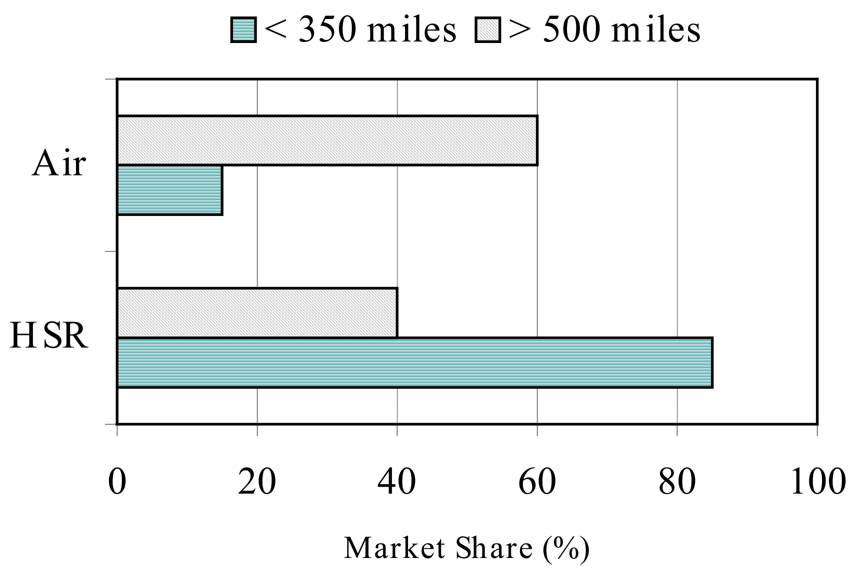


Figure 9-1: Market Share vs. Distance

- Both air and high-speed rail travel between Osaka and Tokyo is quite expensive in comparison to the California high-speed rail proposal (Table 9-4). This is largely due to the high cost of fuel in Japan, expensive airport landing fees, and the high recovery costs of repaying the cost of the Shinkansen construction. Assuming California taxpayers front all the capital cost of the initial construction with long term repayment by the operator through a leasing agreement or purchase plan, the San Jose–Los Angeles market can be made attractive for a private operator whether it be Amtrak, an airline company, or an independent transportation company.

Table 9-4. Comparing HSR and Airline Travel

Area Market	Distance (miles)	Airfare (one-way)	HSR Fare (one-way)
Tokyo – Osaka	320	$149	$129
San Jose – Los Angeles	350	$60	$22-40

- In comparing the actual transportation cost (Table 9-5) for an individual passenger between Tokyo and Osaka, the Shinkansen is by far the most attractive and convenient form of transportation. The automobile cannot compete with the Shinkansen's high speed, convenience, and quick travel time. The high cost of gasoline, road tolls, and parking charges as well as the congested expressways discourage Japanese travelers from using their automobiles. But as disposable income has risen and expressways have been developed, the automobile remains a popular choice for providing flexible mobility.

Table 9-5. Comparison of Transport Cost

Area Market	Bus (one way)	Auto (one way)	Airfare (one-way)	HSR Fare (one-way)
Tokyo – Osaka (320 miles)	$74 (8 hrs)	$163 (6.5 hrs)	$149 (2.5 hrs)	$129 (2.5 hrs)

Note: Auto cost includes gasoline, bridge and expressway toll, Exchange rate = 110

In California, the automobile will continue to dominate the overall mode of transportation even with rising gasoline prices. As gasoline prices rise to new levels, however, consumers will be willing to make other choices that previously never entered their minds. The attraction to high-speed rail for the intercity traveler will be quick delivery time, convenience, and ease of destination connectivity.

The success of a California high-speed rail system would likely require:

- higher population density in the Los Angeles Basin and the San Jose-San Francisco Bay Area;
- advocating, marketing, and informing the public of the benefits of a statewide high-speed network through public forums and workshops;
- steady increase in regional gas tax to rival the prices in Europe and Japan, or develop practical cost-saving incentives to encourage change;
- assurances that up-front capital costs and associated long-term debt services will not be detrimental to the California economy and taxpayers and operating costs will not be publicly subsidized;

- avoiding construction cost overruns of the 700 mile-long high-speed rail by employing the partnership concept with contractors and developing cost-saving construction techniques;
- providing adequate connectivity at end destination, easy access to stations, and convenience prior to high speed rail revenue service; and
- exemplifying confidence and having the CHSRA take a strong leadership role in transforming California transportation.

RECOMMENDATIONS

General

The California High-Speed Rail Authority is projecting 16 years to complete a 700 mile system, which with the projected population increase, could be a perfect time to introduce an alternative transport mode. Given the transport market values today, however, it will be a challenge to convince Californians to buy into a $25 billion project, but it is an achievable goal if properly advertised and understood by the public.

A state and federal gasoline tax increase of four to five fold could drive up the retail price of a gallon of gasoline to be in line with other industrialized countries, and encourage the construction of high-speed and commuter rail systems along appropriate areas—however, that scenario does not appear to be a viable solution to America's historical values. While OPEC controls the price at the pump and consumers seek relief, timing being everything, the next several years could be an opportunity to address, debate, and implement new transportation alternatives and funding packages.

<u>Recommendation 1</u>
The CHSRA should continue to educate, inform, and conduct workshops for the general public. In addition, the CHSRA should establish High-Speed Train visitor's centers in Sacramento, San Jose, Fresno, Los Angeles, and San Diego to showcase and familiarize the public with model HSR and maglev train interiors.

<u>Recommendation 2</u>
Capital expenditures to construct a high-speed network will need to be fronted by California taxpayers and this should be openly discussed with the long-term objective of repayment. Prior to constructing the system, general line leasing concepts and purchasing options should be in place. Opposition to the use of public funds to construct the facility and eventually introduce a private operator and competitor against other transport modes should be legally and

administratively addressed by a legitimate process well in advance of pursuing public support.

Recommendation 3

Instead of completing the entire 700 mile high-speed rail network at once, the backbone of the system, between San Jose and Los Angeles, should be in operation immediately after construction completion of the initial phase infrastructure and service testing. After the Tokaido Shinkansen went into revenue service, the public demanded more and the same could occur in California. Effort should be made to expedite construction completion of the backbone and find cost-efficient construction techniques to accelerate completion.

Recommendation 4

After completion of California's proposed high-speed rail network, the CHSRA should contract out segments to private companies wanting to operate the system. Consideration should be made to divide the network into three segments that could include the south branch between San Diego and Los Angeles, the central line between Los Angeles and the Bay Area, and the northern branch between the Bay Area and Sacramento. Another option is to divide the lines according to the CHSRA's service plan for highest return on investment route, which consists of San Francisco–San Diego, Sacramento–San Diego, and San Francisco–Sacramento. Once high-speed rail revenue service begins, to steadily capture a greater share of the overall transportation market between Los Angeles and San Jose, fares will need to be extremely competitive and provide a high level of customer service to attract individual users.

Recommendation 5

Areas around existing train stations—Los Angeles Grand Terminal and Downtown San Jose Diridon Station—or potential sites for a high-speed rail stations need to be reserved and closely evaluated by redevelopment agencies. The CHSRA, MTC, SCAG, and local redevelopment agencies will need to jointly coordinate individual developmental proposals and associated parcels so as not to lose sight of strategic opportunities. Adjacent to the downtown stations, future hotel sites should be included in the master general plan as well as other amenities that attract passengers, local consumers, and tourists. At the downtown San Jose Diridon Station, a precise master plan could include a number of attractive amenities connected to the station including the possibility of a Silicon Valley high-technology research library, hotels, restaurants, trendy stores, and a high concentration of office buildings within comfortable walking distance of the station.

Recommendation 6

During the sixteen years it will take the California High-Speed Rail Authority to deliver high-speed rail into revenue service, the major hub cities—San Diego, Anaheim, Los Angeles, San Jose, San Francisco, and Sacramento—should systematically develop their mass transit system to ultimately disperse the future HSR passengers to their desirable endpoints. Existing light and commuter rail lines should be grade separated to eliminate the conflict with other modes and connect to high speed rail stations.

Recommendation 7

A renewed interest in bringing back maglev technology to the United States should be considered by substantially increasing the availability of federal research funds for the sole purpose of encouraging private companies to explore and develop an incredible technology. To reclaim maglev technology, the Maglev Deployment Program and associated federal funding should be revised to emphasize research and testing instead of designating $1 billion for design and construction. Partnerships with Japan and Germany to share technology will expedite a major breakthrough and foster global cooperation.

REPORT SUMMARY

There is little doubt that high-speed trains could eventually play a major role in California if a comprehensive high-speed train network is constructed. In highly dense metropolitan areas, where the population of the metropolitan service area exceeds several million people, and there are other major cities that have an existing highway network and are separated by a distance of 200 to 400 miles, linkage can be effectively linked by high-speed technology.

While Japan and Germany have expended billions of dollars developing maglev technology, the United States cannot afford to move forward with such unproven technology. The costly technology could jeopardize the public's perception of a publicly financed alternative transportation system. To renew the public's interest in train ridership, high-speed rail may well be the most suitable solution for California. The importation of advanced and reliable high-speed rail technology from Europe (TGV) and Japan (Shinkansen) can promote and quickly position California to construct an integrated system. Moreover, with the high concentration of the best scientists, engineers, and business professionals residing in California's metropolitan areas, private enterprise—large companies such as Boeing and Lockheed Martin or joint ventures with NASA—could result in the development of a new industry and the creation of thousands of new jobs.

In the United States, the automobile will remain king as long as gasoline is relatively inexpensive for the solo automobile driver, and as long as alternative forms of transportation remain obscure. However, in California's largest metropolitan cities—San Diego, Anaheim, Los Angeles, San Jose, San Francisco, Oakland, and Sacramento—the building of the basic mass transportation system infrastructure steadily needs to improve, and the outlook does not look promising without a regional effort to finance a massive transportation grid system. In the short term, MTC and SCAG regions will need to systematically eliminate slow trains and ineffective routes, and upgrade existing rail track to accommodate high-speeds; a regional gas tax could be the magic bullet that could invariably improve the quality of life in each metropolitan region.

Europe and Japan have chosen rail as the primary way for people to travel in the 21st century. Both countries embraced the train early and it is now time for the United States to reclaim the glory that trains once held nationally by developing a reputable high-speed system. Advances made in the United States during the remarkable 20th century now need, more than ever, to continue at a much higher level. The U.S. now needs to make a transition and do what it is best at—embracing technological change. Although the automobile and associated federal funding will continue for some time, there will be a time when consumers will overcome their pro-car attitude or seek higher gratification with the next generation of non-internal combustion engine automobiles.

The movement of large numbers of people will require a comprehensive infrastructure in each metropolitan region to allow for a mobile society. In the years before a high-speed rail system is completed, automobiles will still be used to provide the greatest flexibility in short-distance trips, but they will likely lose out in medium-distance travel. The automotive industry will have to advance technology away from the internal combustion engine to retain a consumer base that will be increasingly influenced by the price of a gallon of gasoline, right-of-way constraints to build more highways, and increased knowledge of environmental realities. When it comes to difficult economic decisions, California takes the lead in making progressive changes. Californians say they are genuinely concerned about the environment, but enjoy the lifestyles and the personal freedom that their gas-guzzling automobiles provide.

A high-speed network attracts passengers by having a successful and convenient mass transit system at the destination point. If California chooses to connect Los Angeles and the Bay Area with a high-speed train system, the metropolitan regions will need to further develop their regional mass transportation systems and effort to do so should be made over the next 16 years. Steady progress towards implementing a high-speed rail network requires regional and statewide coordination and cooperation.

Further delays in investing in high-speed rail will have similar consequences as the unwillingness of the United States to convert over to universal metric standards—over the long run, it will hurt U.S. workers and consumers as the global economy will continue to move forward without the United States and possibly overtake the U.S. in GNP output.

California has 16 years to prepare for a high-speed rail network between Los Angeles and San Jose. This preparation will need to include systematic and strategic mass transportation improvements for passengers to get to and from the train station at either end of the destination point. Given the lack of success in Los Angeles, even with the tremendous amount of transportation funds committed and improvements constructed, it will be a challenge to divert users to another mode of transportation unless there is a benefit. In the end, as Steve Heminger, Assistant Executive Director of MTC, stated during a presentation on mass transportation, “It’s not important to convince all of the public to change, it just takes a few to make a big difference." The challenge itself is no doubt the biggest hurdle.

Once a publicly-financed high-speed rail system is completed, Amtrak as well as an airline could have a role in operating the medium-distance passenger market. The HSR operation could be set up by forming JR equivalent companies to manage rail by regions with the most highly profitable business route paying a greater lease charge. High-speed rail has been a part of Japanese life for over 36 years and, like the automobile, the high-speed rail could become part of California's prominence.

APPENDIX A:
POPULATION DATA

Population Data (in 1,000s)

	Japan	California	SJ/SF/Oak	LA/Ana	Osaka	Tokyo
1900	43,847					2,019
1910	49,184			662		2,732
1920	55,473			1,194		3,699
1930	64,450			2,658		5,408
1940	71,933	6,950		3,312		7,354
1950	83,200	10,643		4,997		6,277
1960	93,419	15,863		7,824	6,657	9,683
1970	103,720	20,039	4,631	10,055	7,620	11,408
1980	117,060	23,782	5,180	11,590	8,473	11,618
1985	120,336	26,879	5,561	14,590	8,668	11,829
1990	123,611	29,976	6,253	14,531	8,734	11,855
1995	124,863	31,749	6,539	15,620	8,797	11,773
2000	**126,892**	**33,521**	**6,824**	**16,709**	**8,939**	**11,895**
2005	127,257	34,441	7,663	17,827		
2010	127,623	37,907	7,986	19,416		
2015	125,878	41,373	8,308	20,885		
2020	124,133	45,329	8,661	22,353		
2025	120,641	49,285				
2030	117,149					
2040	108,964					
2050	100,496					

APPENDIX B:

AUTOMOBILE OWNERSHIP DATA

	Japan	California	Bay Area
1960	1,500	3,404	1,620
1970	9,104	10,004	2,503
1975	14,000	11,119	2,892
1980	23,646	13,161	3,281
1985	27,790	14,584	3,618
1990	35,152	16,800	3,955
1995	45,069	17,262	4,219
1996	47,215	17,508	4,285
1997		17,754	4,219
1998		17,932	4,285
2000			4,483
2010			5,094
2020			5,470

Source:
U.S. Census
California Statistics Annual
California Department of Motor Vehicles
Japan Almanac 1999

APPENDIX C:

DOLLAR—YEN EXCHANGE RATE

Dollar – Yen Exchange Rate

Year	Average Yen Rate
1964	363.0
1965	362.0
1966	362.5
1969	357.8
1973	272.2
1974	292.1
1975	296.8
1976	296.5
1977	268.3
1978	210.1
1979	219.5
1980	226.5
1981	220.8
1982	249.3
1983	237.6
1984	237.6
1985	238.1
1986	168.0
1987	144.5
1988	128.2
1989	138.1
1990	144.9
1991	134.6
1992	126.6
1993	111.1
1994	102.2
1995	93.9
1996	108.8
1997	120.9
2000	109.0

Source: Japan Almanac 1999, World Almanac, SJ Mercury News

APPENDIX D:

TOKAIDO SHINKANSEN STATIONS

Tokaido Line Average Time

Station Name	Distance from Tokyo (miles)	Nozomi	Hikari	Hikari	Kodama
Tokyo	0.0				
Shin Yokohama	15.8		16 min		17 min
Odawara	47.6				41 min
Atami	59.3				51 min
Mishima	69.2				1hr 02m
Shin-Fuji	83.9				1hr 15m
Shizuoka	104.0			1hr 02m	1hr 30m
Kakegawa	131.3				1hr 52m
Hamamatsu	148.4			1hr 35m	2hr 04m
Toyohashi	170.4				2hr 24m
Mikawa-Anjo	194.4				2hr 41m
Nagoya	212.5	1hr 36m	1hr 54m	2hr 09m	2hr 54m
Gifu-Hashima	228.1				3hr 10m
Maibara	253.7				3hr 26m
Kyoto	296.0	2hr 15m	2hr 39m	2hr 54m	3hr 52m
Shin-Osaka	320.3	2hr 30m	2hr 57m	3hr 12m	4hr 10m

APPENDIX E:
CONSTRUCTION COST INDEX IN JAPAN

Year	Public Works Index
1964	23.5
1965	24.3
1966	26.2
1967	28.5
1968	29.4
1969	31.1
1970	33.3
1971	34.2
1972	36.4
1973	45.9
1974	57.4
1975	58.3
1976	62.3
1977	66.3
1978	71.2
1979	78.6
1980	87.7
1981	89.5
1982	89.1
1983	88.4
1984	89.9
1985	88.7
1986	88.4
1987	89.8
1988	91.7
1989	96.4
1990	100.0
1991	102.8
1992	104.3
1993	104.5
1994	105.0
1995	105.4
1996	106.1
1997	107.4
1998	106.7

Source: Japan Ministry of Construction

APPENDIX F:

METRIC CONVERSIONS

1 meter = 3.2808 feet

1 kilometer = 0.6213699 mile

1 km^2 = .03861006 mi^2

3.785 liters = 1 gallon

APPENDIX G:

SHINKANSEN LINE CONSTRUCTION COST-PER-MILE

	(A)	(B)	(C)	(D)	(E)	(F)	(G)
Shinkansen Line	Line Length (Miles)	Year Constructed	Construction Cost (million yen/km)	Exchange Rate in Completion Year	(Note 1) Construction Cost ($million /mi)	(Note 2) Construction Index Factor	(Note 3) Year 2000 Construction Cost ($million /mi)
Tokaido	320	1964	640	363.0	$2.8	4.76	$45.0
Sanyo, Ph. I	100	1972	(Note 4)				
Sanyo, Ph. II	244	1975	1,643	296.8	$8.9	1.88	$45.6
Tohoku	309	1991	5,358	134.6	$64.1	1.02	$80.7
Joetsu	168	1982	6,048	249.3	$39.1	1.21	$108.1

Note:

(1) = (C)/(.621 x (D))

(2) Japan Ministry of Construction Public Works Index

(3) = (C) x (F)/(.621 x 109)

(4) Unit price per kilometer for Sanyo Line did not disclose whether for entire line or phase II only

In Year 2000, 1 U.S. Dollar = 109 Yen

1 kilometer = 0.621 mile

ABBREVIATIONS AND ACRONYMS

ABAG	Association of Bay Area Governments
AGT	Automated Guideway Transit
ANA	Anaheim
Caltrans	California Department of Transportation
CEQA	California Environmental Quality Act
CHSRA	California High-Speed Rail Authority
CSU	California State University
DOT	Department of Transportation
FHWA	Federal Highway Administration
GDP	Gross Domestic Product
GRP	Gross Regional Product
HSR	High Speed Rail
ICE	Intercity Express (Germany)
IISTPS	International Institute for Surface Transportation Policy Studies (the Mineta Transportation Institute)
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
JNR	Japan National Railway
JR	Japan Railway
JRTR	Japan Railway & Transport Review
LA	Los Angeles
Maglev	Magnetic levitation
MSTM	Master of Science in Transportation Management
MTC	Bay Area Metropolitan Transportation Commission
NEPA	National Environmental Policy Act
OPEC	Organization of Petroleum Exporting Countries
SCAG	Southern California Association of Government
SF	San Francisco
SJ	San Jose
SUV	Sports Utility Vehicle
TEA-21	Transportation Equity Act for the 21st Century (1998)
TGV	Train a Grande Vitesse

BIBLIOGRAPHY

Bureau of Transportation Statistics, *Transportation Statistics Annual Report 1998*, U.S. Department of Transportation, 1998.

California High Speed Rail Authority, *Draft Final Report- California High-Speed Rail Corridor Evaluation*, prepared by Parsons Brinckerhoff, December 30, 1999.

California High Speed Rail Authority, *Draft Final Report – Independent Ridership and Revenue Projections for High Speed Rail Alternatives in California*, prepared by Charles River Associates Incorporated, January 2000.

California High Speed Rail Authority, *Draft Business Plan-Building a High Speed Train System for California, January 2000.*

East Japan Railway Culture Foundation, *Japan Railway & Transport Review*, Tokyo, Japan.

Ishikawa, Tatsujiro and Imashiro, Mitsuhide*, The Privatization of Japanese National Railways: Railway management, market and policy*, Athlone Press, New Brunswick, New Jersey, 1998.

Institute of Transportation Studies, U.C. Berkeley, *Regional Forum on Maglev Planning and Implementation: Summary*, 1991.

JR Central Company, 1998 Annual Report.

JR East Company, 1998 Annual Report.

Mizutani, Fumitoshi, *Japanese urban railways: a private-public comparison*, Ashgate Publishing Limited, England, 1994.

Yago, Glenn, *The Decline of Transit: Urban Transportation in Germany and US cities, 1900 – 1970*, Cambridge University Press, 1984

ABOUT THE AUTHOR

Robert Kagiyama is a graduate student in candidacy in the Master of Science Transportation Management (MSTM) Program at the College of Business at San José State University, California. This capstone paper was submitted as partial fulfillment of the MSTM program.

A professional civil engineer with over 20 years' experience, Kagiyama has worked on the design, construction and project management of municipal public works projects including several major regional water supply and mass transportation projects. He is a Member of the American Society of Civil Engineers (ASCE) and the American Public Works Association (APWA). In March 2000 he was recipient of the 2000 George Krambles National Transit Scholarship Award in Chicago, Illinois.

Kagiyama received his Bachelor of Science and Master of Science in Civil Engineering from San José State University. During his capstone paper research, he had the opportunity to travel numerous times between Osaka and Tokyo on the Tokaido Shinkansen bullet train line and observed several manned runs of an experimental 3-car maglev train going 300 mph along a 40 km long (25 mile) test track.

PRE-PUBLICATION PEER REVIEW

San José State University, of the California State University system, and the MTI Board of Trustees have agreed upon a peer review process required for all research published by the Mineta Transportation Institute. The purpose of the review process is to ensure that the results presented are based upon a professionally acceptable research protocol.

Research projects begin with the approval of a scope of work by the sponsoring entities, with in-process reviews by the MTI Research Director and the project sponsor. Periodic progress reports are provided to the MTI Research Director and the Research Associates Policy Oversight Committee (RAPOC). Review of the draft research product is conducted by the Research Committee of the Board of Trustees, and may include invited critiques from other professionals in the subject field. The review is based on the professional propriety of the research methodology.

ENDNOTES

[1] California High Speed Rail Authority Draft Business Plan, January 2000

[2] CHSRA January 2000 report

[3] California High Speed Rail Authority Draft Business Plan, page 25

[4] Central Japan Railway Company, California High Speed Rail Authority

[5] Central Japan Railway Company Web Site

[6] See note 3

[7] SJ/LA HSR Fare from CHSRA Report

[8] Parson Brinkerhoff in association with SYSTRA Consulting, Inc. The Duffey Company, Valley Research and Planning Associates, December 1999.

[9] Charles River Associates Incorporated, Boston, MA. January 2000

[10] Figure is not pertinent to study report

[11] Figure could be low because of economic effect of Kobe Earthquake

[12] Data collected from ABAG, World Almanac, Japan Almanac

[13] *Nipponia Quarterly Magazine*, "A Statistical View of Railways Today," January 1998.

[14] *Japan Railway & Transport Review*

[15] JR Central Company information for 1998

[16] 1998 Exchange Rate – 115 yen = 1 U.S. Dollar

[17] Yasuaki Fujimori*, Global Mass Transit Systems, Overview of the Mass Transits Systems in Japan*, 1998

[18] JR Central Company Annual Report

[19] Construction costs were converted from yen to dollars of completion year.

[20] The first phase of the Sanyo Line was 100 miles and completed in 1972. Phase II constructed 244 miles and was completed in 1975

[21] Ryohei Kakumoto, *Japan Railway & Transport Review*, "Transportation Investment and Japan's Experience," April 1997

[22] The historical figure ranges from 24 seconds to 39 seconds

[23] Photograph by Robert Kagiyama, 1988

[24] 1998 exchange rate: 109 yen = 1 U.S. Dollar

[25] Interview conducted by Robert Kagiyama after witnessing incidents

[26] Photographs by Robert Kagiyama, July 1999

[27] 1965 exchange rate: 360 yen = 1 U.S. Dollar

[28] See note 3

[29] SJ/LA HSR Fare from CHSRA Report

[30] Actual time from San Jose Airport to LAX to Downtown LA.

[31] Yen to dollar conversion for that year. In 1965, the exchange rate was 1 dollar = 363 yens, therefore, 55 billion yen = 55,000,000,000/363 = $151,515,000 U.S. dollars.

[32] Glenn Yago, The Decline of Transit, Urban transportation in Germany and U.S. cities, 1900-1970

[33] U.S. Department of Energy, Japan Ministry of Energy, 1996

[34] Price as of February 2000 in the Tokyo region

[35] Central Japan Railway Company, California High Speed Rail Authority

[36] Central Japan Railway Company Web Site

[37] SJ/LA HSR Fare from CHSRA Report