

**High-Speed Rail Commuting in the United States:
A Case Study in California**

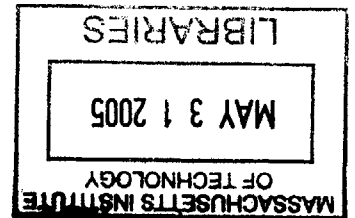
By

SHUICHI KASUYA

Master of Engineering, University of Tokyo (1998)

Submitted to the Department of Civil and Environmental Engineering on May 6th,
2005, in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE
in Civil and Environmental Engineering
At the Massachusetts Institute of Technology
June 2005



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Abstract

High-speed rail (HSR) is primarily for intermediate distance intercity passenger travel. The concept of high-speed rail commuting is to provide short distance commuting transportation service on dedicated HSR, by sharing the same rolling stock and infrastructure. HSR commuting benefit all city commuters by relieving inner city traffic congestion as well as providing intercity service. HSR commuting also benefits its operators providing an additional financial resource.

In the US, the rail is primarily for freight. Passengers usually take airlines and automobiles, but the congestion of airports and roads are increasing, which makes another transportation option necessary. Rail passenger transportation is less energy consuming and it is effective for the environment. For the sustainable development of many cities in the US, HSR is a potential option.

From successful HSR examples in Japan, French, and Germany, the primary purpose of HSR is intermediate distance intercity passenger transportation, and dedicated tracks are necessary. In the US, there are no HSR by our definition, but there are still HSR transportation potential regional corridors in California, Texas, Florida, and other regions. There are several statewide HSR projects, but none has been constructed. The most difficult hurdle for HSR projects in the US is financial resources, and HSR commuting is a potential for those.

Japanese HSR, Shinkansen is the only case of practical HSR commuting in the world. HSR commuting needs no large additional investment. As commuting and intercity travel are complementary behaviors, additional fundamental investments, such as extra tracks and rolling stock, are not necessary. In contrast, for effective HSR commuting, some considerations, such as monthly commuter passes and shifting seat configuration, are necessary. HSR commuting provides fast travel for passengers, but also it is a potential revenue source for intercity HSR projects and operators.

Though the geographical and social background in the US is different from that in the countries that have successful HSR, thorough deliberate policy initiative and investment, we suggest HSR commuting would benefit both all commuters in the region and the HSR operator in California.

Thesis Supervisor: Dr. Joseph Sussman

Title: Professor of Civil and Environmental Engineering, Professor of Engineering Systems,
JR East Professor

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List of Abbreviations

AADT	Average Annual Daily Traffic
Amtrak	The National Railroad Passenger Corporation
AVE	Alta Velocidad Espanola
BART	San Francisco Bay Area Rapid Transit Authority
BNSF	Burlington Northern Santa Fe Railway Company
CALTRANS	The State of California Department of Transportation
CIA	The Central Intelligence Agency
CN	Canadian National Railway Company
DB	Deutsche Bahn
FRA	The Federal Railroad Administration
HSR	High-Speed Rail
ICE	Inter City Express
JNR	Japan National Railway (-1987)
JPB	The Peninsula Corridor Joint Powers Board
JR	Japan Railway (1987-)
KTX	Korean Train Express
LAX	Los Angeles International Airport
LGV	Ligne a Grande Vitesse (Line at High-Speed)
LRT	Light Rail Transit

Maglev	Magnetic Levitation system
MARS	Multi Access Seat Reservation System
MAX	Multi Amenity Express
MBTA	Massachusetts Bay Transportation Authority
METRO	Los Angeles County Transportation Authority
MNRR	Metro North Railroad
MTDB	The San Diego Metropolitan Transit Development Board
Muni	San Francisco Municipal Railway
NEC	North East Corridor (Boston – New York – Washington D.C.)
RT	Sacramento Regional Transit District
SDTI	San Diego Trolley, Inc
SFO	San Francisco International Airport
SNCF	Societe Nationale des Chemins de fer Francais
TGV	Train a Grande Vitesse (Train at High-Speed)
UP	Union Pacific
US DOT	The United States Department of Transportation

Chapter 1 Introduction

1.1 Concept of High-Speed Rail Commuting and Thesis Overview

The basic concept of high-speed rail (HSR) commuting is to provide short distance commuting transportation service on intercity high-speed rails. Figure 1.1 shows “Intercity HSR,” “Commuting HSR”, and “Intercity & Commuting HSR”. High-speed rail is primarily for intermediate distance intercity passenger travel. By sharing HSR rolling stock and infrastructure for regional short distance commuting, high-speed rail can provide not only intercity travel but also commuting travel. By introducing high-speed rail commuting, not only HSR commuters but also all other commuters receive benefits from existent transportation congestion relief. In addition, HSR operators gain additional revenue from the commuting service. This revenue provides relief for the initial significant HSR infrastructure expense.

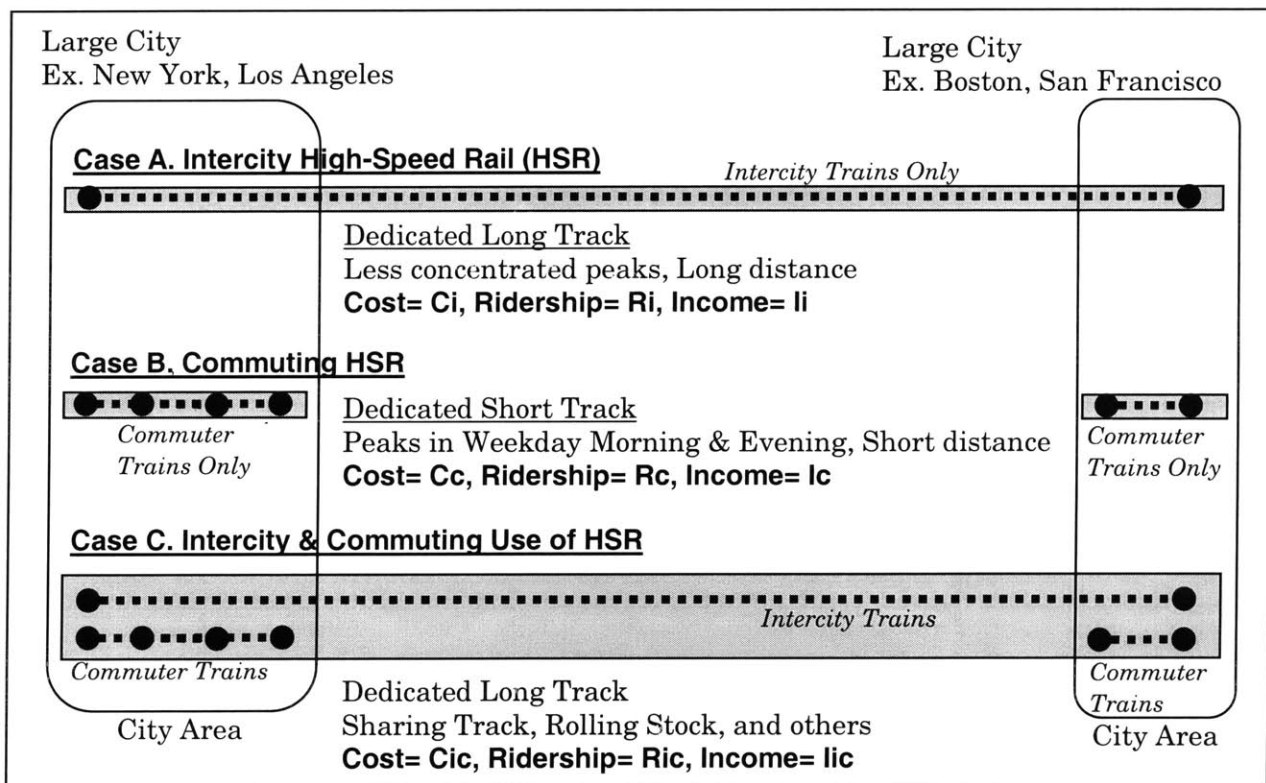


Figure 1.1 Intercity and Commuting Use of HSR Concept

Legend: Dot Lines=Train Operation, Shaded Square=HSR Infrastructure

Intercity and commuting use of HSR (Case C) benefits commuters with short commuting time, In addition, it benefits the HSR operator by the additional income from HSR commuting. Commuting HSR (Case B) is a hypothetical HSR with short HSR track in the city and dedicated rolling stock. This type of HSR has a possibility for inner city congestion relief, but this needs a lot of initial expense only for commuting and is inefficient.

The intercity & commuting use of HSR have the total ridership and income from both intercity and commuting HSR service.

Intercity & Commuting Use of HSR Ridership = Ric = Ri + Rc (1)

Ric: Ridership of intercity & commuting use of HSR (**Case C**) (Unit: Passengers/day)

Ri: Ridership of HSR intercity service (**Case A**) (Unit: Passengers/day),

Rc: Ridership of HSR commuting service (**Case B**) (Unit: Passengers/day)

Intercity & Commuting Use of HSR Revenue = Vic = Vi + Vc = Ui*Di*Ri + Uc*Dc*Rc (2)

Vic: Revenue from intercity & commuting use of HSR (**Case C**) (Unit: \$/day)

Vi: Revenue from HSR intercity service (**Case A**) (Unit: \$/day)

Vc: Revenue from HSR commuting service (**Case B**) (Unit: \$/day)

Ui: Unit revenue from HSR intercity service (**Case A**) (Unit: \$/passenger-miles)

Uc: Unit revenue from HSR commuting service (**Case B**) (Unit: \$/passenger-miles)

Di: Average HSR intercity ride distance (**Case A**) (Unit: miles)

Dc: Average HSR commuting ride distance (**Case B**) (Unit: miles)

However, as intercity & commuting use of HSR shares rolling stock, track, and other infrastructures, the cost is lower than the total of each intercity and commuter HSR service.

Therefore, the HSR operator have the benefit from the intercity & commuting use of HSR.

Intercity & Commuting Use of HSR Cost = Cic < Ci+Cc (3)

Cic: Cost for intercity and commuting use of HSR (**Case C**) (Unit: \$/day),

Ci: Cost for HSR intercity service (**Case A**) (Unit: \$/day),

Cc: Cost for HSR commuting service (**Case B**) (Unit: \$/day)

Intercity & Commuting Use of HSR Income = Iic = Vic - Cic > (Vi+Vc) - (Ci+Cc) = Ii + Ic (4)

Iic: Income from intercity and commuting use of HSR (**Case C**) (Unit: \$/day),

Ii: Income from HSR intercity service (**Case A**) (Unit: \$/day),

Ic: Income from HSR commuting service (**Case B**) (Unit: \$/day)

This thesis's primary objective is to study HSR projects in the US. Specifically, after presenting an overview of the US's transportation issues and worldwide HSR, we will discuss the value and aptness of applying the concept to the California HSR plan, which is currently the most practical HSR plan in the US.

Chapter 1 is an introduction. We will briefly discuss both the passenger and freight transportation's current situation and issues in the US. As we will use the Japanese HSR commuting as an example, we will assess the current situation and issues in the US, compared with Japan. Then "high-speed rail" and "intermediate distance" will be clarified.

Chapter 2 is an overview of world high-speed rail. First, we will discuss successful HSR transportation examples from other countries, such as Japan, France and Germany. Then we will discuss US HSR projects in California, Texas and Florida, which provide intercity passenger transportation. (Only Japan has HSR commuting.)

Chapter 3 introduces the concept of HSR commuting, based on a Japanese model. Because commuting passengers travel short-distances that require slower speeds, commuting services need different infrastructures and operations than long-distance intercity services. However, depending upon the time of day, these intercity and commuting services can share one infrastructure.

Chapter 4 applies HSR shared infrastructure approach to the California HSR project. However, we find that because each region has unique issues and challenges, we must customize the requirements of the California project.

Chapter 5 concludes this thesis. After summarizing whole thesis, we will state the major conclusions for HSR commuting in the US.

1.2 Transportation Issues and alternates in the US

1.2.1 Passenger Transportation in the US

More passengers travel in privately owned automobiles and on commercial airlines than any other form of transportation. For example, in 2000, cars and vans logged 85% of total passenger miles in the US; at the same time, air carriers logged 11% of US passenger miles

Transit, commuter and intercity/Amtrak rails logged less than 1% of total passenger-miles in the US. In contrast, 27% of Japan's passenger-miles were logged by rail.

Table 1.1 Passenger-Miles in the US and Japan by Mode

US			JAPAN		
Mode	Million Pax Miles		Mode	Million Pax Miles	
	2000			2000	
Air Carriers	516,129	10.9%	Airlines	49,523	5.6%
General aviation	15,200	0.3%			
Passenger Cars	2,544,457	53.6%	Passenger Cars	536,831	60.9%
Motorcycles	11,516	0.2%			
Vans etc	1,467,664	30.9%			
Buses	160,919	3.4%	Buses	54,249	6.1%
Rail Transit	15,200	0.3%	Rail	238,881	27.1%
Rail Commuter	9,402	0.2%			
Rail Intercity/Amtrak	5,498	0.1%			
Other transit	1,631	0.0%	Ship	2,674	0.3%
Total	4,747,616	100%	Total	882,158	100%

Source: US: Pocket Guide to Transportation 2005, Bureau of Transportation Statistics, January 2005, JAPAN: Nihon Kokusei Zue 2003, Yano Kouta Kinenkai

In the US, since the 1970s, air carrier passenger-miles have slightly increased, and bus passenger-miles have very slightly increased since the 1980s. However, the major passenger mode is still automobiles with passenger-miles increasing. In Japan, car transportation volume has increased, but rail and bus has remained the same.

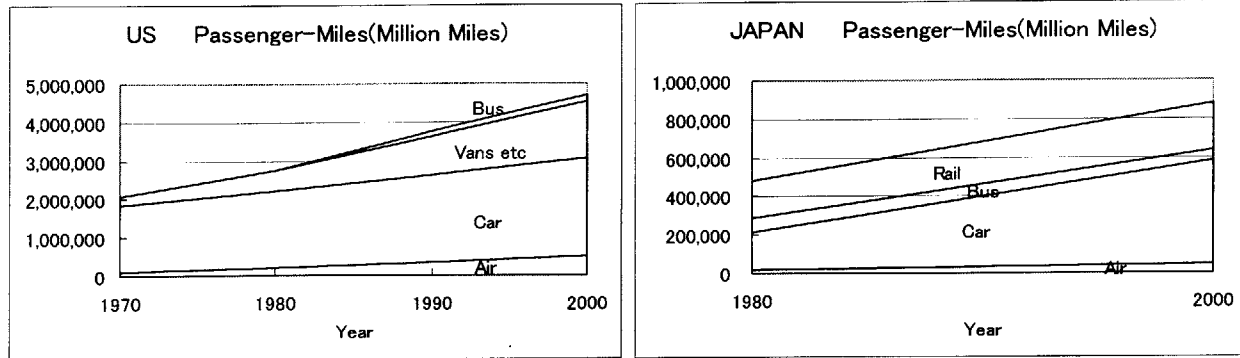


Figure 1.2 Passenger-Miles Trend

Source: US: Pocket Guide to Transportation 2005, Bureau of Transportation Statistics, January 2005, JAPAN: Nihon Kokusei Zue 2003, Yano Kouta Kinenkai

1.2.2 Rail transportation in the US

In the United States, the rail system is used primarily used for freight. In 2002, it was the second most popular form of transport. By contrast, in Japan, trucks and ships carry most freight.

Table 1.2 Freight Shipments in the US and Japan by Mode

US			JAPAN		
Mode	Million Ton Miles		Mode	Million Ton Miles	
	2002			2000	
Truck	1,311,000	42.9%	Truck	194,563	54.2%
Rail	1,199,000	39.3%	Rail	13,755	3.8%
Water	323,000	10.6%	Water	150,167	41.8%
Air	6,000	0.2%	Air	668	0.2%
Intermodal	215,000	7.0%	Intermodal	N/A	
Total	3,054,000	100%	Total	359,153	100%

Source: US: Pocket Guide to Transportation 2005, Bureau of Transportation Statistics, January 2005, JAPAN: Nihon Kokusei Zue 2003, Yano Kouta Kinenkai

Thus, because in the US intercity railroads, the longest in the world, are used mainly for freight, rail freight companies own most of intercity railroads, which are the longest one in the world. There are several profitable large freight rail companies created by mergers, but there is still no nationwide company with a continuous track network. Therefore, currently all trains have to get permission to pass through sections of tracks to cross the US continent. Moreover, most of these tracks alternate directions, causing delays and low speed limits. One of few

exceptions is the North East Corridor (NEC) railroads from Boston to Washington D.C., owned by Amtrak. In contrast, in Japan, passenger rail companies own most conventional and all HSR railroads, the latter of which are dedicated to passenger use.

In this thesis, we focus on high-speed railroads with dedicated lines, rather than incremented trains on conventional tracks.

1.2.3 Backgrounds

Compared to travel in Asian and European countries, US travel offers extensive advantage in its use of automobile. Until the 1950s, US railways were popular for passenger transportation. Long distance travel by automobiles was difficult without adequate highways, and airline travel was expensive.

The price of oil was relatively low, and there were few tolls. Oil price was less than half of that in Asian and European countries, and gas taxes were much lower. In addition, with the establishment of Federal Aid Highway Act in 1956, interstate networks expanded rapidly and dramatically improved automobile transportation. Ninety percent of the cost of interstate construction was from federal grants, and the cost were relatively low.

In contrast, currently in Japan, gas prices are twice that of the US. In addition, Japanese intercity highways impose high tolls. The basic charge rate is ¥150+¥24.6/km (\$1.44+\$0.38/miles)¹. For a 200-mile trip, it is necessary to pay about \$70.

¹ Source: Ministry of Land, Infrastructure and Transport, Japan

Table 1.3 Gas Price in the US and other countries (Unleaded Gasoline & Diesel)

Unleaded	Price	Tax	Total	%
United States	1.52	0.39	1.91	100%
Mexico	1.79	0.27	2.06	108%
Canada	1.52	0.89	2.40	126%
Japan	1.94	2.04	3.99	209%
Korea	1.67	2.85	4.52	237%
France	1.59	3.71	5.30	278%
Germany	1.65	3.78	5.43	285%

Source: Inter National Energy Agency(IEA)
 2004 4th Quarter Unleaded Gasoline
 \$/gal US Price =100%

Diesel	Price	Tax	Total	%
Mexico	1.01	0.68	1.70	93%
United States	1.37	0.45	1.83	100%
Japan	1.94	1.20	3.15	172%
Germany	1.65	2.79	4.43	242%
France	1.88	2.77	4.65	254%

Source: Inter National Energy Agency(IEA),
 2004 4th Quarter Automotive Diesel
 \$/gal US Price =100%

In the US airline industry, due to deregulation in 1978, fares are now very low. Again, Japan's airline fare deregulation only began in 2000, making current airfares relatively high.

Consequently, US automobile travel is most affordable, while passenger rail travel is relatively expensive and slow. In contrast, in Japan, although HSR fares and automobile tolls are still comparable. HSR is still faster.

For rehabilitation of intercity rail transportation, HSR with dedicated tracks are necessary.

Table 1.4 Intermediate Distances Intercity Passenger Transportation Comparison

	Airlines	Rail	Highway Bus	Automobiles
US BOSTON-NEW YORK (231 miles) Operator/Time/ Fare/Frequency	Delta US-Air etc Delta shuttle etc 1:04-1:34 \$155-257 42(6:00-20:30)	Amtrak Acela Express 3:20 \$85-99 11(5:20-18:20)	Gray Hound etc 4:30 \$15 18(7:00-23:30)	I90-I84-I95 (I=interstate) 4:30 Toll\$7+Gas\$14
JAPAN SENDAI-TOKYO (218.6 miles) Operator/Time/ Fare/Frequency	<No Service>	JR "Hayate" Super Express 1:36 \$104 15(8:15-21:24)	JR BUS etc Dream etc 5:30 \$61 11(7:00-23:59)	Touhoku Highway 5:30 Toll\$76+Gas\$27

Airlines ticket price is one week advanced purchase for one-way ticket on March 22, 2005
 \$1=¥104 30 mile/gal US \$1.85/gal JN ¥102/L

Source: Amtrak system timetable fall2004& winter2005 / OAF freight guide Jan 2004 /JR Time Table Dec 2004. Acela Express price differ depending on peak or non-peak hours.

Note: Airlines travel times do not include airport access and city access time

1.2.4 Transportation Issues in the United States

The transportation industry is critical, and its development is essential for a nation's growth. However, with the growth of the population and economy of the US, especially in large city areas, roads and airport congestion have become serious problems.

Table 1.5 Roadway Delay Time and Cost for US persons

	Delay Time per person				Delay Cost per person			
	1992	2002	Change	per day	1992	2002	Change	per day
Very large areas	55	62	113%	16.5	338	567	168%	1.69
Large areas	28	38	136%	8.4	178	364	204%	0.89
Medium areas	14	25	179%	4.2	95	238	251%	0.48
Small areas	9	12	133%	2.7	57	116	204%	0.29
Average	38	46	121%	11.4	242	435	180%	1.21

Hours per Year Minutes Dollars

Source: Pocket Guide to Transportation 2005,
Bureau of Transportation Statistics, January 2005,
Convert one year = 200 working days

Roadway delay time has increases more than 20% in ten years, and has reached more than ten minutes per day per person.

Table 1.6 Congested Airports

	1993		2003	
	rank	%	rank	%
Newark Int., NJ	1	29.0	1	25.8
Chicago O'Hare Int., IL	9	20.1	2	22.7
Philadelphia Int., PA	20	17.7	3	22.7
New York La Guardia, NY	15	18.8	4	22.4
Miami Int., FL	14	19.2	5	20.1
Fort LauderdaleHollywood Int, FL	7	21.9	6	19.5
New York JFK Int., NY	6	22.5	7	19.4
Atlanta Hartsfield Int., GA	5	23.2	8	19.4
San Francisco Int., CA	4	23.3	9	18.4
Boston Logan Int., MA	2	25.4	10	17.7
San Diego Int., CA	16	18.8	14	16.9

Source: Pocket Guide to Transportation 2005,
Bureau of Transportation Statistics, January 2005
Percentage of scheduled flights canceled, diverted, or arriving at least 15 minutes after the scheduled arrival time = Federal Aviation Administration's definition of airlines' delay

As shown above, in the most congested airports, over one-fourth of scheduled flights are delayed more than 15 minutes.

1.2.5 The Rail Alternate

In the United States, rail can be a practical way to relieve road but not airport congestion. As an alternative to automobiles, passenger trains run on freight tracks as commuter rails in some large cities. Also, light-rail transit offers an alternative short-distance travel. In contrast, as an alternative to airlines, some HSR projects are in development, but in the US, these projects have not been completed.

Rail transportation offers more effective environmental and safety benefits than automobiles and airlines, if ridership is sufficient. Figure 1.3 and Figure 1.4 show rail's low energy consumption and CO₂ emission. Moreover, rail transportation consumes less fuel per passenger at reasonable load factors than do automobiles and airplanes. In addition, rail transportation is safe. In Japan, since the establishment of the HSR in 1964, there has never been a fatal passenger accident. In contrast, in the US, over 40,000 people lose their lives per year on highways due to automobile accidents². It can be argued that shifting intercity travel in the US from automobile to HSR will vastly reduce fatal passenger accidents.

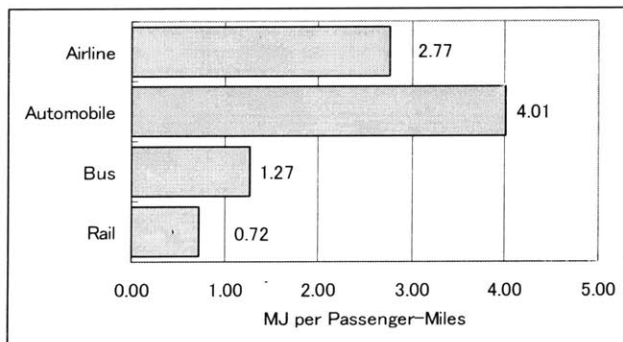


Figure 1.3 Energy Consumption
Source: East Japan Railway Company

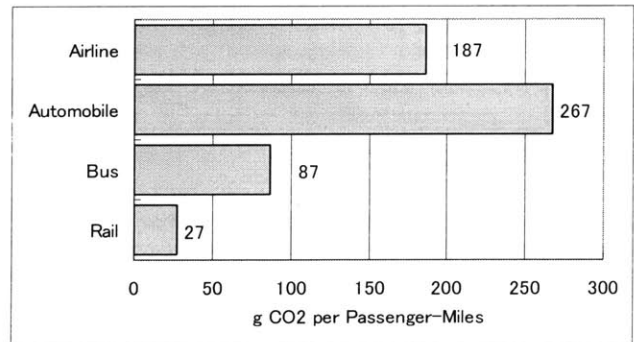


Figure 1.4 CO₂ Emissions
Source: East Japan Railway Company
Note: 1 lb=454 g

1.3 The Definition and Specialty of HSR Transportation

The US has no true HSR to date, in part because HSR projects require dedicated tracks, which are expensive. Even the Acela Express, which runs on tracks not yet replaced for

² Pocket Guide to Transportation 2005, Bureau of Transportation Statistics, January 2005

high-speed rail use, does not constitute a true HSR system. (Three hours and fifteen minutes for the 200 miles from New York to Boston)

We define HSR that run maximum at least 125 miles (200 km) per hour primarily on dedicated tracks for HSR. Dedicated tracks are necessary to avoid schedule conflicts with freight trains, conventional passenger and commuter trains, and also to avoid inadequate physical characteristics of conventional railroads.

However, although HSR dedicated tracks are expensive, generating commuting revenues can be an additional source of income above intercity revenues to address initial construction costs. Also, HSR commuting contributes not only to limiting residents at express train stations but also all residents along the route. Otherwise, HSR dedicated line raises some environmental issues, such as noises and vibration along the route without any benefit. However, the benefit in reducing highway congestion and air quality issues can be important.

In the design of high-speed rails in the US, it is important to note that intermediate travel, or distances of 300-500 miles per trip by HSR, is typically the most popular. In 1998, 60% of Japanese passengers choosing the rail system traveled intermediate distances. For less than 300 miles per trip, nearly 50% of Japanese travelers chose automobiles.

For passengers traveling 500 miles per trip or less, HSR is a practical alternative when one considers that a 500 mile trip takes approximately four hours, while the same trip by air would take one hour flight time plus additional two or three hours for airport access, check-in, security and a commute to the city. Therefore, for this 500 miles range, HSR is a competitive alternative.

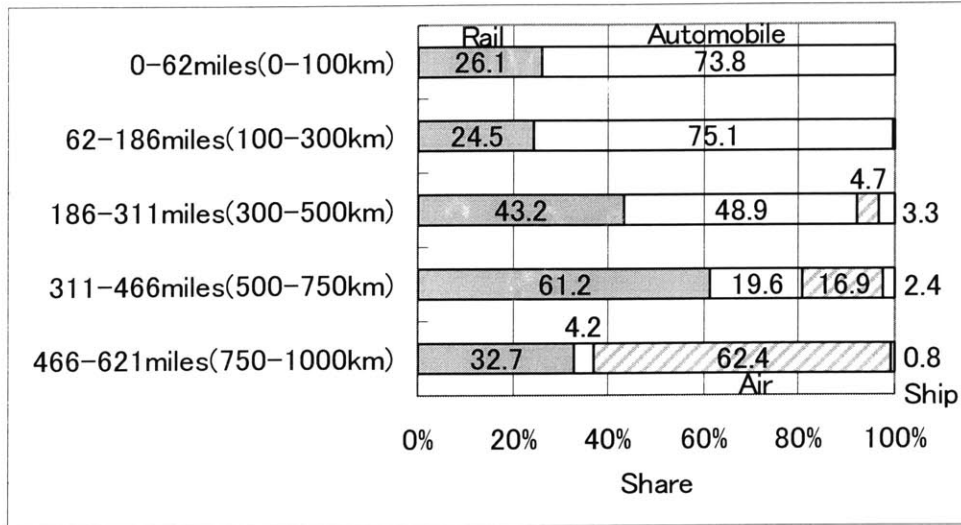


Figure 1.5 Mode Share sorted by distance in Japan 1998
 Source: Minister of Transportation in Japan

In the future, such advanced alternatives as Linear Motor Cars (Magnetic Levitation Systems: Maglev) may become a practical option for high-speed surface travel. This technology, currently being tested in the US and elsewhere, allows for speed of more than 300 miles per hour³ – competing with airplanes in longer distance than HSR. However, because this technology is still highly expensive, it is not yet practical alternative. Therefore, we will focus solely on the use of HSR as a transportation resource in the US.

³ Maximum speed record of Maglev is 343 miles (552km) per hour (1999.4.14, Japan)

Chapter 2 World High-Speed Rail Overview

In this chapter, we will first briefly discuss successful HSR transportation cases in Japan, France and Germany. Second, we will present HSR projects currently in planning stages in the US, specifically California, Texas, and Florida. Our definition of “successful” is not profitability but rather from usage. If the numbers of passengers increase, we view the HSR as successful. In this discussion, we focus on the initial phase of each HSR.

We will discuss not only HSR rolling stock but also all components. Railway transportation is a complex system. Not only high-speed vehicles but also high-grade railway infrastructures, such as reinforced railroads and maintenance facilities, are essential for HSR. In addition, for “mass” revenue service, ticketing and other fare receiving facilities are necessary.

As HSR is mass transportation, the country with HSR has a relatively large area population, and the first HSR line is usually from the capital to the second largest city. In addition, as HSR needs high technology and large funding, the first HSR project is usually a national project.

2.1 High-Speed Rail Transportation in the world

2.1.1 Shinkansen in Japan (Since 1964)

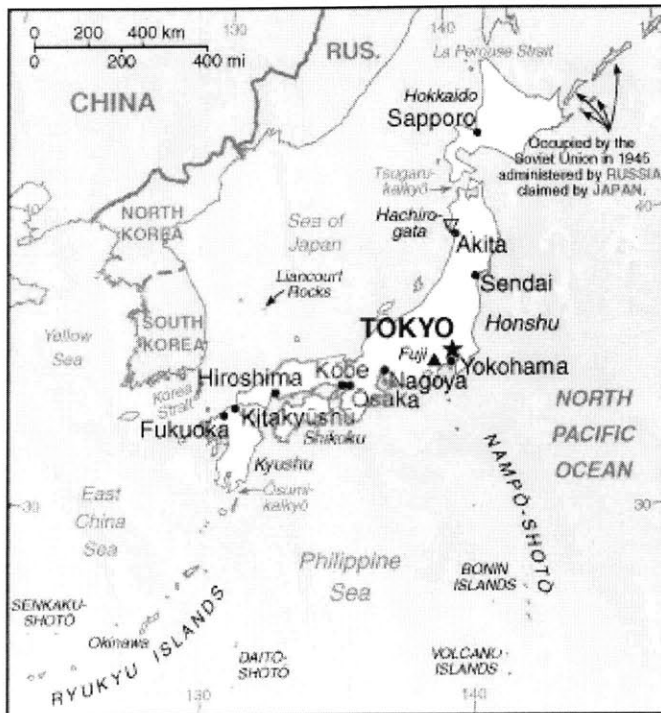


Figure 2.1 Geography and Large Cities in Japan

Source: World Fact Book, the Central Intelligence Agency (CIA)

Japan is a Far East Asian country with a population of 127 million and the third largest national economy in the world, next to the US and China⁴. With the economic growth after WW II, the conventional railroad between Tokyo, the largest and capital city with over 10 million people, and Osaka, the second largest city at that time, had become saturated in the 1950s. To relieve the railroad, the first Shinkansen commercial rail system started on October 1, 1964. The travel distance from the first to last station of this trip required 320 miles (515km) of track. The express train named “Hikari”, connected Tokyo with Osaka in four hours-two hours faster than the fastest conventional express train, the Kodama in 1960s. All Shinkansen lines were dedicated tracks with a maximum speed of 130 miles (210km) per hour. The seating capacity in 16 cars was 1285, including 132 first class and reserved seats.

⁴ World Fact Book, the Central Intelligence Agency (CIA)

Shinkansen has been a successful project. Table 2.1 shows the increasing number of Shinkansen passenger-miles. Recently, Shinkansen logged nearly five times the passenger miles of those in the earlier stage. Currently, over 500,000 passengers per day use Tokaido, Sanyo and Kyushu Shinkansen, and over 300,000 passengers per day use Touhoku, Jouetsu and Hokuriku-Shinkansen.

Table 2.1 Shinkansen Passenger-Mile (Yearly)

	1965	1970	1975	1980	1985	1990	1995	2000
Tokaido(1964-)	6,618	17,330	33,130	25,967	27,256	35,670	33,901	33,228
Sanyo(1970-)	24%	64%	122%	95%	100%	131%	124%	122%
Touhoku(1982-)					7,182	9,176	10,098	10,985
Jouetsu(1982-)					100%	128%	141%	153%

Unit: Million-miles Index: 1985 =100% Source: Shinkansen, Sankaido, 2003

The Shinkansen network has extended to the west and the north after the initial success. (See Figure 2.2) To the west, Tokaido/Sanyo-Shinkansen reached to Hakata (Fukuoka) via Okayama in 1975. To the north, Touhoku-Shinkansen reached to Hachinohe via Sendai and Morioka in 2002, Joetsu-Shinkansen reached to Niigata in 1982, and Nagano-Shinkansen reached to Nagano in 1998. The latest Kyusyu-Shinkansen revenue operation started in 2004. All lines have many intermediate stations. For example, Tokaido-Shinkansen has 14 intermediate stations on its 320 mile route. However, many trains stop only large terminals.

Touhoku-Shinkansen has two feeder lines, Yamagata and Akita-Shinkansen on conventional rail. These feeder lines are improved conventional rails with large gauge⁵. However, maximum speed of these lines is only up to 81 miles (130km) per hour, similar to other conventional rails. In contrast, the recent maximum speed on dedicated line has been 186 miles (300km) per hour. Shinkansen run on dedicated railroads without crossings, with the exception of these two improved conventional railroads.

⁵ Gauge = the width between left and right rail. As the conventional gauge in Japan is 1068mm and different from Shinkansen gauge, which is 1435mm and the universal standard, for high-speed operation, gauge shift construction is necessary.

In addition to its domestic expansion, Shinkansen-based rolling stock have been imported to Taiwan. Taiwan High-Speed Rail is expected to start in October 2005 from Taipei to Takao (214miles =345km).

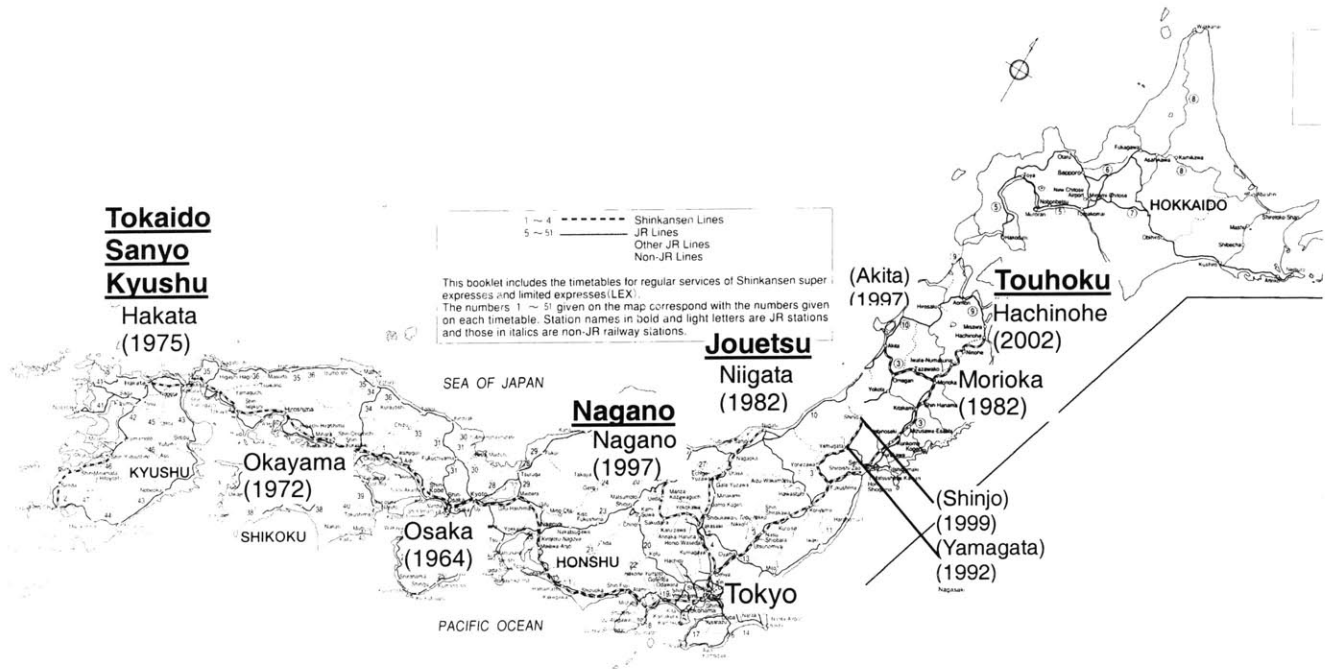


Figure 2.2 Shinkansen Network Expansions

Source: JR TIME TABLE Oct. 2004

Four digit numbers in parentheses are the year of extended operation start

In addition to its intercity transportation, Shinkansen has an HSR commuting function. This is of particular interest in this thesis. East Japan Railway Company (JR-EAST), the operator of Touhoku, Jouetsu and Nagano-Shinkansen, and its former entity Japan National Railway⁶ (JNR) have sold Commuting Pass “FREX” since 1984 and school pass “FREX PAL” since 1986. Table 2.2 shows that over 25,000 commuters and students ride Shinkansen every weekday. In peak hours, Shinkansen trains arrive at the Tokyo terminal every four minutes. Some of those are double deck trains for seating many commuters. Comparing with total over 300,000 passengers per day, commuter number is less than 10%. However, this number is substantial and still increasing. We will examine Shinkansen HSR commuting in detail in the

⁶ JNR was privatized and divide to regional companies in April 1987.

next chapter.

Table 2.2 Commuter Pass Usage

		1988	1993	1998	2003
FREX (1984-)	Touhoku(1982-)	1,336	7,191	11,475	13,367
	Jouetsu(1982-)	797	4,712	6,913	7,865
	Nagano(1997-)			482	1,239
FREX PAL (1986-)	Touhoku(1982-)	643	1,893	2,159	1,911
	Jouetsu(1982-)	303	789	968	864
	Nagano(1997-)			137	264
Total		3,079	14,585	22,134	25,510
Index: 1993= 100%		21%	100%	152%	175%

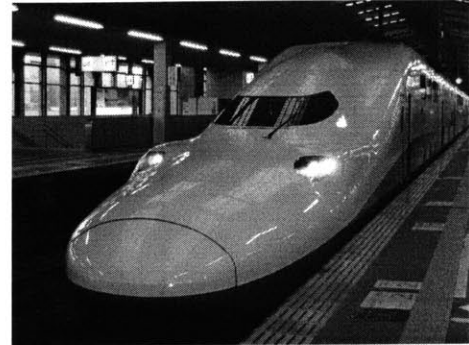


Figure 2.3 Double Deck Shinkansen

Source: JR-EAST Company Catalogue, September 2004
 FREX = Commuter Pass FREX PAL = Schooling Pass

Shinkansen has many tunnels. For example, Tokaido Shinkansen has a total of 43 miles of tunnels. This is 13% of its total tracks. As Japan is mountainous country, it is unavoidable to dig tunnel to make relatively straight HSR. However, it is expensive.

Table 2.3 Proportion of Infrastructures

		Completed	Total	Earth Work	Elevated Way	Bridge	Tunnel				
Tokaido	Tokyo-Shin Osaka	1964	321	170	53%	72	22%	35	11%	43	13%
Sanyo	Shin Osaka-Hakata	1975	349	43	12%	100	29%	32	9%	174	50%
Jouetsu	Omiya-Niigata	1982	171	2	1%	82	48%	21	12%	66	39%
Touhoku	Tokyo-Morioka	1982	311	16	5%	178	57%	45	15%	72	23%
	Morioka-Hachinohe	2002	59	9	15%	6	9%	2	3%	43	73%
Nagano	Takasaki-Nagano	1997	78	12	15%	20	25%	7	10%	39	50%

Source: Shinkansen, Sankaido, 2003

Shinkansen is the first HSR in the world, and has over 40 years operating experience. In addition, the safety record of Shinkansen is remarkable. Shinkansen has never had fatal passenger accident since it started the revenue operation in 1964.

Shinkansen has many intermediate stations. Average distance between Tokaido Shinkansen stations is 21 miles at the beginning of its service.

Table 2.4 Intermediate Stations of Shinkansen

Tokaido	Dist.1	Dist.2	Open	Touhoku	Dist.1	Dist.2	Open
Tokyo	0.0		1964.10.1	Tokyo	0.0		1991.6.20
Shinagawa	4.2	4.2 *	2003.10.1	Ueno	2.2	2.2	1985.3.14
Shin-Yokohama	15.8	11.6	1964.10.1	Omiya	19.4	17.2	1982.6.23
Odawara	47.7	31.8	1964.10.1	Oyama	49.9	30.4	1982.6.23
Atami	59.3	11.6	1964.10.1	Utsunomiya	67.7	17.8	1982.6.23
Mishima	69.2	9.9 *	1969.4.25	Nasu-Shiobara	94.7	27.0	1982.6.23
Shin-Fuji	83.9	14.7 *	1988.3.13	Shin-Shirakawa	110.9	16.2	1982.6.23
Shizuoka	104.0	20.1	1964.10.1	Koriyama	132.9	22.1	1982.6.23
Kakegawa	131.3	27.3 *	1988.3.13	Fukushima	158.5	25.6	1982.6.23
Hamamatsu	148.4	17.1	1964.10.1	Shiroishi-Zao	177.8	19.3	1982.6.23
Toyohashi	170.4	21.9	1964.10.1	Sendai	202.2	24.4	1982.6.23
Mikawa-Anjo	194.4	24.0 *	1988.3.13	Furukawa	226.1	23.9	1982.6.23
Nagoya	212.5	18.1	1964.10.1	Kurikoma-Kogen	239.7	13.6 *	1990.3.10
Gifu-Hashima	228.1	15.6	1964.10.1	Ichinoseki	252.5	12.8	1982.6.23
Maibara	253.6	25.5	1964.10.1	Mizusawa-Esashi	268.0	15.5 *	1985.3.14
Kyoto	296.0	42.3	1964.10.1	Kitakami	278.7	10.7	1982.6.23
Shin-Osaka	320.3	24.3	1964.10.1	Shin-Hanamaki	287.8	9.0 *	1985.3.14
	Average	20.0		Morioka	308.5	20.8	1982.6.23
	Except Avg	21.0		Iwate-Numakunai	327.8	19.3	2002.12.1
Sanyo	Dist.1	Dist.2	Open	Ninohe	349.3	21.5	2002.12.1
Shin-Osaka	320.3			Hachinohe	368.5	19.2	2002.12.1
Shin-Kobe	340.5	20.3	1972.3.15		Average	18.4	
Nishi-Akashi	354.3	13.8	1972.3.15		Except Avg	21.7	
Himeji	373.6	19.3	1972.3.15	Jouetsu	Dist.1	Dist.2	Open
Aioi	386.1	12.4	1972.3.15	Omiya	19.4	0.0	
Okayama	420.2	34.2	1972.3.15	Kumagaya	42.2	22.7	1982.11.15
Shin-Kurashiki	436.3	16.0	1975.3.10	Honjo-Waseda	55.3	13.1 *	2004.3.13
Fukuyama	455.5	19.3	1975.3.10	Takasaki	67.5	12.2	1982.11.15
Shin-Onomichi	466.3	10.8 *	1988.3.13	Jomo-Kogen	93.5	26.0	1982.11.15
Mihara	472.9	6.5	1975.3.10	Echigo-Yuzawa	113.5	20.1	1982.11.15
Higashi-Hiroshima	492.1	19.2 *	1988.3.13	Urasa	131.9	18.4	1982.11.15
Hiroshima	510.3	18.2	1975.3.10	Nagaoka	152.3	20.4	1982.11.15
Shin-Iwakuni	537.7	27.5	1975.3.10	Tsubame-Sanjo	167.0	14.7	1982.11.15
Tokuyama	561.4	23.7	1975.3.10	Niigata	186.9	19.9	1982.11.15
Shin-Yamaguchi	586.9	25.5	1975.3.10		Average	18.6	
Asa	601.9	15.0 *	1999.3.13		Except Avg	20.9	
Shin-Shimonoseki	616.7	14.8	1975.3.10	Nagano	Dist.1	Dist.2	Open
Kokura	629.6	12.9	1975.3.10	Takasaki	67.5	0.0	
Hakata(Fukuoka)	664.3	34.7	1975.3.10	Annaka-Haruna	79.0	11.5	1997.10.1
	Average	19.1		Karuziawa	93.5	14.5	1997.10.1
	Except Avg	19.9		Sakudaira	104.4	10.9	1997.10.1
				Ueda	119.8	15.4	1997.10.1
				Nagano	140.4	20.6	1997.10.1
					Average	14.6	

Legend: * = Additional Intermediate Stations

Dist.1 = Distance from Tokyo, Dist.2 = Distance from the previous station

Average = Average distance between HSR stations

Except Avg. = Average distance except ADDITIONAL intermediate stations

2.1.2 TGV in France (Since 1981)



Figure 2.4 Geography and Large Cities of France

Source: World Fact Book, the Central Intelligence Agency (CIA)

France is a European country with a population of 60 million and the seventh largest national economy in the world. Paris is the largest European metropolis and the capital of France, with a population of 10 million. The second largest city area is Marseille and the third is Lyon. Most of large cities are riverside or ocean side. Hills divide northern and southern areas. There no steep mountains.

In 1981, the first Train a Grande Vitesse (TGV = Train at High Speed) revenue service began between Paris and Lyon, 255 miles (410 km). The French National Railway Company (SNCF) constructed new dedicated tracks for HSR passenger train and developed exclusive rolling stock. Dedicated tracks for TGV trains used to be called Ligne a Grande Vitesse (LGV). TGV dedicated lines are steeper than conventional railroads and have fewer tight curves. The maximum speed was 168 miles (270km) per hour in 1981, and now is 186 miles (300km) per hour. In urban areas, TGV runs on conventional railroads.

TGV project is a successful project. Ridership has been increasing and SNCF has

expanded its network from Paris to the west, the north and the east.

Table 2.5 TGV Usage

Passengers	1981	1982	1983	1984	1985	1986	1987	1988
Thousands	1,249	5,972	8,962	13,325	14,734	15,231	16,540	17,297
per year	8%	41%	61%	90%	100%	103%	112%	117%
per day	3,422	16,362	24,553	36,507	40,367	41,729	45,315	47,389

Source: Roth, Daniel L., "The TGV System: A Technical, Commercial, Financial, and Socio-Economic Renaissance of the Rail Mode." 1990, Index: 1985 = 100%



Figure 2.5 TGV Dedicated Line Network Expansion

Source: TGV web, Clem Tillier, <http://www.railfaneurope.net/tgv/jpg/tgvgeomap.jpg>

The first TGV line, southeast bound to Lyon, reached to the Mediterranean coast area including Marseille in 2001. The second, westbound TGV line was the Atlantic line and reached the Tours area in 1990. The third, northbound TGV line was an access to London, England via Eurotunnel (Channel Tunnel), and opened in 1993. The fourth, eastbound line is under construction and will reach Germany. In addition to these outbound lines from Paris, SNCF constructed connecting lines between the southeast bound and northbound lines. Figure 2.7 shows the location and stations of the connecting line.

The prototype TGV train unit passenger capacity is smaller than that of Shinkansen. One TGV train unit consists of two locomotives on each end and eight intermediate passenger cars. Passenger capacity is 386 (including 108 first class seats) and coupling of two units is possible. SNCF developed all double deck TGV, Dulpex type, which was for long distance intercity travel and not for commuting. Most cars' seats are reserved, but some have non-reserved seats.

In addition to its domestic network expansion, TGV based rolling stock have been imported to other countries, such as Channel tunnel (Eurostar), Belgium & Holland (Thalys), Spain (AVE), the US (Acela) and Korea (KTX). Recent maximum speed is 186 miles (300km) per hour and the highest in the world.

Comparing with Shinkansen, TGV dedicated lines has small numbers of stations, and average distance between these is long. Figure 2.6 shows that the first southeast bound station Montchanin was 191 miles (305 km) away from Paris, and HSR commuting is not possible with this configuration. TGV lines are primarily for long-distance intercity transportation.

However, TGV lines have potential for building new stations with relatively small expense; because TGV dedicated lines have small numbers of tunnels, and run on flat land in a large portion. As these lines are only for passenger trains, which have lower loads than freight trains, and allow relatively steeper slopes, each line has only a few tunnels. The first TGV

southeast line had no tunnels. The second TGV Atlantic line had only four tunnels, three of which were for noise reduction and the other was to protect vineyards. Comparing with Shinkansen, TGV had a small portion of tunnels.

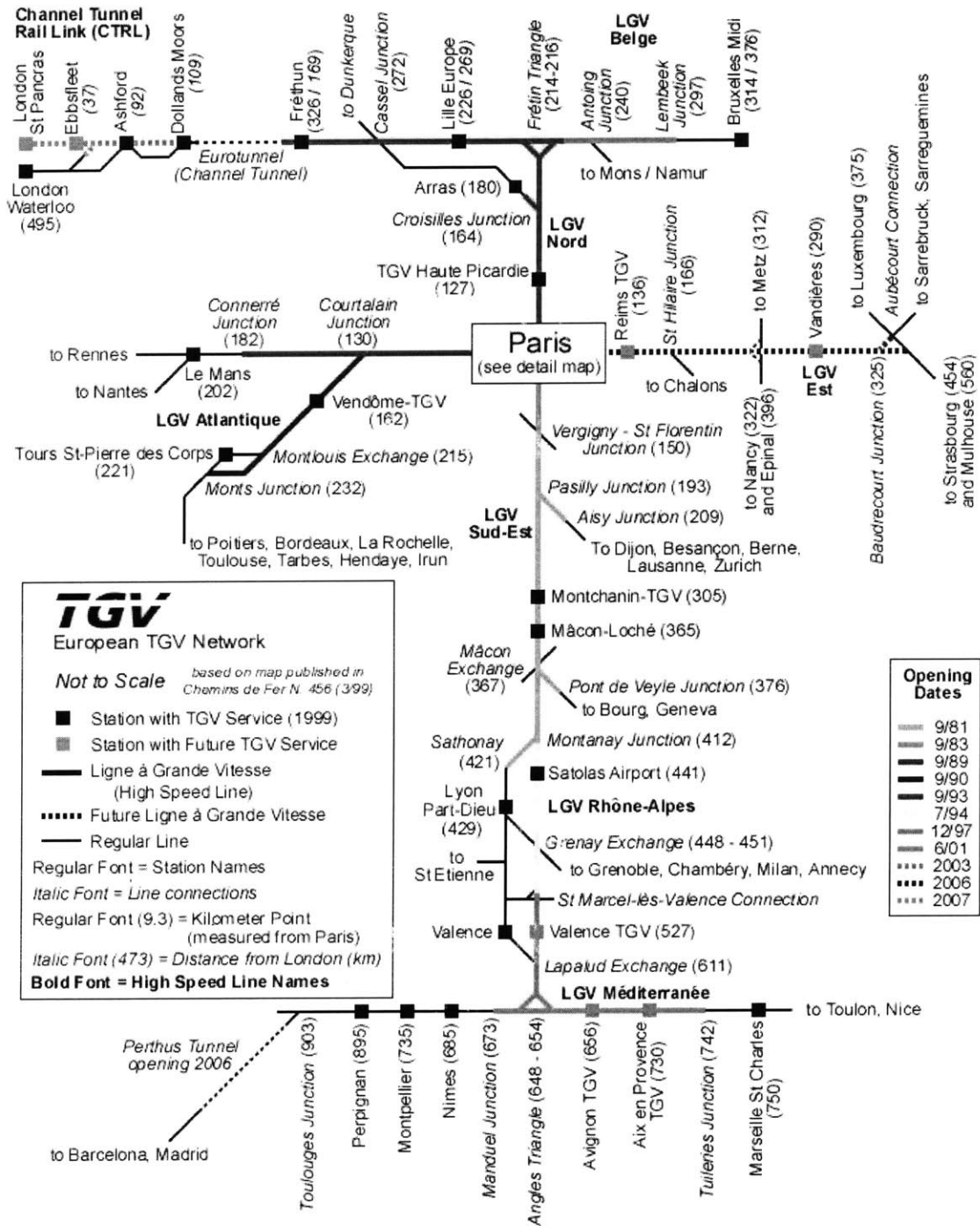


Figure 2.6 TGV Stations (Nationwide Excluding Paris area)

Source: TGV web, Clem Tillier, <http://www.railfaneurope.net/tgv/jpg/tgvgeomap.jpg>
 Numbers in parentheses are distance from Paris by km.

TGV

Paris Area Line Map
Not to Scale

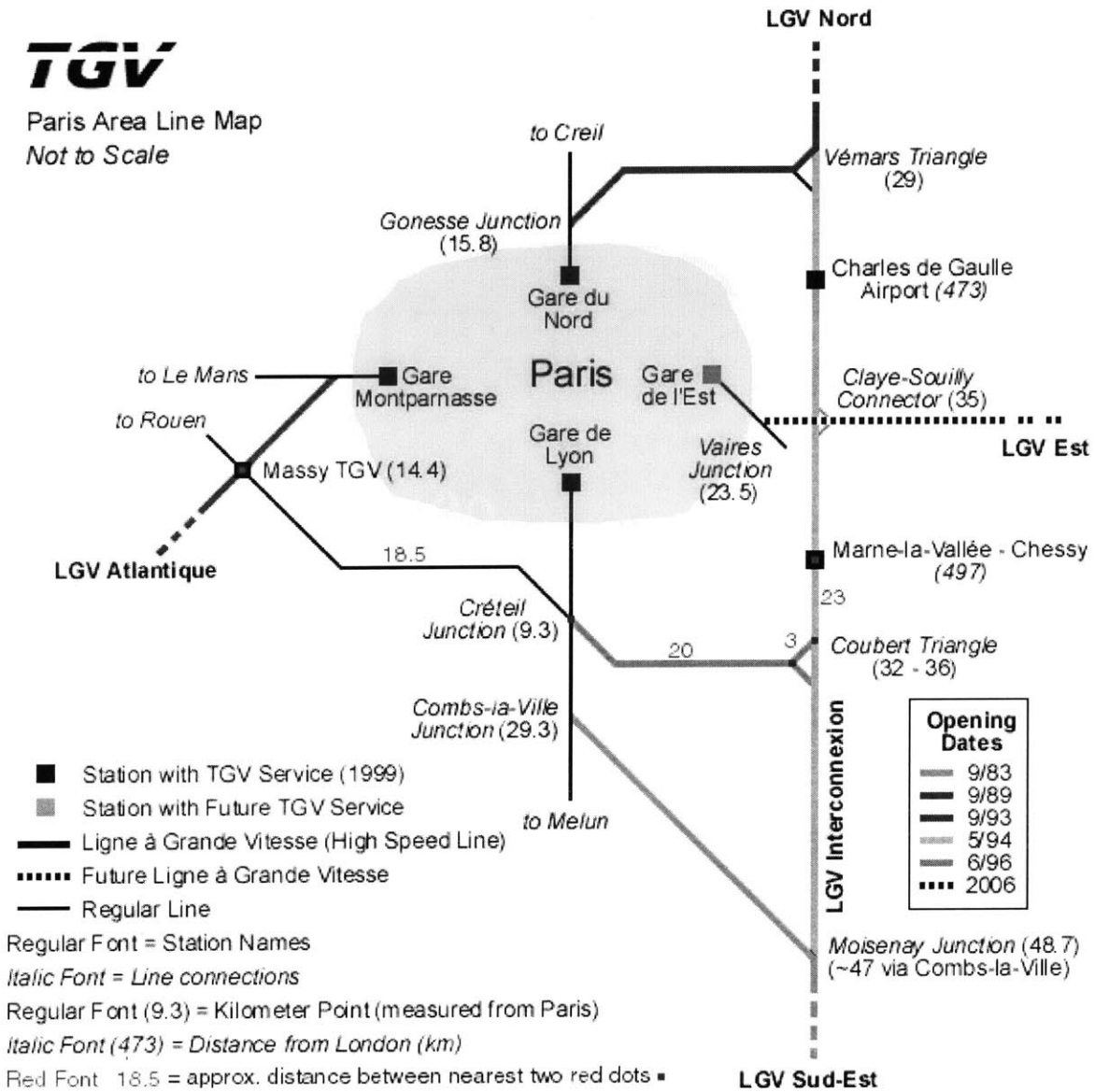


Figure 2.7 TGV stations (Paris area)

Source: TGV web, Clem Tillier, <http://www.railfaneurope.net/tgv/jpg/tgvgeomap.jpg>

Numbers in parentheses are distance from Paris by km.

2.1.3 ICE in Germany (Since 1991)



Figure 2.8 Geography and Large Cities of Germany
Source: World Fact Book, the Central Intelligence Agency (CIA)

Germany is a European country to the east of France with a population of 80 million and the fifth largest national economy in the world⁷. The country had been separated, west and east, in the Cold War period, and the western area is more developed than the eastern. The northern part is low level plain and the southern part is mountain district. The southern border to Austria and Switzerland is steep Alps Mountains.

Comparing with Japan and France, Germany has fewer large cities. The capital and largest city is Berlin with a population of over three million. However, as Berlin was in the east part during the Cold War, railroads between Berlin and other developed western cities are now under improvement. The second largest city is Hamburg with a population of 1.7 million and the third is Munich with 1.2 million. Frankfurt am Main is small, but has the nation's largest hub airport and is the center of EU economy with central bank. The Hamburg, Frankfurt and Munich line is the backbone of national transportation. In addition, there are many relatively

⁷ Ibid.4.

large cities on Rhine riverside, served by this line.

ICE-Netz 2004

Gültig vom 14.12.2003 bis 11.12.2004



DB Fernverkehr AG

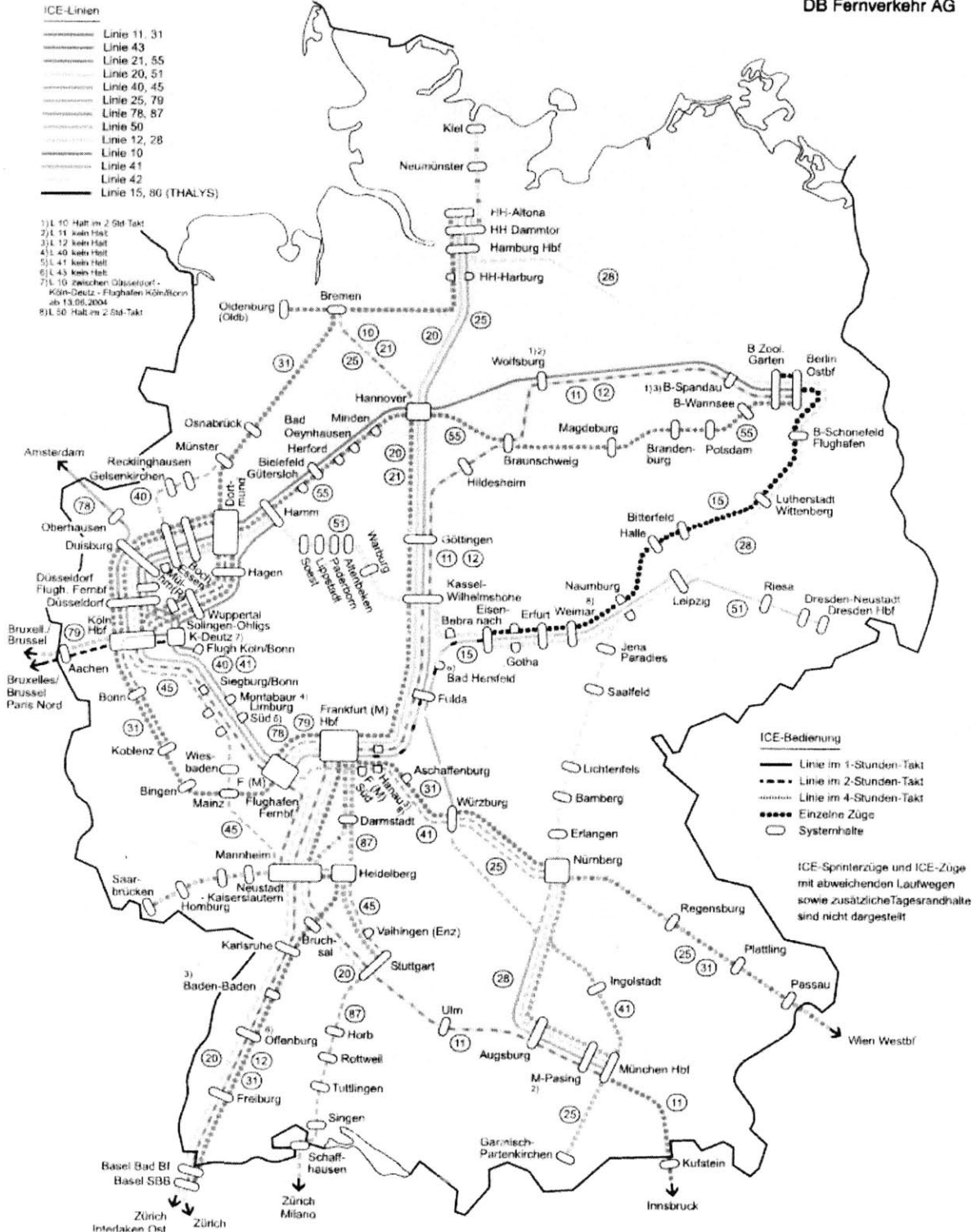


Figure 2.9 ICE Network in 2004 Source: DB homepage

In 1991, the first dedicated tracks for HSR were completed between Hannover and Wurzburg (near Nurnberg) and between Nurnberg and Augsburg. The Germany national railway company “Deutsch Bahn (DB)” started revenue service with ICE (Inter City Express) rolling stock on these tracks.

The prototype ICE, ICE 1 consists of 14 cars including two locomotives and one dining car. Passenger capacity is 645, including 144 first class seats. Maximum operation speed is 174 miles (280km) per hour on dedicated railways and 124 miles (200km) per hour on conventional tracks. All seats required reservation.

Construction of HSR dedicated lines started in 1985. The proposed network was 2,500 miles (4,000 km) and 2400 million dollars. As German HSR dedicated lines were for both passenger and freight trains with heavy loads, the slopes were relatively less steep, and the lines had many tunnels. For example, 36% of Hannover-Wurzburg line and 30% of Mannheim-Stuttgart line are in tunnels. Main rail structure consisted of ballast. For safety, freight trains run only at midnight to separate its operation from passenger trains.

From the network map of ICE (Figure 2.9), each large city area has only central stations in downtown. It is hard to commute by HSR to suburban area. In the future, considering the city’s population size, the Berlin area has significant potential for HSR commuting after renovation.

2.1.4 Korean Train Express⁸

Korea has HSR commuting perspective. Korean Train Express (KTX) started its revenue services in April 2004 between Seoul, the capital and largest city with over ten million people, and Pusan, the second largest city. In the Seoul metropolitan area, the KTX authority sells HSR commuting passes and attempts to provide HSR commuting services. With less than

⁸ Source: Korean Train Express Website <http://ktx.korail.go.kr>

one year since its start, more time is needed before the initiative can be evaluated.

KTX adopted French TGV based HSR technology. One KTX train unit consists of two locomotives on each end and 18 intermediate passenger cars. Total capacity is 935 seats including 127 first class seats. Maximum speed was 186 miles (300 km) per hour. The number of intermediate stations is relatively small and only three intermediate stations between Seoul and Daejeon.



Figure 2.10 KTX Route Map

area, Los Angeles is the largest city with the population of about 9,870,000⁹. Both San Francisco and San Diego have population of over one million.

Table 2.6 Top 10 most populated States in the US

Source: US Census 2000

					Area (sq miles)	Density (sq miles) in land	
		Population	Housing Units	Total Area	Land Area	Population	Housing Units
	U.S.A.	281,421,906	115,904,641	3,794,083.06	3,537,438.44	79.6	32.8
1	California	33,871,648	12,214,549	163,695.57	155,959.34	217.2	78.3
2	Texas	20,851,820	8,157,575	268,580.82	261,797.12	79.6	31.2
3	New York	18,976,457	7,679,307	54,556.00	47,213.79	401.9	162.6
4	Florida	15,982,378	7,302,947	65,754.59	53,926.82	296.4	135.4
5	Illinois	12,419,293	4,885,615	57,914.38	55,583.58	223.4	87.9
6	Pennsylvania	12,281,054	5,249,750	46,055.24	44,816.61	274	117.1
7	Ohio	11,353,140	4,783,051	44,824.90	40,948.38	277.3	116.8
8	Michigan	9,938,444	4,234,279	96,716.11	56,803.82	175	74.5
9	New Jersey	8,414,350	3,310,275	8,721.30	7,417.34	1,134.40	446.3
10	Georgia	8,186,453	3,281,737	59,424.77	57,906.14	141.4	56.7

Source: <http://factfinder.census.gov>

In the US, there are no dedicated lines for HSR passenger trains. Even along the busiest corridors, the NEC or Empire corridor, high-speed trains run on conventional railroads and are thus incremental high-speed trains. Only in the NEC, does Amtrak own the track.

2.2.1 The NEC and Acela Express

The NEC is an HSR intercity transportation potential area including Boston, New York and Washington D.C. Distances between the large cities are intermediate. Therefore, there is potential for HSR intercity transportation. Amtrak owns most of the NEC tracks and has operated French TGV-based rolling stock Acela Express trains since 2000.

The trial runs for operating HSR between New York and Washington D.C. started in 1966. Metro Liner rolling stock started revenue operation in 1969, and Amtrak continued this project from 1971. But those were very slow service.

⁹ Source: U.S. Census Bureau <http://quickfacts.census.gov/qfd/states>

An Acela train has 304 seats including 44 first class seats, similar to TGV. The train consists of eight cars, including two locomotives and one snack car. The maximum operating speed is 150 miles (241km) per hour. However, interference with conventional trains keeps the travel time long. According to the schedule for winter 2005, Amtrak operates 11 trains between Boston and New York and 15 trains (almost every hour) between New York and Washington D.C on weekdays. The fastest train runs between Boston and New York (231miles=372km) in three hours and twenty minutes, and between New York and Washington D.C. (226miles=364km) in two hours and forty-seven minutes. Considering the time for airport access and check-in time, Acela Express trip hours could be competitive over airlines for intercity trips.

Acela Express requires seat reservations, but seats are not assigned. Acela stops at several stations in large cities, but is not for commuting. No commuting passes are provided, and one-way tickets are expensive. Table 2.7 shows the comparison of intercity and commuting fares from Boston to Providence. Acela Express is faster, but the travel time is more than half of those of regional trains. However, the fare of Acela Express is almost twice of that of regional trains, and four to five times of that of commuter rails.

Table 2.7 Intercity and Commuting Fares from Boston to Providence

Operator	Train	Time Arrival and Departure are based on Boston South station	Peak Fare	Shoulder Fare	Off- Peak fare
Amtrak	Acela Express	0:39(no.2190 9:50am arrives) 0:34(no.2175 5:20pm departs)	\$32	\$30	\$26
	Regional	0:45(no.66 8:15am arrives) 0:41(no.177 5:35pm departs)	\$16	N/A	\$13
Massachusetts Bay Transportation Authority(MBTA)	Commuter Rail	1:04(no.806 8:12am arrives)	\$6	\$6	\$6

Source: Amtrak Time Table Fall04-Winter05, MBTA web site Boston-Providence: 43 miles

2.2.2 Empire Corridor

The Empire Corridor is the second busiest corridor in the northeast area. The corridor is from New York to Buffalo and Niagara Falls via Albany. The corridor is owned by Amtrak (New

York – Yonkers: 14 miles), Metro North Railroad (MNRR: Yonkers – Poughkeepsie: 59 miles), CSX (Poughkeepsie – Albany - Niagara Falls: 387 miles) and Canadian National (CN: Niagara Falls – Toronto 82 miles). From New York to Albany (141 miles), passenger trains run in trip of two and half hours almost every hour. The average speed is 55 mph. CSX has two lines along the Hudson River and the Empire Corridor is on the east shore of the Hudson River. As a freight company, CSX's main line is on the west side of the Hudson River, the Empire Corridor is for passengers, therefore, the freight and passenger lines do not cross each other.

2.2.3 California High-Speed Rail (CAHSR)

California is the largest state in the US in terms of population with 33 million people. It has some large cities, such as Los Angeles and San Francisco within intermediate distances. From the 1990s, the State of California has been working on the HSR passenger transportation project. The referendum for the State's initial expense for HSR construction has been postponed from 2004 to 2008. As the project is the most practical and feasible in the US, we will pick it up as a case for HSR commuting in the US. In Chapter Four, we will examine and discuss the California HSR project in detail.

2.2.4 Texas TGV¹⁰

Texas has the second largest population in the US, with 21 million people. The Texas TGV project will connect three “triangle” large city areas, Fort Worth, San Antonio and Houston, with TGV based rolling stock. The first step is to connect Dallas& Fort Worth and Houston (about 240 miles as the crow flies).

It seems relatively easy to construct HSR dedicated lines on Texas flat field. Expensive tunnels are unnecessary, and land is cheap. Moreover, Texas has a strong political connection

¹⁰ Primary source of this section is “A High-Speed Rail Revolution in the US? Lessons from the French and The Texas TGV”, Hellen NG, MIT Thesis, 1995.

with the federal capital. Some presidents including the current president George W. Bush have come from Texas. However, the project stopped on August 19, 1994 due to financial feasibility problems, and strong opposition from the airlines, especially Southwest.

The project started by the initiative of a West German consortium in 1985. The Texas Turnpike Authority (TTA)'s study of February 15, 1989, which referred to the construction of HSR in Texas, motivated the Texas Legislature. The Legislature established a state institute, the Texas High Speed Rail Authority, in spring 1989.

Two private companies submitted franchising applications at the authority's request for bids. The German ICE-based company

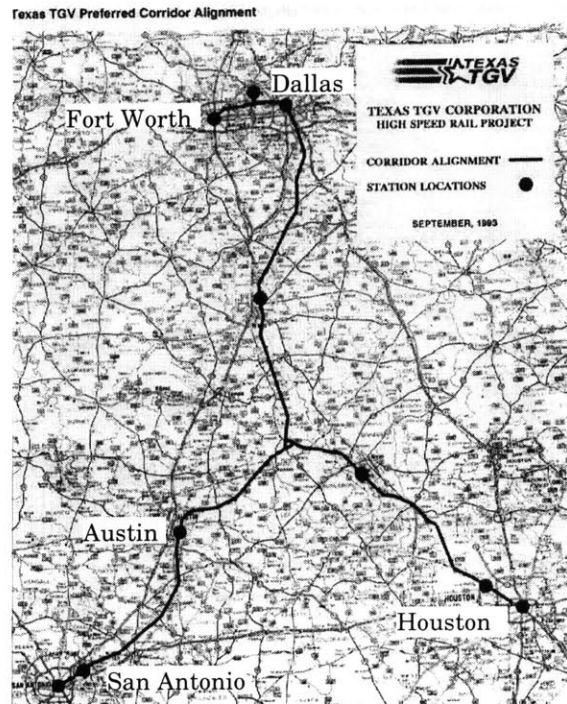


Figure 2.12 Texas TGV, September 1993

proposed private/public partner financing and a \$6.7 billion project cost. The French TGV-based company proposed full private financing and a \$5.7 billion project cost. Both companies similarly asked the authority for some subsidies, but the State HSR Act of 1989 clearly forbids subsidizing. Without the state funding, the project could not receive federal subsidies. The latter had asked the authority to issue bonds for funding rights-of-way and infrastructures, but just before the deadline, it decided on full private financing. The authority accepted two proposals in January 1991, and the TGV based company won the 50-year franchise on May 28, 1991.

The TGV-based company had to fund \$170 million for the authority's operations by the end of 1992. The authority extended the deadline for another year, but the following year, the company failed to fund and the project failed.

The primary project purpose of Texas TGV is intercity travel. Therefore, from the Houston area to the Dallas area, there are only two intermediate stations in the current design.

The average distance between intermediate stations is over 80 miles.

2.2.5 Florida High Speed Rail

Florida is the fourth largest state in the US with a population of 16 million. Florida has some large cities and tourist attractions, such as Disney Land and Key West. As the climate in Florida is mild, tourists visit the State all year round. The State has been planning HSR networks. The State established the HSR authority in 2002. Figure 2.13 shows HSR expected corridors in Florida. The first phase defined by the authority establishing law is from Tampa to Orlando (about 80 miles). The authority requested a project proposal in October 2002, and four parties submitted HSR proposals in February 2003. After the review, the authority put the Fluor Bombardier (FB) proposal first and the Global Rail Consortium (GRC) proposal second at the October 2003 board meeting. Fluor is a construction company, and Bombardier is a train-manufacturing company. The estimated cost by these two parties is about \$2.4 billion.

However, the project stopped in November 2004. The State referendum in 2000 once approved the HSR project, but the 2004 referendum disapproved the former approval.

The primary purpose of Florida HSR is also for intercity travel.

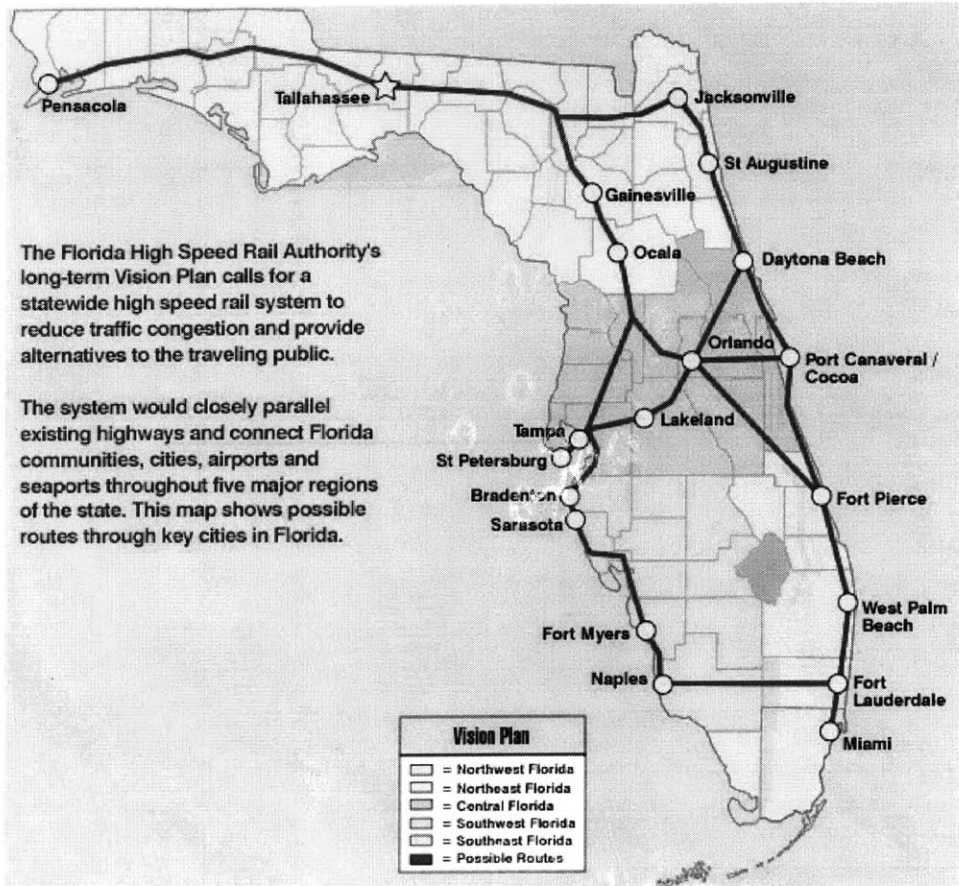


Figure 2.13 Florida High Speed Rail Authority's long-term Vision Plan
 Source: Florida High Speed Rail Authority

2.3 General HSR Strategy

In most parts of the world, the primary purpose of successful HSRs is to provide intercity transportation. In the US, all high-speed rail projects intend to provide inter city passenger transportation. Currently only the Japanese Shinkansen provides HSR commuting, while KTX is developing HSR commuting.

So far, there are a lot of HSR project plans at international standard in the US. However, no one come to the construction stage.

In order to introduce the concept of HSR commuting to the US, an examination of practical HSR commuting cases in detail is necessary. In the next chapter, therefore we will examine the Japanese HSR commuting.

Chapter 3 Introduction to HSR Commuting: the Japanese Case

In this chapter, we examine the case of HSR commuting in Japan as a benchmark for HSR commuting in the US. We also discuss the main features of HSR commuting. Currently, there are two HSR commuting services available in the Tokyo Metropolitan area: one from the north to the center of the city, operated by East Japan Railway Company, and the other from the south to the center, operated by Central Japan Railway Company. We will primarily examine the HSR commuting from the north.

3.1 HSR commuting in Japan

3.1.1 Service Area and Passenger Benefits

The HSR commuting service in Japan normally covers an area within 200 miles of large cities. For example, there are three Shinkansen; Touhoku-Shinkansen, Jouetsu-Shinkansen, and Nagano-Shinkansen from the north. The farthest distances from Tokyo for which commuters can buy their monthly passes are Fukushima (Touhoku-Shinkansen, 169.5miles from Tokyo), Tsubame–Sanjo (Jouetsu-Shinkansen, 182.6miles), Nagano (Nagano-Shinkansen, 138.2miles.)

Most of the HSR commuters are from large cities, such as Utsunomiya and Takasaki cities. Utsunomiya-city area has a population of 443,000, while Takasaki-city area, which includes the nearby Maebashi-city area, has 525,000¹¹.

¹¹ Nihon Kokusei Zue

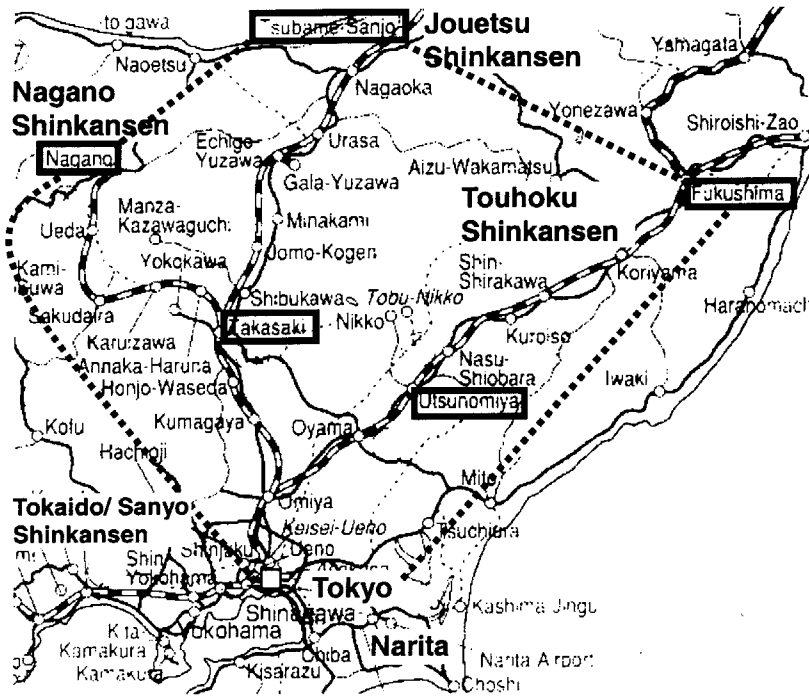


Figure 3.1 HSR Commuting Area in northern Tokyo

Legend: **-----** HSR (Shinkansen) **————** Conventional Rails

In Japan, HSR commuting services are also available in areas other than the Tokyo Metropolitan area. For example, in the North Kyushu area, six trains run only 42 miles between Kokura (Kitakyushu-city) and Hakata (Fukuoka-city,) without stopping at any intermediate stations from 6:30 AM to 9:00 AM on weekdays. Combined with long distance trains, twelve HSR trains run within this section during those hours.

Conventional railroads and highways run parallel with all Shinkansen lines. In the case of Tohoku-Shinkansen case, almost the same number of conventional commuter trains run at peak hours as HSR trains. Table 3.1 shows commuting times and fares by HSR and alternative modes. As expected, commuting by HSR results in shorter travel times. The conventional commuter trains are less expensive than HSR, but these take twice as long as or longer than Shinkansen. Compared with trains, a small number of highway buses are available, but these are not a common way for commuting. Meanwhile, expensive highway tolls and parking fees reduce the incentives to drive automobiles.

Table 3.1 Alternative Modes to HSR Commuting in the Northern Tokyo Area

Time, Frequency, One Way Fare, Monthly Pass Fare	HSR Shinkansen	Conventional Rail	Highway Bus	Highway Toll (Autos)
From Utsunomiya to Ueno (65.8miles;105.9km), Ikebukuro or Shinjyuku	0:49 5 \$39(¥4,100) \$954(¥99,210)	1:56 6 \$18(¥1,890) \$488(¥50,700)	2:35(To Shinjyuku) 1(Arrival at 8:50) \$19(¥2,000) N/A	\$35(¥3,650)
From Takasaki to Ueno (63.0miles;101.4km) or Ikebukuro	0:53 8 \$39(¥4,100) \$951(¥98,890)	1:53 7 \$18(¥1,890) \$478(¥49,760)	2:05(To Ikebukuro) 1(Arrival at 8:40) \$18(¥1,900) N/A	\$37(¥3,800)

Source: JR Time Table, December, 2004 Ikebukuro and Shinjyuku is other Tokyo Terminal \$1=¥104 during most peak period, arriving at terminals from 7:30 am to 8:30am

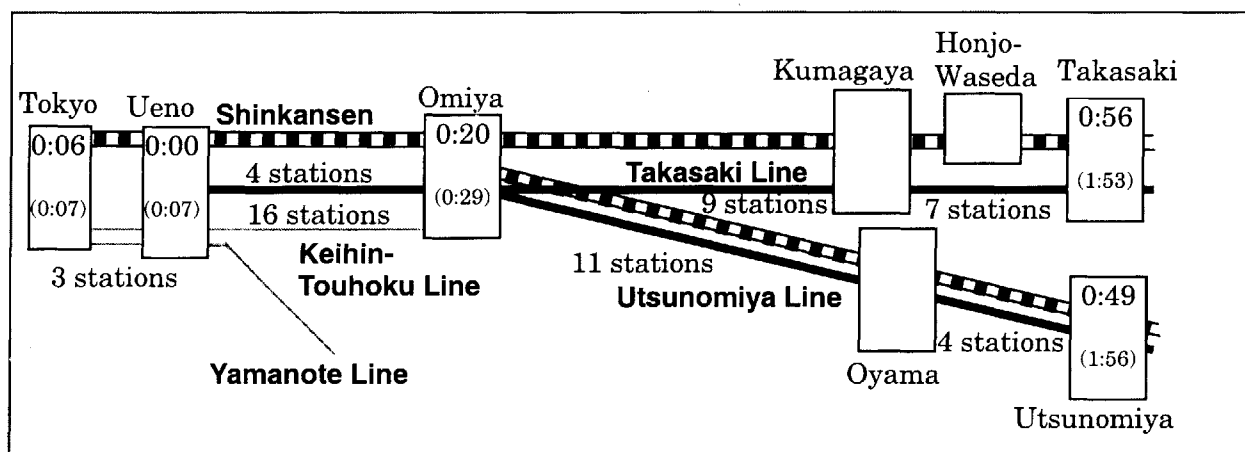


Figure 3.2 HSR and Conventional Rail Station Map

Legend: **-----** HSR (Shinkansen)
———— Conventional Intercity Rails **————** Conventional Regional Rails
 All single lines indicate double tracks.

By HSR commuting, passengers enjoy shorter commuting time. For example, from Utsunomiya to Ueno, conventional trains take almost 2 hours with 21 intermediate stops. Meanwhile, HSR trains take only 49 minutes with at most two intermediate stops. The numbers of each HSR trains and conventional trains are almost same and enough.

However, HSR fare is expensive. While conventional rail one month pass is \$488 from Utsunomiya to Ueno, HSR one month pass for the same route is \$954. HSR commuting takes half the time, but the fare is almost double. Table 3.2 shows revenue per passenger miles by

modes and areas. In FY2004, Shinkansen passengers with commuter passes paid an average of 0.21 dollars per mile ride. Conventional passengers in Tokyo area with commuter passes paid an average of 0.10 dollars per mile ride.

In Japan, usually employers pay the commuting expense of employees. For employers, this expense is tax-exempt within ¥100,000 (about \$962). Many employers pay HSR commuting expense for employees as long as HSR commuting is effective for reducing commuting time.

Table 3.2 Revenue per Passenger Miles

FY2004.3		M dollars	M miles	RPM
Shinkansen	Commuter Passes	206	974	0.21
	Other	4,274	10,675	0.40
	Subtotal	4,481	11,649	0.38
Conventional (Tokyo Area)	Commuter Passes	3,300	32,064	0.10
	Other	4,849	15,609	0.31
	Subtotal	8,150	47,673	0.17
Conventional (Other Area)	Commuter Passes	1,134	11,790	0.10
	Other	2,257	7,025	0.32
	Subtotal	3,391	18,816	0.18
Total	Commuter Passes	4,641	44,828	0.10
	Other	11,382	33,310	0.34
	All	16,023	78,139	0.21

Source: East Japan Railway Company Website, Fact Sheet \$1=¥104

Table 3.3 shows ridership of both HSR and conventional rail lines between Utsunomiya and Tokyo, and between Takasaki and Omiya. The Utsunomiya Line is a conventional rail connecting Utsunomiya and Ueno, parallel with Touhoku Shinkansen. A total of about 80,000 passengers takes inbound trains from Utsunomiya and outbound trains to Utsunomiya. Takasaki Line is a conventional line connecting Takasaki and Ueno, parallel with Jouetsu Shinkansen. A total of about 62,000 passengers takes inbound trains from Takasaki and outbound trains to Takasaki.

Table 3.3 Ridership of HSR and Conventional Rail Lines

Miles from Tokyo		HSR	Conventional Total			Conventional Intercity Only		
		Total	Commuters	Others	Total	Commuters	Others	Total
Touhoku Shinkansen (HSR), Utunomiya Line (Conventional)								
68.0	Utsunomiya	52,100	21,356	57,898	79,254	21,356	57,898	79,254
50.1	Oyama	52,100	26,621	65,225	91,846	26,621	65,225	91,846
35.5	Kurihashi	52,100	62,477	72,809	135,286	62,477	72,809	135,286
30.4	Kuki	52,100	120,851	87,260	208,111	120,851	87,260	208,111
18.8	Omiya	52,100	224,076	112,698	336,774	224,076	112,698	336,774
18.8	Omiya		653,092	284,890	937,982	386,793	118,334	505,127
8.2	Akabane		553,779	248,788	802,567	376,447	85,047	461,494
2.2	Ueno		858,658	498,419	1,357,077	203,168	90,899	294,067
0.0	Tokyo		677,716	363,663	1,041,379			0

Jouetsu Shinkansen (HSR), Takasaki Line (Conventional)								
65.2	Takasaki	42,900	11,560	50,350	61,910	11,560	50,350	61,910
53.4	Honjo	42,900	26,581	55,921	82,502	26,581	55,921	82,502
40.2	Kumagaya	42,900	68,201	74,257	142,458	68,201	74,257	142,458
31.3	Konosu	42,900	117,051	85,846	202,897	117,051	85,846	202,897
18.8	Omiya	42,900	255,207	122,304	377,511	255,207	122,304	377,511

Source: Toshi Koutsu Nenpo 2000 (Annual Urban Transportation Report)

Figure 3.3 and 3.4 shows daily rail passenger numbers and the distance from Tokyo. All lines are electrified, and have more than double tracks. Between Utsunomiya and Omiya, and between Takasaki and Omiya, both lines have double tracks. From Omiya to Tokyo, local conventional trains run on Keihin-Touhoku Line with more intermediate stops than intercity conventional trains from Utsunomiya and Takasaki. Because there is no intercity track between Ueno and Tokyo, Ueno is the terminal for intercity trains. Between Ueno and Tokyo, only regional transit train runs, such as Yamanote Line and Keihin-Touhoku Line.

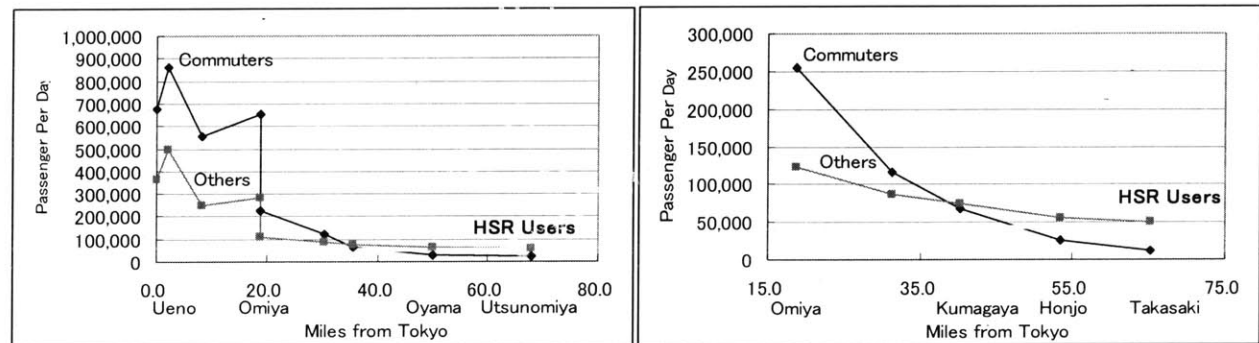


Figure 3.3 The Number of Passengers

Figure 3.4 The Number of Passengers (Touhoku Lines)

(Jouetsu Lines)

Source: Toshi Koutsu Nenpo 2000(Annual Urban Transportation Report)

Table 3.4 shows the number of peak hour passengers at weekday morning rush hours. About 46,000 commuters take inbound Utsunomiya line trains to Omiya, and about 51,000 commuters take inbound Takasaki Line trains to Omiya. HSR commuters are about 11% of conventional commuter rail commuters.

Table 3.4 Peak Hour Trains and Passengers Traffic

	Line	From	To	Cars	Trains	Interval	Traffic	Per Capacity
HSR	Touhoku Shinkansen	Utsunomiya	Omiya	10-16	6	10:00	5,000 (11%)	75%
	Utunomiya Line	Toro	Omiya	15	13	4:30	46,195 (100%)	167%
HSR	Jouetsu Shinkansen	Takasaki	Omiya	8-16	7	8:30	5,500 (11%)	85%
	Takasaki Line	Miyahara	Omiya	15	13	4:30	51,400 (100%)	190%
(Local)	Yamanote Line	Ueno	Okachimachi	11	24	2:30	85,300	223%
(Local)	Keihin Tohoku Line	Ueno	Okachimachi	10	24	2:30	75,500	225%

Source: East Japan Railway Company, Fact Sheet, 2003 & Hearing

All peaks are weekday morning. The number of trains is per hour.

The percentage of HSR traffic is based on paralleling conventional intercity rail traffics.

Table 3.5 shows operating revenue and expenses of both HSR and conventional rail in East Japan Railway Company. HSR unit operating revenue is over twice of the conventional rail unit operating revenue, but unit operating expense is not so different.

Table 3.5 Operating Revenue and Expense (HSR and Conventional Rail) in the East Japan Railway Company

	HSR	Conventional	All
Date	2004.3	2004.3	2004.3
Passenger Line Network (miles)	654	4,022	4,676
Passenger miles (thousands)	11,649	66,490	78,139
Operating Revenue (\$millions)	4,579	12,769	17,347
Operating Expense (\$millions)	2,818	11,839	14,657
Operating Income (\$millions)	1,760	930	2,690
Unit Operating Revenue (\$/mile)	0.39	0.19	0.22
Unit Operating Expense (\$/mile)	0.24	0.18	0.19
Unit Operating Income (\$/mile)	0.15	0.01	0.03

Source: East Japan Railway Company, First Half of FY2005.3 Investors' Guide, Appendix November 17, 2004

As HSR commuters in Japan are former conventional rail commuters, if there are no HSR commuting, current HSR commuters would use conventional rails. Table 3.6 shows the

comparison of cost and revenue between HSR and conventional commuting rail with the assumption of same number and distance commuters. In the Japanese case, as HSR fare is almost twice conventional rail fare and HSR unit cost is almost same as the conventional rail unit cost, HSR commuting is profitable for the operator. If there were no HSR commuting, the income of the operator would be 43 million dollars lower in a year. In addition, a large amount of passengers add to crowding of conventional trains.

Table 3.6 Comparison of Cost and Revenue between HSR and Conventional Rail Commuting in the East Japan Railway Company

	HSR	Conventional	Difference
Cost Daily (\$thousands)	290	214	77
Cost Yearly (\$millions)	76	56	20
Revenue Daily (\$thousands)	472	230	241
Revenue Yearly (\$millions)	123	60	63
Income Daily (\$thousands)	181	17	165
Income Yearly (\$millions)	47	4	43

Assumption: Touhoku Shinkansen from Utsunomiya to Tokyo,
 The number of passenger: 10,000
 Commuting distance: 60 miles One Year: 261 week days
 Unit Costs and revenues are based on Table 3.6

3.1.2 Schedules

A large number of short distance HSR commuting trains with many cars run every weekday morning. Table 3.7 shows that HSR commuting trains arrive at Tokyo Terminal almost every 4 minutes from 7:20 AM to 9:00 AM. The first train, Nasuno 228, departs Oyama station on the Touhoku-Shinkansen Line, which is 50.1 miles from Tokyo at 6:21, makes brief stops at Omiya and Ueno, and arrives at Tokyo terminal at 7:04. This train consists of 10 cars, and all cars except first class cars have non-reserved seats. The next train arriving at Tokyo terminal is Tanigawa 470. This train departs Takasaki station on the Jouetsu-Shinkansen Line at 6:17, makes brief stops at Honjo-Waseda, Kumagaya, Omiya and Ueno, and arrives at Tokyo terminal at 7:20. This train returns as Tanigawa 471 to Takasaki station at 7:32. Some trains pass intermediate stations. Asama 500 departs Nagano station on Nagano-Shinkansen Line at 6:00.

After a brief stop at Takasaki station at 6:47, the train passes Honjo-Waseda and Kumagaya stations. Then, after brief stops at Omiya and Ueno station, the train arrives at Tokyo terminal at 7:40. This train consists of eight cars and some fraction of seats are reserved. The train returns as Asama 553 to Nagano station at 7:52.

Most trains consist of over 10 cars and sometimes as many as 17 cars. Most commuting trains run shorter distances than intercity ones, and the originating stations of HSR commuting trains are less than 150 miles from Tokyo Terminal. For example, the most popular HSR commuter train origin of Touhoku-Shinkansen is Nasu-Shiobara (98.1miles.) Compared with intercity trains from Sendai (Touhoku-Shinkansen, 218.6miles), commuting trains run only short distances.

Distribution of limited seat capacity is necessary, because not all trains have enough seats. Even in peak hours, trains do not stop at all stations. Long distance trains with limited seat capacity pass several stations in metropolitan areas. The names of these express trains are different from regional trains that stop at all stations. For example, Asama 500 and Asama 502, both of which consist of only eight cars, pass two stations.

There are no schedule conflicts between commuting and intercity HSR trains. Commuting HSR trains arrive in Tokyo before the first intercity super-express HSR train. Super-express trains, which connect major cities without intermediate stops, such as Asahi 2 and Hayate 2, arrive at Tokyo station at 9:19 AM and 9:51 AM respectively. In addition, all cars of Hayate trains have only reserved seats. Passengers have to purchase reserved seat express tickets before the ride.

Some trains consist of double deck trains. For example, part of Nasuno 230 rolling stock, arriving at Tokyo terminal at 7:24, is double deck trains, and all rolling stock of Max Tanigawa 430 are double deck trains.

Table 3.7 Touhoku / Jouetsu / Nagano Shinkansen Morning Commuting Train Schedule

Line & Station	TrainID Miles	N	Ta	N	N	Mta	A	N	Mta	N	A	N	Mto	N	Mta
		228	470	230	232	430	500	234	472	236	570	238	300	240	474
TO Morioka	332.6														
TO Sendai	218.6														
TO Fukushima	169.5														
TO Koriyama	140.9										6:16				
TO Nasu-Shiobara	98.1			6:08	6:20			6:32		6:43		6:51		7:03	
TO Utsunomiya	68.0			6:25	6:36			6:48		7:00		7:07		7:19	
TO Oyama	50.1	6:21		6:38	6:48			7:00		7:12		7:20		7:32	
JO Nigata	207.5													6:02	
JO Echigo-Yuzawa	123.8					6:02							L		
NA Nagano	138.2						6:00								
JO Takasaki	65.2		6:17			6:33	6:47		6:51		7:00		7:13		7:17
JO Honjo-Waseda	53.4		6:28			6:44	L		7:02		7:10		L		7:28
JO Kumagaya	40.2		6:38			6:54	L		7:12		7:20		7:30		7:38
ALL Omiya	18.8	6:38	6:54	6:58	7:06	7:10	7:14	7:18	7:26	7:30	7:34	7:38	7:46	7:50	7:54
ALL Ueno	2.2	6:58	7:14	7:18	7:26	7:30	7:34	7:38	7:46	7:50	7:54	7:58	8:06	8:10	8:14
ALL Tokyo	0.0	7:04	7:20	7:24	7:32	7:36	7:40	7:44	7:52	7:56	7:59	8:04	8:12	8:16	8:20
Formation		10	10	P15	10	D12	8	16	D16	16	8	16	D12	16	D16
Reserved Seats		Non	Non	Non	Non	Non		Non	Non	Non	Non	Non	Non	Non	Non
Return As			Ta	MYT	Y	Ta	A	H&K	Ta				Mto	H&K	
Train ID			471	103	153	471	553	3	433				309	5	
Main Destination			TAK	SEN	SEN	TAK	NAG	HAC	ECH				NII	HAC	
Departure			7:32	7:36	7:44	7:48	7:52	7:56	8:04				8:24	8:28	

Line & Station	TrainID Miles	Y	A	Mta	MN	Mto	A	Y	Mto	MY	Ta	A	MYT	Y	H&K	
		152	502	432	242	302	550	154	304	202	476	2	102	42	2	
TO Morioka	332.6														6:00	7:30
TO Sendai	218.6	6:04						6:35		6:49			7:08	7:21	8:15	
TO Fukushima	169.5	6:34						7:01		7:19			7:39	7:47	L	
TO Koriyama	140.9	6:51						7:18		7:35			7:55	8:04	L	
TO Nasu-Shiobara	98.1	L			7:28			7:44		8:01			L	L	L	
TO Utsunomiya	68.0	7:32			7:44			8:00		8:17			8:28	8:37	L	
TO Oyama	50.1	L			7:56			8:12		8:29			8:40		L	
JO Nigata	207.5					6:24			6:51							
JO Echigo-Yuzawa	123.8			7:02		7:18			L							
NA Nagano	138.2		6:37				6:57					7:50				
JO Takasaki	65.2		7:31	7:34		7:46	7:52		8:04		8:15	L				
JO Honjo-Waseda	53.4		L	7:44		L	8:02		L		8:26	L				
JO Kumagaya	40.2		L	7:55		8:02	8:12		8:20		8:36	L				
ALL Omiya	18.8	7:58	8:02	8:10	8:14	8:18	8:26	8:30	8:34	8:46	8:50	8:55	8:57	9:02	L	
ALL Ueno	2.2	8:18	8:22	8:30	8:34	8:38	8:46	8:50	8:54	9:06	9:10	L	9:18	9:22	L	
ALL Tokyo	0.0	8:24	8:28	8:36	8:40	8:44	8:52	8:56	9:00	9:12	9:15	9:19	9:24	9:28	9:51	
Formation		16	8	D16	D16	D12	8	16	D12	D16	10	8	P15	16	16	
Reserved Seats				Non	Non						Non				ALL	
Return As		Y	A	Ta			A	Y		MY		A	MYT			
Train ID		155	503	435			505	81		47		507	107			
Main Destination		SEN	NAG	ECH			NAG	MOR		MOR		NAG	SEN			
Departure		8:44	8:40	8:48			9:12	9:08		9:24		9:32	9:36			

Source: RAILWAY TIMETABLE October, 2004 JR-GROUP

Legend

(Line and Train Destination)

TO= Tohoku-Shinkansen HAC =Hachinohe (393miles), MOR =Morioka (333miles), SEN =Sendai

JO = Jouetsu-Shinkansen NII =Niigata, ECH = Echigo-Yuzawa, TAK =Takasaki

NA = Nagano-Shinkansen NAG = Nagano

(Train ID)

H =Hayate, Y =Yamabiko, N =Nasuno, T=Tsubasa (To Yamagata, Shinjyo, combined with Yamabiko), K=Komachi (To Akita, combined with Hayate) To =Toki, Ta =Tanigawa, A =Asama

M =Max (e.g. Mto =Max Toki, MYT= Max Yamabiko & Tsubasa)

D = All Double Deck Car Units (MAX) P = Partly Double Deck Car Units

(Schedule Columns)

Bold times = Origin and Destination L = Pass

(Seat Reservation Requirement)

Non = All cars are NON-reserved seat cars EXCEPT first class

ALL = All cars are reserved seat cars

Shadow Cells = No commuting pass from Tokyo Station

3.1.3 Sharing of Rolling Stock

All HSR train cars are compatible for both commuting and intercity services, but only for HSR dedicated track use. Even in the Tokyo station, which is the central station and congested all day, HSR trains run only on dedicated tracks. During the morning rush hours, most trains return, not as short-distance commuting trains, but as long-distance intercity trains after a twelve-minute stop at Tokyo Terminal. These minutes include passengers' getting off and on and cleaning up the cabin.

By sharing the same rolling stock both for intercity and commuting services, high quality and safe commuting is achieved. HSR rolling stock are luxurious and provide rapid and comfortable commuting. In addition, HSR operators need neither additional safety investment nor specially trained drivers. Compared with conventional rails in the US, which are a mixed use of freight and passenger trains, a simpler operation is achieved by sharing rolling stock, which prevents mixture of different systems and results in safer services.

3.1.4 Double Deck HSR Trains

To provide enough seats for commuters in peak hours, all double-deck HSRs were developed in Japan. As we mentioned before, Shinkansen commuter trains run every 4 minutes in peak hours and have reached the maximum limit of the track capacity. Table 3.8 shows the specification comparison between the most recent double-deck trains and single deck trains. Series E4 is the most recent all double-deck trains, which are developed primarily to have large passenger capacity.

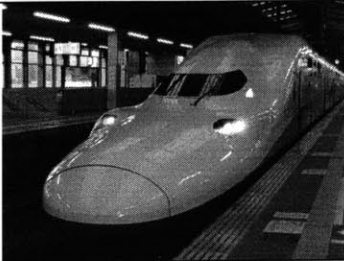
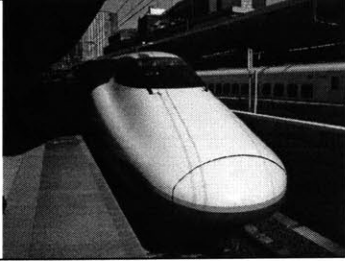
In contrast, the main objective of Series E2-1000, which is the most recent single-deck train, is rapid service for long-distance intercity travels. E2-1000 series trains are used for super-express trains, which stop at only large stations and pass intermediate small stations. E2-1000 started providing services in 2002, the same year as the extension of Touhoku Shinkansen. As Shinkansen extends its services to longer distance, higher-speed trains are necessary to compete against other long-distance modes of transportation, such as airlines.

The seating capacities of these series are almost the same; an E4 Series unit consists of eight cars, while an E2-1000 Series unit consists of 10 cars. Therefore, the average capacity of E4 series is over one hundred persons per car and is 125% of that of the E2-1000 Series.

Double-deck HSRs are heavy and require high-power motors. The maximum axle load for the E4 series with passengers loaded is 15.9 tons, and is 123% of that of the E2 Series. The motor output of the E4-series trains is less powerful than that of the E2-1000 Series. The average interval between stations for commuting services is less than for intercity services. However, the acceleration time is almost the same.

In Japan, the double-deck HSR cars are called Multi Amenity Express (MAX). All trains of these types have train names with the word “MAX”.

Table 3.8 Specifications of the Most Recent Double Deck and Single Deck trains

	Series E4	Series E2-1000
		
Operated for	“MAX” trains	“HAYATE” trains
Operator	JR East	JR East
Operation Line	Touhoku / Jovetsu	Touhoku
Year of Manufacture	1997-	2001-
Number of Cars(Mar.2003)	192	88
Year of Service Start	1997-	2001-
Train Information	8 cars per unit= 4M4T (2M2T*2units)(All: Bi-level)	10 cars per unit = 8M2T (2M*4units+2T)
Seating Capacity(First Class/ Standard Class)	817(54/763) (102.1seats/car)	814(51/763) (81.4seats/car)
Maximum Axle Load(loaded)	15.9tons(35,100lbs)	12.9tons(28,400lbs)
Train Weight(tale)	428tons(944,000lbs)	442.8tons(976,000lbs)
Train Weight(loaded)	472.9tons(1,043,000lbs)	487.6tons(1,075,000lbs)
Train Motor: Rating output	420kW*16 sets=6,720kW (840kW/car)	300kW*32 sets=9,600kW (960kW/car)
Balancing Speed at Level	270 km/h(167.8 mph)	360 km/h(223.7 mph)
Maximum Service Speed	240 km/h(149.1 mph)	275 km/h(170.9 mph)
Starting Acceleration	1.7 km/h/s(1.06 mph/s)	1.6 km/h/s(0.99 mph/s)
Coupling Operation	YES	YES
Gauge	1435 mm(4ft8.5in)	1435 mm(4ft8.5in)
Signal System(ATC ¹²)	Double-frequency combination	Double-frequency combination (Digital ATC)

Source: Japan Overseas Rolling Stock Association, THE SHINKANSEN, 2004

Legend: M=Motor car T=Trailing car

Photos by Mr. Kikuchi Yoshiki

Balancing speed “at level” is the maximum speed that is achievable given certain train mechanical specifications. “At level” means on the level ground with no slope. With a downward slope, balancing speed is higher than when the trains run on the level. The balancing speed of the E4 Series is about 170 mph, which is less than that of the E2-1000 Series.

These two series adopt the same kind of gauge and signal systems. In addition, both have compatible coupling capability to connect to each other.

¹² ATC: Automatic Train Control

3.1.5 Coupling and Shifting Seat Configurations

Shinkansen has coupling functions and shifting seat configurations. A coupling train consists of two units. However, the length of one unit varies. Figure 3.5 shows two examples of 16 cars. The E2 series trains with 16 cars consist of one ten-car unit, and one six-car unit. In contrast, the E4 series trains with 16 cars consist of two eight-car units, and this set of HSR trains has the largest HSR capacity in the world.

In addition, by coupling, multi-destination trains can share limited train capacity. Most of the E2 "Hayate" trains combined with the E3 "Komachi" trains run from Tokyo to Morioka (333 miles). Then the E3 trains go to Akita (412 miles) on conventional railroads, and the E2 trains go to Hachinohe (393 miles) separately. All seats on these trains are reserved. Coupling and de-coupling take less than two minutes, therefore resulting in very little time loss.

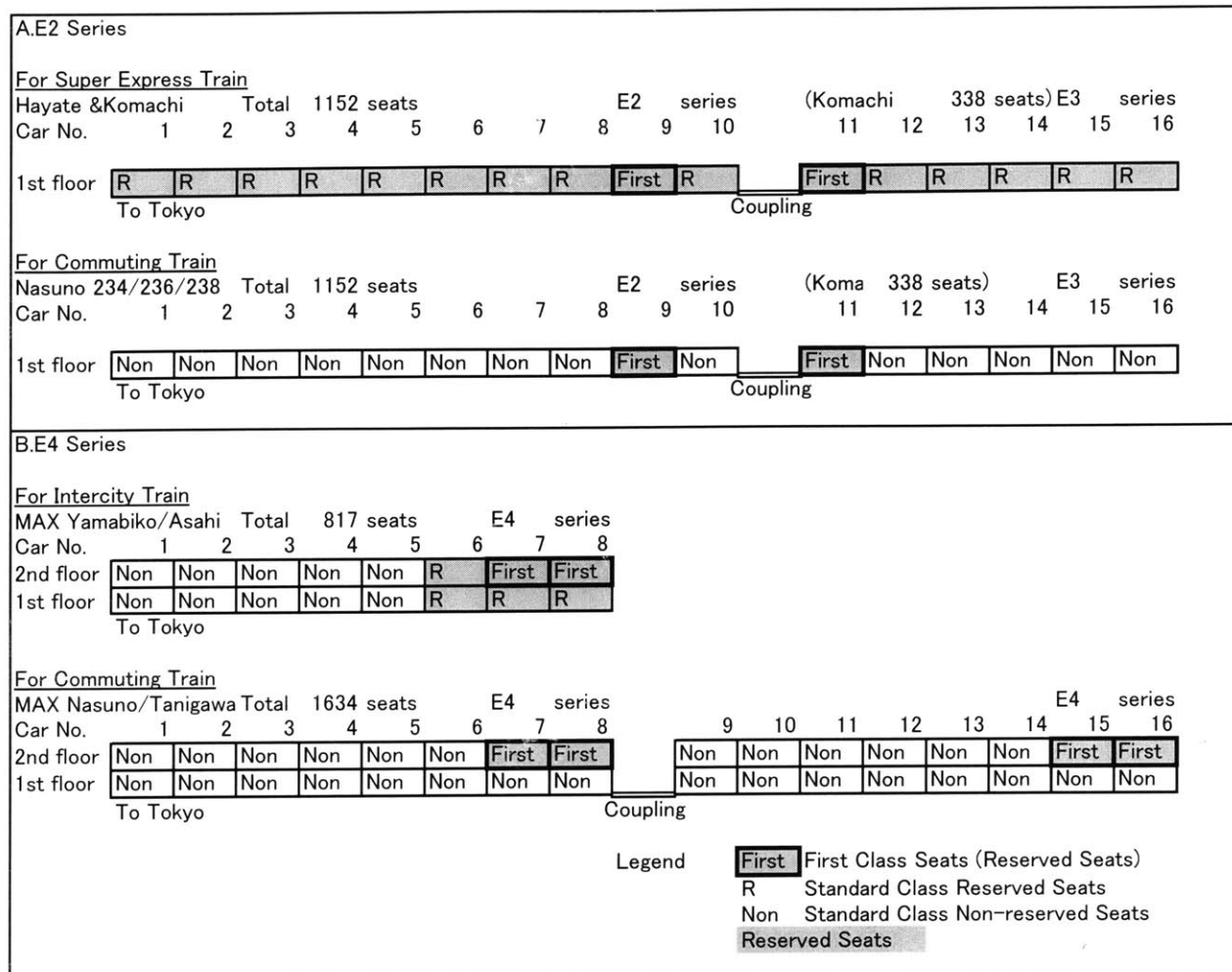


Figure 3.5 Configuration Shifting
 Source: JR TIMETABLE December 2004

Shifting seat configurations is another essential part of HSR commuting. In Japan, limited express services guarantee seats and even the seating position for each passenger. Japan Railway (JR) group owns “Multi Access Seat Reservation System” (MARS). MARS is a computer-based network seat reservation system. Table 3.9 shows the development of MARS. Passengers can buy any train tickets from one month before the departure at any stations and travel agencies with MARS terminal.

Currently, more than half of the seats on standard limited express trains are reserved. Super-express trains, Hayate, Komachi and Nozomi have only reserved seats.

Table 3.9 MARS System Development

Introducing year	System	Scale	Accommodation to total seats
1960.2-	MARS 1	12 terminals 2,300 seats	
1964.2-	MARS 101		
(1964.10 "Shinkansen" starts)			
1965.10-	MARS 102		70%
1968.10-	MARS 103		94%
1970.10-	MARS 104	1,021 terminals 400,000seats	100%
1972-	MARS 105		100%
1985-	MARS 301		100%
1993-	MARS 305		100%
2002.10-	MARS 501		100%

However, for HSR commuting, cars with unreserved seats are necessary. It is impossible to allocate all seats every morning to all commuters. The most efficient way is to allocate on a first-come-first-served basis for passengers with express tickets or HSR commuting passes. In Japan, most HSR commuting trains consist of unreserved seats cars, except for first class seats. For example, table 3.2 shows all arriving trains at Tokyo Station until 8:20am. All but one are unreserved trains for all seats except for first class seats. In Japan, first class seats are in the so-called "the green car", and several cars (usually less than three cars) are first-class cars.

The seat reservation systems are different in the US and Japan. In Japan, seat reservation indicates the exact number and position of the seat, both in first and reserved standard class seats. A passenger can take non-reserved seats if he or she purchases a non-seat-reserved express ticket, which indicates the section and the valid date. So in peak periods, such as vacation seasons and morning peak hours, all non-reserved seats are occupied and some passengers ride without seats. Standees in HSR are allowed in Japan. On the other hand, in the US, Acela Express trains and other advanced booking trains limit the number of passengers on board. However, passengers can choose the position of the seat on a first-come-first-served basis.

As HSR commuters spend much money for commuting, it is necessary to allocate as many seats as possible for them. This is the motivation behind the development of all double-deck trains in Japan.

3.1.6 Commuting Passes

In Japan, many HSR commuters have monthly passes. The commuting pass “FREX” and the student pass “FREX PAL” are valid for one or three months. Schooling passes are discounted for college students, and identification is necessary for purchase. HSR passes are expensive. For a distance of 200 miles, it costs about \$2,000 for a one-month commuting pass. All passes have magnetic stripes with valid section and validity period information; automated gates read this information to determine whether the pass is valid or not. All monthly passes extend for one or three months, starting from the date of purchase.

In Japan, as the population of young people is decreasing, the sales of commuting passes by conventional trains are decreasing. However, the sale of HSR commuting passes is still increasing¹³. These passes do not guarantee seating. However, the operators are now trying to provide as many seats as possible by increasing the number of trains and by developing double-deck trains.

For HSR commuting, monthly passes are the most effective way for both operators and customers. It is only once a month or less for HSR commuters and operators to trade passes.

3.1.7 Additional Intermediate HSR Stations

Building new stations on the existing lines is a potential option for HSR commuting. However, since the primary objective of HSRs is to serve intercity passenger transportation, construction of intermediate commuting stations is a secondary objective for the HSR operators.

As shown in table 2.4, there are twelve additional intermediate Shinkansen stations,

¹³ Table 2.2

which opened after the line operation started. The oldest is Mishima Station, which opened five years after the first Shinkansen service had started.

Honjo-Waseda Station is the newest additional intermediate Shinkansen station, and the station is located within Tokyo HSR commuting area. The station is 55.3 miles from Tokyo Station and the fastest train takes only 49 minutes with intermediate brief stops from Honjo-Waseda to Tokyo Station. Every weekday from 6 am to 9 am, 10 trains to Tokyo stop here. There are no feeder conventional rails to this station, but the regional government provides free parking spaces for 1,000 cars.

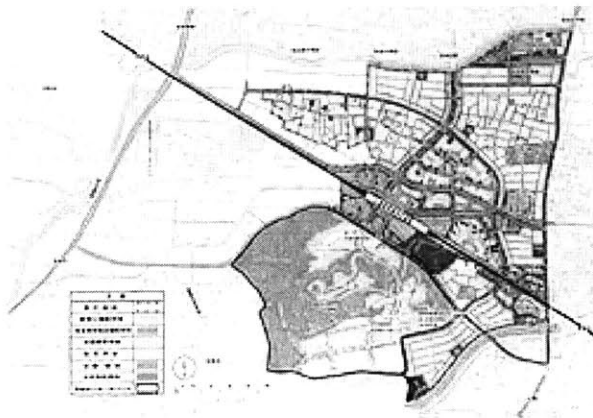


Figure 3.6 Development Plan of Honjo-Waseda
Source: Honjo-City Website

Meanwhile, the construction of additional intermediate HSR stations is difficult and expensive. As HSR trains run next to the construction sites of new stations, careful consideration of safety is necessary. To separate the high-speed railroads from construction sites, tall and strong fences need to be put in place. In addition, for a long time, slowing down for track work is necessary, because the rails of main HSR lines in the sites are cut for track works, such as base works and crossing insertion. Slowing down is a critical issue for HSRs. Moreover, as the time for Shinkansen maintenance is limited from midnight to 6:00 AM, the time slot for track working is limited. However, a lot of work is necessary. As a result, cost increases and service level degrades.

For example, the Honjo-Waseda station, opened in March 2004. Two additional lines,

two platforms for 16 cars and a station below the elevated railways were constructed. The initial cost estimation for this project was ¥12,300,000,000 (approximately 120 million dollars), and regional governments provided all funding. As HSR additional intermediate station construction is time consuming and expensive, it is better to consider additional intermediate station possibilities at the time the HSR is initially constructed.

3.1.8 Feeder Service Facilities

Feeder service facilities, including parking, buses and other transportation connections, are essential to support HSR commuters. Because not many people can live within walking distance to HSR stations, it is necessary to consider feeder service facilities. In Japan, most feeder facilities are usually public transportation, such as conventional railroads and buses. However, automobiles also have potential as a feeder service facility. Especially in low-density areas with less public transportation, automobiles are a useful feeder for high-speed transportation. Most of newly built stations have a lot of parking space.

3.2 Findings from the Japanese HSR commuting Case

3.2.1 Complementary Behaviors between Intercity Travel and Commuting

The Japanese case has shown that HSR commuting services are compatible with intercity travel services. The commuting is a behavior from living place to workplace like an office or factory. Commuting is an every-weekday behavior and is relatively short-length trip. Commuting trips are concentrated during peak hours, and most commuting trips are inbound to city centers in the morning and outbound to the suburbs in the evening. On the other hand, intercity travel is less concentrated during peak hours.

In some countries, such as Japan, public transportation to school is very large in volume. Most high school students use public transportation to go school, and even many university students use HSR to go to school. However, in the US, there is less public transportation to

school.

Table 3.10 Behaviors of Commuting and Intercity Travels

	Commuting travel	Intercity travel
1)Day	Every Weekday	Everyday
2)length	Short length less than 200 miles	Long length 300-500 miles
3) Concentration of traffic volume	Concentrated during peak hours Morning inbound to the city center Evening outbound to the suburban	Less concentrated during peak hours

As the main objective of intercity express trains is to connect cities in an intermediate distance range of 300 to 500 miles, HSR intercity trains usually take 2 to 3 hours. That is the reason why most commuting trains arrive at the final terminals before the first super express train. Therefore, there is little interference. With a linear motor car with a maximum speed of 300 mile per hour or more for intercity service, this situation would change.

After a brief stop at terminal, such as Tokyo Terminal, most trains return as long-distance intercity trains. No trains return to the commuting origins, and repeat the commuting operation.

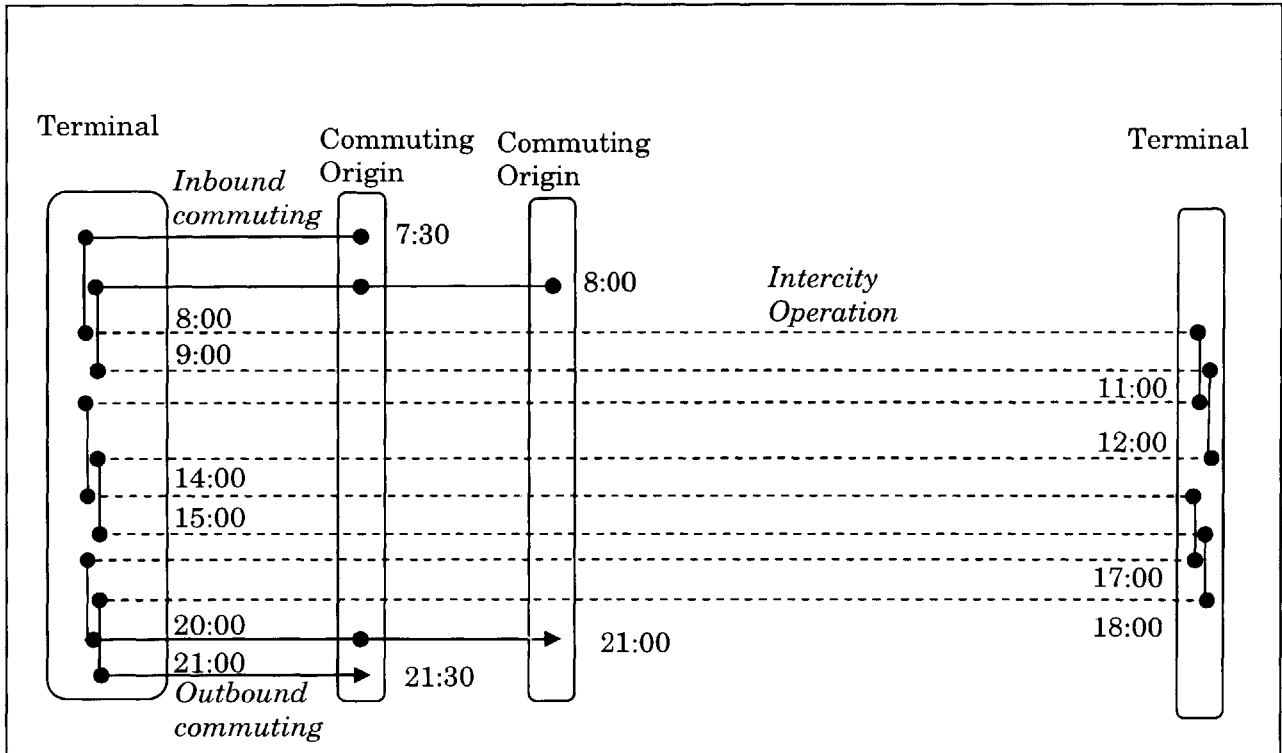


Figure 3.7 Complementary Train Operation Example

3.2.2 Compatible Infrastructure Use and Safety Assurance

By using HSR rolling stock for both intercity and commuting services, Japanese HSR services secure high efficiency and safe operation. From the initial investment perspective, it is less expensive to provide two services with one type trains than with two or more types of trains. Moreover, only one type of maintenance facility and technical staff is necessary.

In addition, single type rolling stock usage needs only one type of safety system. It is not necessary to prepare several safety systems. A complex system may cause connection defect troubles. A simple system is safer than a complicated system.

3.2.3 Small Additional Investments for the Commuting Use of HSR

Possibly, HSR commuting needs additional investments for several components, such as vehicles, commuting stations, and ticketing facilities. As transportation is a complex system of

sub-components, at least, vehicle and track components are necessary for rail transportation. However, by sharing basic infrastructures, HSR commuting is possible with relatively small amount of additional investment.

In addition, other operation facilities, such as a ticketing system and commuter stations, are also necessary. However, commuting pass and non-reserved seat make the ticketing of HSR commuting simple and efficient.

Figure 3.8 shows the overall Japanese HSR commuting benefit for the operator. As Commuting HSR (**Case B**) needs huge dedicated infrastructure, its income estimation is negative. However, the intercity and commuting use of HSR (**Case C**) has surplus.

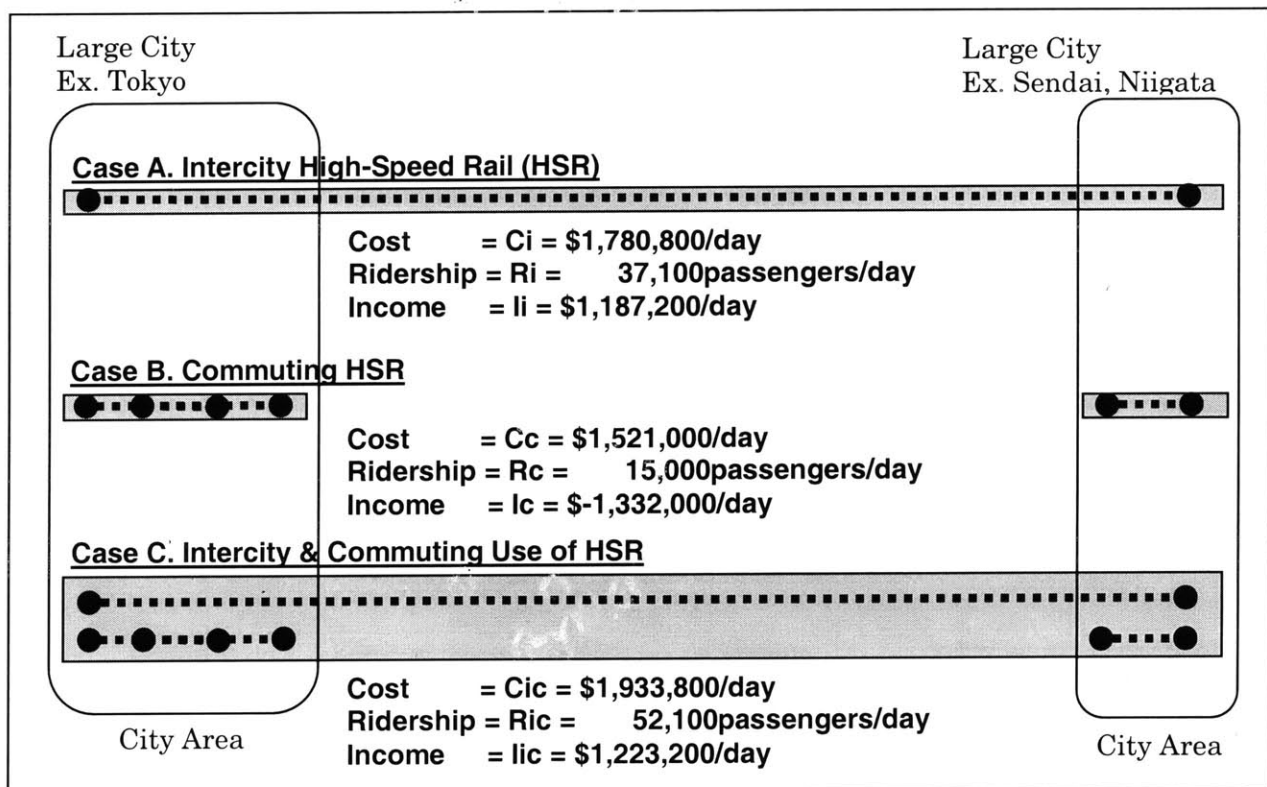


Figure 3.8 Japanese HSR Commuting

Legend: Dot Lines=Train Operation, Shaded Square=HSR Infrastructure

C_i = Cost for Intercity Train Operation, from Table 3.5

C_{ic} = Cost for the commuting use of HSR, the estimated commuting HSR unit cost is a 60% of intercity HSR.

C_c = Cost for inner city HSR, including C_{ic} and the redemption of 60 miles dedicated track, 250 million dollars per mile, for 30 years, no interest, see foot note no.14

R_i = Ridership of HSR Intercity Passengers, reduced R_c from Table 3.3, Daily Tohoku

Shinkansen passenger number

Ric = Ridership in the commuting use of HSR case

Rc = Ridership of HSR Commuting Passengers, from Table 3.4, three times of HSR Touhoku Shinkansen peak passengers

The assumption of average ride distance: intercity = 200 miles, commuting = 60 miles

$$\begin{aligned} \text{Intercity \& Commuting Use of HSR Ridership} &= \text{Ric} = \text{Ri} + \text{Rc} \\ &= 37,100 + 15,000 = 52,100 \text{ passengers/day} \quad (5) \end{aligned}$$

$$\begin{aligned} \text{Intercity \& Commuting Use of HSR Revenue} &= \text{Vic} = \text{Vi} + \text{Vc} = \text{Ui} \cdot \text{Di} \cdot \text{Ri} + \text{Uc} \cdot \text{Dc} \cdot \text{Rc} \\ &= 0.40(\$/\text{mile}) \cdot 200(\text{miles}) \cdot 37,100(\text{passengers/day}) \\ &+ 0.21(\$/\text{mile}) \cdot 60(\text{miles}) \cdot 15,000(\text{passengers/day}) = \$3,157,000/\text{day} \quad (6) \end{aligned}$$

$$\begin{aligned} \text{Intercity \& Commuting Use of HSR Cost} &= \text{Cic} < \text{Ci} + \text{Cc} \\ \text{Cic} &= \text{Ei} \cdot \text{Di} \cdot \text{Ri} + \text{Ec} \cdot \text{Dc} \cdot \text{Rc} = 0.24(\$/\text{mile}) \cdot 200(\text{miles}) \cdot 37,100(\text{passengers/day}) \\ &+ 0.17(\$/\text{mile}) \cdot 60(\text{miles}) \cdot 15,000(\text{passengers/day}) = \$1,933,800/\text{day} \\ \text{Ci} + \text{Cc} &= \text{Ei} \cdot \text{Di} \cdot \text{Ri} + \text{Ecp} \cdot \text{Dc} \cdot \text{Rc} = 0.24(\$/\text{mile}) \cdot 200(\text{miles}) \cdot 37,100(\text{passengers/day}) \\ &+ 1.69(\$/\text{mile}) \cdot 60(\text{miles}) \cdot 15,000(\text{passengers/day}) = \$3,301,800/\text{day} \quad (7) \end{aligned}$$

Cic: Cost in the commuting use of HSR case (Unit: \$/day)

Ci: Cost for HSR inner city service (Unit: \$/day)

Cc: Cost for HSR commuting service (Unit: \$/day)

Ei: Unit Expense for HSR intercity passengers (Unit: \$/passenger-mile)

Ec: Unit Expense for HSR commuters (Unit: \$/passenger-mile)

Ecp: Unit Expense for HSR commuters (Unit: \$/passenger-mile)

including initial capital expense for inner city HSR dedicated track and rolling stock

$$\begin{aligned} \text{Intercity \& Commuting Use of HSR Income} &= \text{Iic} = \text{Vic} - \text{Cic} > \text{Ii} + \text{Ic} = (\text{Vi} - \text{Ci}) + (\text{Vc} - \text{Cc}) \\ \text{Iic} &= \text{Vic} - \text{Cic} = \$1,223,200/\text{day} > -\$144,800/\text{day} = \text{Ii} + \text{Ic} \\ &= \$1,187,200/\text{day} + -\$1,332,000/\text{day} \quad (8) \end{aligned}$$

In the Japanese case, intercity and commuting use of HSR generates surplus for the operator. HSR commuting benefits many commuters. However, if the operator provided both intercity and commuting HSR service separately, it would make a large deficit from commuting service. Separated operation for intercity and commuting service is impossible and many commuters will lose the benefits of HSR commuting.

In the case of Japan, both HSR and conventional rails are fully used for commuting. The East Japan Railway Company provides large passenger capacity in peak hours by the combination of HSR commuting and conventional rail. However, as shown in Table 3.4,

conventional rail loads are still over the capacity. As the demand for commuting is large, East Japan Railway Company operates both HSR and conventional rail for commuting transportation. However, in low commuting demand area, it is possible to provide both services by sharing only HSR infrastructures. For new construction of 60 miles conventional commuter line in Tokyo area, \$15 billion is needed¹⁴. However, by sharing HSR infrastructure, HSR operator can provide commuting transportation without this expense. This is benefit for HSR operators.

3.3 Remarks

1) Route Planning

For intercity travels, a straight connection between large cities is the fastest way. By having a straight connection, the number of curves would be reduced, and high-speed operations would become possible. However, to connect large cities directly, in most cases, long tunnels and long river bridges are necessary, which increases the overall construction cost, in spite of decreasing of HSR ridership. For HSR commuting uses, a route via high-density areas is a better planning option.

2) Initial Optimum Allocation of Train Depot Site

In most cases of HSR commuting in Japan, extra rail infrastructure and rolling stock infrastructure is not necessary. However, with the initial construction of rolling stock depot, HSRs become more useful for commuting use. Choosing suburban depot site has another merit. As land prices in urban center, are expensive, constructing train depot in suburban areas is more cost efficient. The most convenient place for these depots is at the fringe of commuting areas.

¹⁴ From Unit Construction Expense of Tsukuba Express (250 million dollars per mile, Expected Open Date :8/24/2005, Initial Cost: 9,038 Million Dollars, Length: 36.2miles)

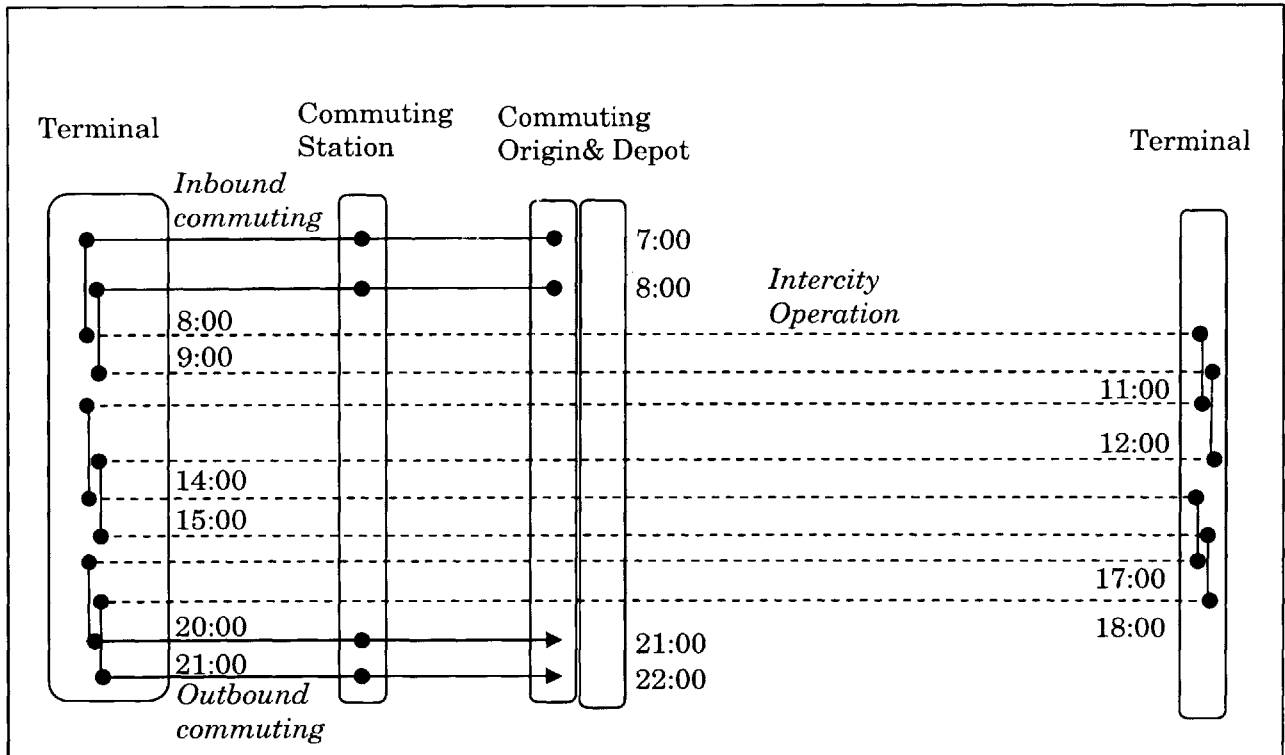


Figure 3.9 Model of Train Depot Allocation and Train Operation Example

In this chapter, we have laid out several key lessons for HSR commuting from Japan. Sharing infrastructure and rolling stock as much as possible allows HSR commuting with a relatively small amount of additional investment. By combining intercity and commuting HSR services, in the next chapter, we will examine the way in which these key lessons can be applied to the HSR plans in the US.

Chapter 4 Application of High-Speed Rail Commuting to California Project¹⁵

The California HSR project is the proposal for a total of 700 miles of dedicated tracks in California. HSR trains are planned to run at a maximum of 220 miles per hour and travel about 440 miles between Los Angeles and San Francisco in two and half hours. Expected construction cost is about 25 billion dollars over 16 years. We choose this project as our case, because the project is in the most populated State in the US, and has some chance for development. In this chapter, after a brief description of California and the HSR project, we will examine the benefits of HSR commuting in California, using the insights served in the Japanese case in the previous chapter.

4.1 The State of California and Transportation Overview

The establishment of the State of California occurred later than the eastern US states, and the major transportation methods in recent times are airlines and automobiles. California was established in 1850 as the 31st state of the US, just after the peak period of the 1849 gold rush. The transportation issue in the 1850s and 1860s was a connection with eastern states, which were the economical and political center of the US. After major construction to cross the Rocky Mountains, the transcontinental railroad was completed in 1869. The capital of California is Sacramento. Figure 4.1 shows main cities and roads of California. To the west, Interstate 80 links to New York via Chicago, and Interstate 10 links to Jacksonville, Florida, via Houston and New Orleans. To the North, Interstate 5 goes thorough the State to Oregon and Washington State. To the South California, Interstate 5 goes to the international border with Mexico.

¹⁵ Primary resource of this Chapter: California High-Speed Rail Authority, The final business plan, 2000

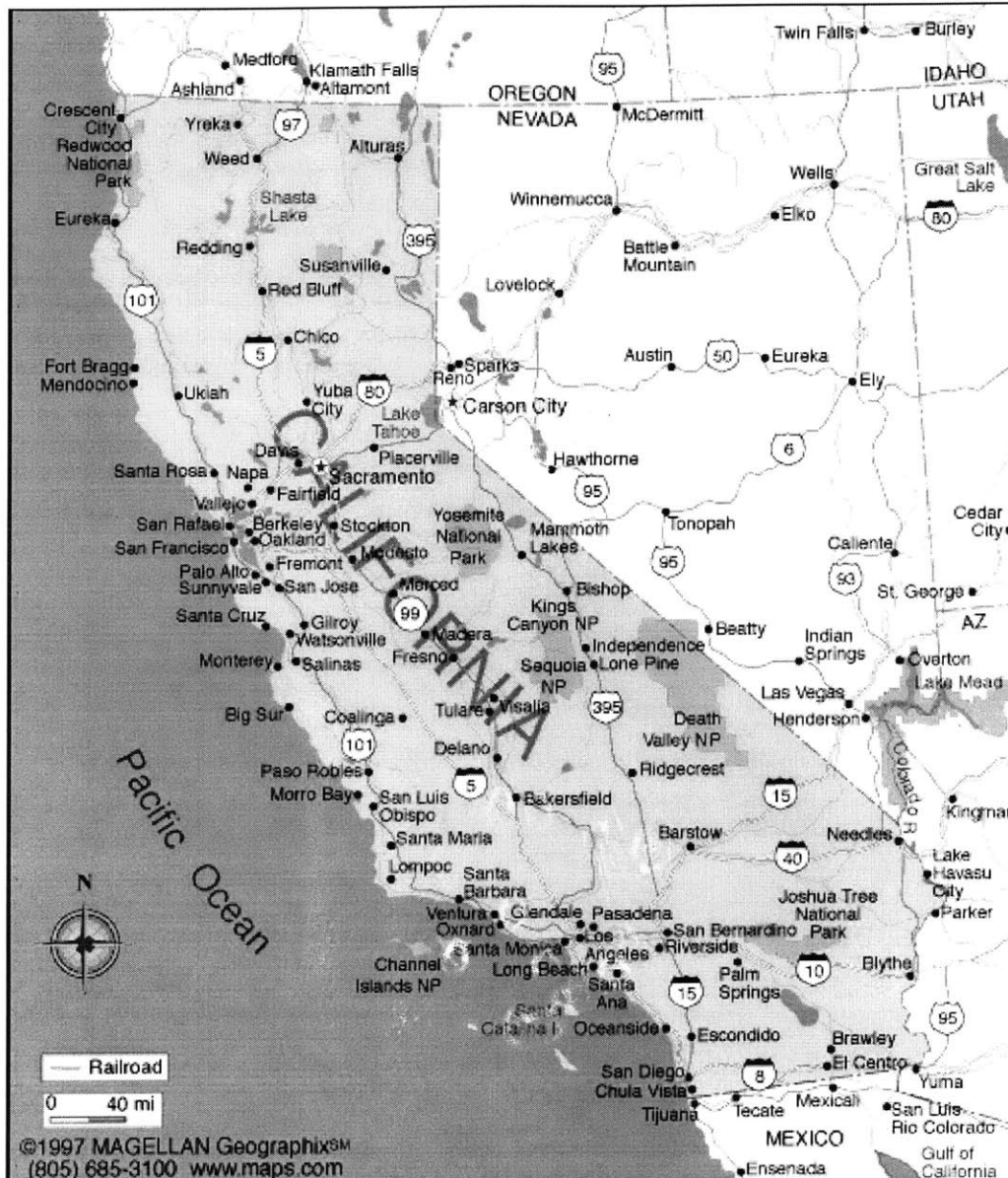


Figure 4.1 California State Map

Source: MAGELLAN Geographix

<http://www.infoplease.com/atlas/state/california.html>

In contrast to the early transcontinental rail construction, the state's common transportation method has been automobiles. Its largest city, Los Angeles, grew largely after the development of the automobile. As such, the State has a massive and speedy highway network. Table 4.1 shows a brief description of the State's transportation history. The main financial resource for road construction has been gas taxes and bonds. The gas tax, which was originally one cent per gallon, became 18 cents in 1994. In rural areas, the maximum speed on highways

was raised to 70 miles per hour in 1996.

Large earthquakes are a major threat to California and its transportation networks. The Sylmar earthquake struck the northern part of Los Angeles in 1971, the Loma Prieta earthquake struck the San Francisco Bay area in 1989, and the Northridge earthquake struck the Los Angeles area in 1994. As the west coast of the US is in the circum-Pacific earthquake belt, it is impossible to avoid large earthquakes.

In recent times, rail transportation has been discussed as an alternative for road travel, motivated by huge congestion levels. Later in this chapter, we will discuss recent rail construction in large California cities.

Table 4.1 The state and Transportation History of California

1769	California's first road, El Camino Real was established by Spanish explorers.
1849	California ceded to the United States. Thousands of "49ers" migrate to California in wagon trains to search for gold.
1850	California admitted into the Union.
1853	All mountain passes through <u>the Sierra Nevada Mountain Range</u> had been opened up by immigrants.
1855	Marlette commissioned the first formal survey toward construction of a wagon road across the Sierra Nevada roughly where <u>U.S. Highway 50 is today from Placerville to Nevada.</u>
1863	Central Pacific Railroad begins laying track in Sacramento for the Transcontinental Railroad.
1869	Transcontinental railroad completed.
1895	The Bureau of Highways created by the Legislature.
1896	Lake Tahoe Wagon Road deeded to California, becoming the first state highway.
1897	The Department of Highways replaces Bureau of Highways.
1907	The Department of Engineering replaces Department of Highways.
1909	First State Highway Bond Act issued to establish a State Highway system (\$18 million).
1912	Construction begins on California State Highway Contract No.1, between South San Francisco and <u>Burlingame.</u>
1916	Second highway bond issue for \$15 million approved by voters.
1919	Third highway bond issue for \$40 million approved by voters.
1920	Highway Commission recommends fuel tax solely for highway construction.
1921	Department of Public Works created to include Department of Highways.
1923	Two-cent-per-gallon fuel tax approved. One cent devoted to maintenance and reconstruction, and one cent for county roads. Highway Commission created as separate state department.
1926	U.S. Highway Numbering System adopted.
1927	One cent increase in fuel tax approved for new construction (total 3 cents). Department of Public Works re-established with Division of Highways as a major division. Governor to appoint five Highway Commissioners to serve without pay, with powers to alter state routes,

authorize rights-of-way, and allocate money to build or repair state highways.

1929 Department of Public Works authorized to begin work on the San Francisco Bay Bridge.

1934 State highway code realigned to allow state highway department to build state highways in cities, and reapportioned gas tax revenues to allow building of urban highways.

California State Sign Route Numbering System adopted.

1936 San Francisco-Oakland Bay Bridge opens to traffic on Nov. 12.

1937 Golden Gate Bridge opens, located on Highway 101 between San Francisco and Marin counties.

1938 Key System electric train service begins across the San Francisco-Oakland Bay Bridge.

1940 California's first freeway, the 6-mile Arroyo Seco Parkway, now known as the Pasadena Freeway, opens to traffic in Los Angeles County on Dec. 30. It connects Pasadena, South Pasadena and Los Angeles.

1947 Gas, diesel and LPG taxes are raised to 4.5 cents per gallon.

1953 Fuel tax increased to 6 cents per gallon. Diesel taxes increased to 7 cents. With fuel tax money plus federal aid, Division of Highways plans Freeway and Expressway System totally 12,414 miles.

1959 Senate Bill 480 establishes a 12,414-mile freeway and expressway system.

1961 Legislature combines Departments of Public Works, Motor Vehicles and Highway Patrol into Highway Transportation Agency.

1963 Legislature increases gas and liquid petroleum taxes and commercial weight fees to aid cities and counties. Fuel tax stands at 7 cents per gallon.

1965 Highway Transportation Agency changes name to Transportation Agency.

1971 Sylmar earthquake strikes north of Los Angeles, causing damage to the under-construction Antelope Valley Freeway and prompting engineers to re-examine the way bridges are affected by earthquakes.

1972 Assembly Bill 69 consolidates the Department of Public Works and Aeronautics into the Department of Transportation (Caltrans) with six divisions: Transportation Planning; Highways, Mass Transportation; Aeronautics; Administrative Services and Legal.

1974 Proposition 5 passes. Shifts highway dollars to public transportation.

1978 California Transportation Commission formed to replace California Highway Commission, State Transportation Board, Aeronautics Board and California Toll Bridge Authority.

1983 State gas tax increased to 9 cents a gallon.

1984 Santa Clara County becomes the first California County to approve a county sales tax increase devoted to transportation improvements.

1987 Governor signs bill allowing counties to ask voters for up to a penny hike in the state sales tax to pay for new roads and mass transit.

1989 Governor signs SCA1, a transportation package designed to provide \$18.5 billion for transportation over 10 years. The package depends on voter approval of three ballot measures in June of 1990. Loma Prieta earthquake strikes the San Francisco Bay area, causing widespread damage to infrastructure. The Cypress Freeway (880) and the San Francisco-Oakland Bay Bridge are damaged. A temporary statewide quarter-cent sales tax increase is enacted to pay for rebuilding and retrofitting in the wake of the Loma Prieta earthquake. The tax expires in 1991.

1990 Proposition 108, 111 and 116 pass, designed to generate \$18.5 billion for transportation improvements. The state gas tax is raised to 14 cents per gallon.

1991 State gas tax is raised to 15 cents per gallon.

1992 State gas tax is increased to 16 cents a gallon. Voters reject a \$1 billion rail bond measure.

1993 The 17.3-mile Glenn Anderson (Century) Freeway, Interstate 105, opens to traffic

between Norwalk and El Segundo in Los Angeles County. The \$2.3 billion project, which includes interchanges to four other freeways, is billed as the last new freeway in Los Angeles. State gas tax increased to 17 cents a gallon.

1994 Northridge earthquake strikes the Los Angeles area, causing widespread damage. Four major freeways suffer heavy damage and are closed: the Santa Monica Freeway (I-10), the Simi Valley Freeway (118), the Golden State Freeway (I-5) and the Antelope Valley Freeway (14). Accelerated rebuilding effort results in all freeways being reopened by year's end. **State gas tax increased to 18 cents a gallon.** Voters reject a \$1 billion rail bond measure.

1995 In response to the federal government granting states the authority to set their own speed limits, Caltrans raises the speed limit from 55 mph to 65 mph on 2,800 miles of freeway and expressways.

1996 Voters approve Proposition 192, the Seismic Retrofit Bond Act, providing \$2 billion in bonds to strengthen bridges to better withstand earthquakes. Opening of \$498 million Harbor Freeway Transitway, a 10.3-mile bus and car-pool facility running down the median of the Harbor (110) Freeway in Los Angeles. The project includes the first-ever viaduct built along an existing freeway in Los Angeles. **Speed limit rose from 65 mph to 70 mph along 1,300 miles of mostly rural interstates.**

Source: Department of Transportation, State of California
<http://www.dot.ca.gov/hq/paffairs/about/cthist.htm>

The California HSR project plan has potential for three reasons. There are several large cities, such as Los Angeles, San Francisco, San Diego and Sacramento that are separated by intermediate distance. For example, from Los Angeles to San Francisco is about 440 miles. Table 4.2 shows the population of these cities. The population of Los Angeles is nearly ten million people. Including surrounding areas, the populations of each of these four cities are at least one million.

Second, the State's recent growth rate has been remarkable. Table 4.2 shows recent population and density comparing the US, California and Japan. California's population density is one-fourth of Japan, but its population is increasing far more, nearly 5% population increase every three years.

Table 4.2 Population and Density in the US, California and Japan

NATION STATE COUNTRY	Population 2003 estimate	Population 2000 census	Increase 2003 -2000	Land Area Sq. miles	Person per Sq. miles 2000
United States	290,809,777	281,421,906	3.3%	3,537,438	79.6
California	35,484,453	33,871,648	4.8%	155,959	217.2
Los Angeles	9,871,506	9,519,338	3.7%	4,061	2,344.2
San Francisco	751,682	776,733	-3.2%	47	16,634.4
San Diego	2,930,886	2,813,833	4.2%	4,200	670.0
Sacramento	1,330,711	1,223,499	8.8%	966	1,267.0
Japan	127,619,000		0.1%		875.0
Tokyo	12,310,000		0.7%		14,302.7
Osaka	8,816,000		-0.0%		11,917.3

Source: U.S. Census Bureau <http://quickfacts.census.gov/qfd/states>

Japan: Bureau of Statistic, Japan

Finally, California has studied HSR for a long time from the 1990s and established the California High-Speed Rail authority in 1996. The presence of this key authority is a necessary step toward development. The authority adopted a business plan in 2000 and now is preparing environmental impact reports.

Commuting time in California is relatively long by US standards, but it is almost half comparing with it in Japan. The average commuting time in the US was 24.3 minutes in 2003. In California, the average commuting time was 26.5 minutes, and it was the sixth longest in the US in 2003¹⁶. Los Angeles is the sixth longest average commuting time city with 29.0 minutes. The longest average commuting time is 30.4 minutes in the State of New York, and the shortest is 15.2 minutes in the State of South Dakota. In Japan, the average commuting time was 69 minutes in 1995¹⁷.

In addition, California and Los Angeles have a large number of workers with long commutes. By the “Extreme” Commuting Rankings¹⁸, which shows the rate of workers with more than 90 minutes commuting time, California is fourth state with 2.8 % extreme commuters. In the US, River City, California was the fourth city with 5.0% extreme commuters, and the Los

¹⁶ US Census Bureau, American Community Survey 2003

¹⁷ Metropolitan Transportation Census in 1995, The Bureau of Transportation

¹⁸ Ibid 16

Angeles city is the fifth city with 3.0% extreme commuters.

Table 4.3 Extreme Commuters Ranking in the US

State		City		
1	New York	4.3%	1 Baltimore city, MD	5.6%
2	New Jersey	4.0%	2 New York city, NY	5.6%
3	Maryland	3.2%	3 Newark city, NJ	5.2%
4	California	2.8%	4 Riverside city, CA	5.0%
5	Washington	2.7%	5 Los Angeles city, CA	3.0%
6	Virginia	2.3%	6 Philadelphia city, PA	2.9%
7	Georgia	2.3%	7 Chicago city, IL	2.5%
8	Illinois	2.2%	8 Washington city, DC	2.2%
9	District of Columbia	2.2%	9 San Francisco city, CA	1.5%
10	Massachusetts	1.8%	10 Miami city, FL	0.7%

Source: US Census Bureau, American Community Survey 2003

Extreme commuter is a commuter with 90 or more minutes to get to work.

The California High-Speed Rail authority is independent from the State's department of transportation (Caltrans), and directly reports to the Governor. The origin of the department of transportation is the Bureau of Highways, established in 1895, which became the State's department of transportation (Caltrans) in 1972 including the mass transportation division. At present, Caltrans has a rail division, and works on developing passenger rail transportation. For example, Caltrans intends to improve the LOSSAN (Los Angeles to San Diego) conventional rail corridor. Table 4.4 shows transportation institutions in federal and state government and Table 4.5 shows rail transportation provided in California

Table 4.4 Transportation Institutions in the US and California

	Federal (The United States)	State (California)
Government	Department of Transportation (US DOT, Washington D.C.,1966-) The Federal Railway Administration (FRA, Washington D.C.,1966-)	California Department of Transportation (Caltrans, Sacramento, 1972-)
		The California High-Speed Rail Authority (Sacramento, 1996-)

Table 4.5 Rail Transportation Providers in California

Passenger Intercity Rail Operator	The National Railroad Passenger Corporation (Amtrak, 1971-)(9,301*:Amtrak California, except the Coast Starlight)
Passenger Commuter Rail Operator	Los Angeles: Metrolink (37,410) San Francisco: Caltrain (25,551), BART (295,158) San Diego: Coaster Sacramento: N/A
Passenger Inner city Rail Operator	Los Angeles: Metro (226,587) San Francisco: Muni Metro (700,000) San Diego: Trolley (74,674) Sacramento: Light Rail Transit (36,700)
Intercity Freight Rail Operator	Burlington Northern Santa Fe(BNSF) Union Pacific (UP) etc.

*Numbers are average weekday ridership

At present, the State has a conventional intercity passenger rail network operated by Amtrak as in other parts of the US. In addition, the State has commuter rail and light rail transit in large city areas, such as Metro link in Los Angeles and the trolley in San Diego. The bus usage in Los Angeles is the second highest in the US, next to in New York, but the area also has some rail transit.

4.1.0 California State Wide Intercity Rail Network

Amtrak operates the Coast Starlight from Los Angeles to Seattle through the State, and the three intercity routes within the State, such as the San Joaquin Route, the Capital Route, and the Pacific Surfliner Route. However, only the Coast Starlight connects Los Angeles and the San Francisco Bay Area, the two biggest cities in California, via Pacific Coast tracks once a day and it takes nearly 12 hours. Rail freight companies own most intercity tracks in California.

In the fall 2004 and winter 2005 weekday schedule, 12 trains connect Bakersfield with Oakland or Sacramento on the San Joaquin Route. Twenty-four trains connect Sacramento with San Jose or Oakland on the Capital Route. Twenty-two trains connect Los Angeles and San

4.1.1 The Los Angeles Area and Existing Rail Transportation²¹

Los Angeles has had commuter rails and subways since the 1990s. In 1992, Metrolink started commuter rail service on Ventura, Santa Clarita, and San Bernardino Lines.

In December 2004, 144 trains on seven commuter lines carry, on average, 37,410 passengers on weekdays. Currently the total route is 512 miles with 53 stations, and average speed is 41 miles per hour. The major destination is Los Angeles Central Business District. The percentage of work trips destined for Los Angeles Union Station is 62%, and for Los Angeles Central Business district is 37%. With the exception of the Inland Empire-Orange Country line, all lines depart from Los Angeles Union Station. Farebox revenue was 54% of operating costs. The ridership revenue is small comparing with operating costs, and a large amount of monetary compensation from public fund is necessary,

As Metrolink commuter trains run on conventional tracks, accidents with automobiles are possible at grade crossing. In the early morning on January 26, 2005, one Metrolink commuter train outbound to Burbank crashed into a car in Glendale on Antelope and Ventura Country lines, which was abandoned on the rail tracks. The train jumped the tracks and crashed into an inbound commuter train. Eleven passengers died and over 200 passengers were injured in this accident.

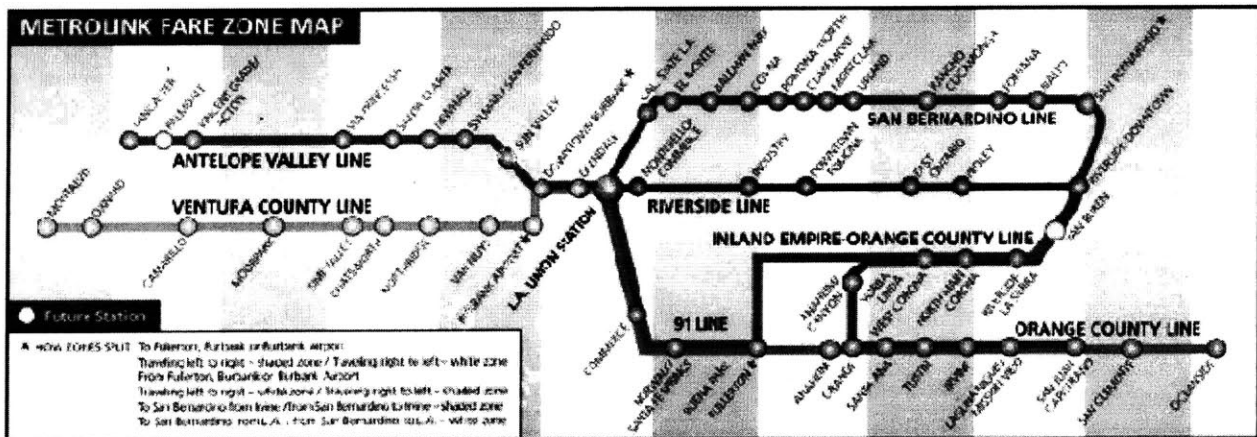


Figure 4.3 Los Angeles Metrolink Route Map

²¹ Primary source of this section: Metrolink website <http://metrolinktrains.com>
 Metro website <http://www.mta.net>

In 1990, the rail sector of Los Angeles County Transportation Authority (Metro), a public transportation entity, opened the first subway, Metro Blue Line. Currently, Metro operates four subway lines, the Metro Red, Blue, Green and Gold lines. Metro has 62 stations on 73-mile track, and the total number of average weekday boarding is 226,587 passengers²². Metro buses carry an average of 1,130,913 passengers²³ on weekdays. Metro is the second bus carrier in the US, next to the New York City Transit²⁴.

Table 4.6 Metro Lines Usage and Cost

	Blue	Green	Red	Gold
Open	1990	1995	1993	2003
Daily Usage	69,868	31,328	111,602	13,789
Cost(M\$)	877	718	4500	Unknown
Length(Mile)	22	20	17.4	13.7
Unit Cost(M\$/mile)	39.9	35.9	258.6	N/A
Unit Usage(per Mile)	3,176	1,566	6,414	1,006

²² February 2005, Source: Metro website <http://www.mta.net>

²³ Ibid. 22.

²⁴ Source: National Transit Database Table 28, in 2001, <http://www.ntdprogram.com>

4.1.2 The San Francisco Area and Existing Rail Transportation²⁵

San Francisco Bay Area Rapid Transit Authority (BART), was established in 1957 by the State Legislature, and started its first revenue service on September 11, 1972 from Oakland to Fremont. Figure 4.5 shows the history of BART. It took 26 years from the early discussions to the opening of its first revenue service. Figure 4.6 shows current routes of BART. The primary object was to connect San Francisco and Oakland area. To attract automobile users, BART introduced high-speed, comfortable, and automatically operated modern rolling stock, a stored fare ticket system, and a park and ride system. The basic technology of BART system is the combination of steel wheel and steel rail, but the gauge is wide (1676mm) to avoid turnovers by high winds.

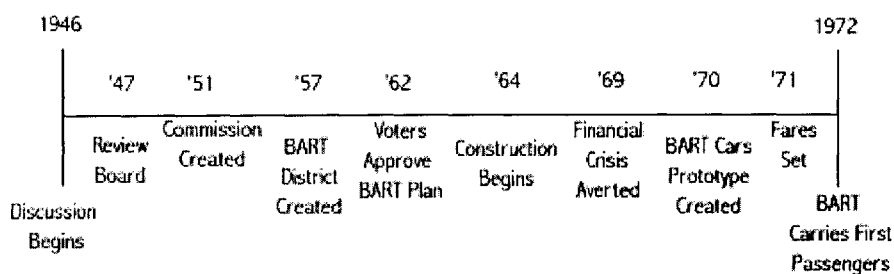


Figure 4.5 BART history Source: BART website

Currently, BART operates five lines with 39 stations. In 2003, the number of average weekday passengers was 295,158. Net passenger revenue was 191 million dollars, and net operating expense was 339 million dollars. Revenue recovered by operations was 56%.

In addition to BART, in the San Francisco downtown area, San Francisco Municipal Railway (Muni) operates light rail transits, cable cars, and buses. On average, Muni weekday passenger is about 700,000. The primary objective of Muni is inner city transportation.

²⁵ Primary source for this section: San Francisco Bay Area Rapid Transit District web site <http://www.bart.gov>, San Francisco Municipal Railway website <http://www.sfmuni.com>, and Caltrain web site <http://www.caltrain.com>

Caltrain is a commuter rail system on the San Francisco Peninsula. Passenger service on the peninsula started on October 18, 1863, but after World War II, the usage of the line declined and the former operator, the Southern Pacific Railway, wanted to eliminate the passenger service. In 1987, San Francisco, San Mateo, and Santa Clara counties established the current entity, the Peninsula Corridor Joint Powers Board (JPB). The JPB bought the rail rights-of-way from San Francisco to San Jose from the Southern Pacific and secured track rights to Gilroy. The JPB chose Amtrak as a commuter rail operator in 1992.

Caltrain has 33 stations on a 77 mile track from San Francisco to Gilroy, at a maximum speed of 79 miles per hour, which is the legal maximum for conventional rail. Average weekday ridership in February 2004 was 25,551.

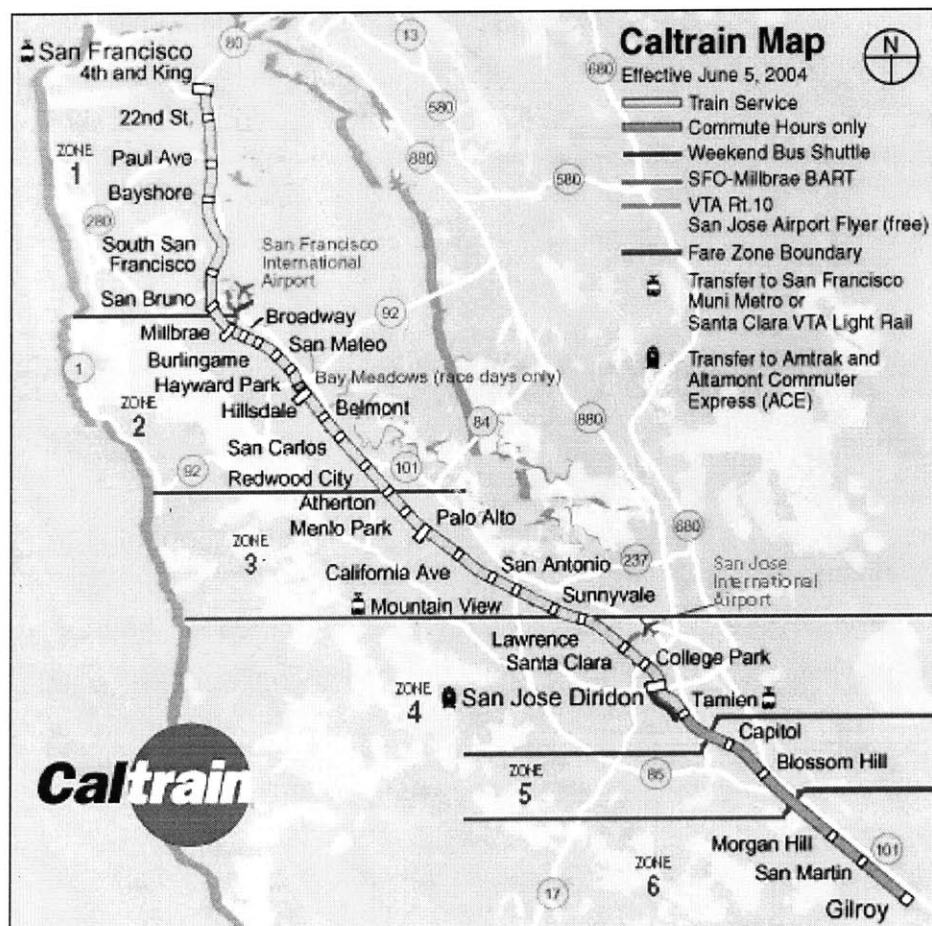


Figure 4.8 Caltrain Route Map

Source: website

4.1.3 The San Diego Area and Existing Rail Transportation²⁶

San Diego Area has a trolley system and one commuter rail line. On July 26, 1981, San Diego Trolley started revenue operation between downtown and the U.S. International Border to Mexico. The first trolley system in San Diego had started in the 1880s, but was discontinued in 1949, despite 600 percent ridership increase in the World War II era²⁷.



Figure 4.9 San Diego Trolley Map
San Ysidro is the last stop of the Blue Line near the border to Mexico

²⁶ Primary source for this section is Metropolitan Transit System website, <http://www.sdcommute.com>

²⁷ Largely by the gas ration

Currently, the trolley system has two routes, with total of 48 mile tracks. San Diego Trolley, Inc (SDTI), which is a subsidiary of the San Diego Metropolitan Transit Development Board (MTDB), owns the system. Average weekday ridership in FY-2002 was 74,674. The ratio of operation revenue to operating cost was 59.3%. Nearly half of the 49 stations have parking lots. Freight trains share the trolley tracks, only from 2:00 AM to 4:00 AM.

The commuter line, the Coaster, runs from San Diego downtown to Ocean Side Transit Center along the Pacific Coast; it is 42 miles length, and started in 1995. Twenty two trains run on weekdays. The number of average daily passengers was 1,208 in 2001²⁸.

4.1.4 The Sacramento Area and Existing Rail Transportation²⁹

The Sacramento Regional Transit District (RT), created by the State Legislature in 1971, has operated a light rail transit (LRT) system since 1987. About 30 mile of track connects both the eastern and northeastern suburbs with downtown Sacramento. In Fiscal Year 2004, the LRT carried an average of 36,700 passengers on weekdays, which is about half of RT's bus passengers. The LRT system has 41 stations, including 20 bus transfer stations and 13 free parking stations, with a total of 6,042 lots. Figure 4.10 shows the LRT map in Sacramento. Including bus and other services, only a 21% of total operating expense was recovered from fares in RT fiscal year 2004, a 58% of total operating expense was from State and local sales taxes, and a 15% of total operating expense was from Federal assistance.

²⁸ Source: National Transit Database Table 28, in 2001, <http://www.ntdprogram.com>

²⁹ Primary source of this section is Sacramento Regional Transit District website, <http://www.sacrt.com>

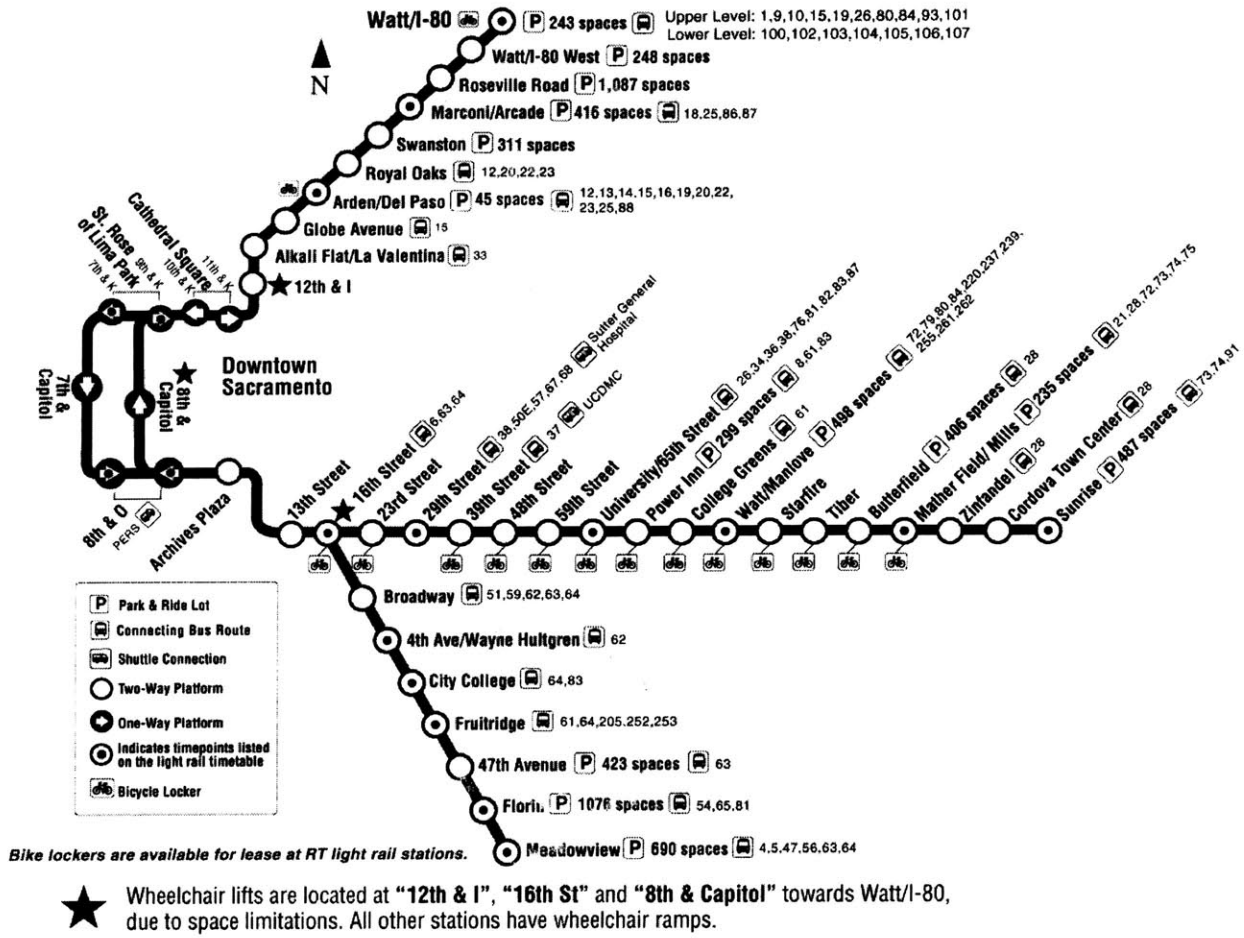


Figure 4.10 Sacramento Light Rail Transit Map

So, the four largest California cities have some kind of regional rail transportation. Los Angeles and San Francisco have subway and commuter rail systems. San Diego and Sacramento have LRT systems. However, the construction of rail transportation in these four cities was relatively recent.

While progress with regional rail transportation systems has occurred, intercity rail transportation in California is still in the planning phase. In the next section, we will discuss the California HSR project.

4.2 California HSR Plan Case Description

The California HSR project, which is still in the planning phase, is a 30 billion dollar investment for HSR rolling stock and 700 mile dedicated lines connecting large cities, such as Los Angeles, San Francisco, San Diego, and Sacramento. The expected construction term is 16 years, and the expected start of revenue service is around 2020. From the 1960s, many nation-wide laws have been introduced to activate passenger rail transportation. However, the beginning of the California HSR project is in the late 1980s³⁰, right after the TGV project was successfully completed in France, and almost 30 years after Shinkansen service began in Japan.

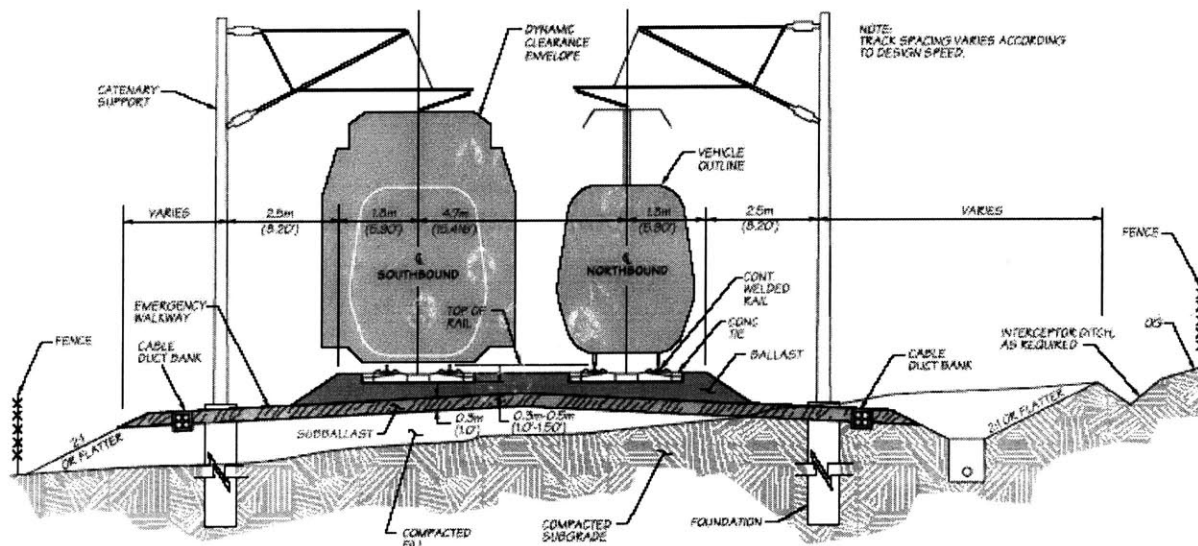


Figure 4.11 California HSR Dedicated Line Image

Source: The California High-Speed Rail Authority, Final Business Plan, 2000

In 1990, the Los Angeles-Fresno-Bay Area/ Sacramento High-Speed Rail Corridor Study Group, including Caltrans, made a report, and Caltrans also made a work plan for a feasibility study.

In 1993, the State Governor and Legislative established Inter City High Speed Rail Commission to examine the feasibility and advisability of HSR in California.

In 1996, the commission concluded that the HSR operation was profitable, but public

³⁰ California State Rail Plan 2003-04 to 2013-14, Chapter VIII, California Department of Transportation

initial construction expense was necessary. Therefore, the public-oriented state authority, “California High-Speed Rail Authority” replaced the commission.

In 2000, the authority adopted the final business plan of California HSR. We will examine the project based on the business plan.

Table 4.7 History of Nation-Wide Rail Implementation Acts in the US and the California HSR Project

Nationwide Activation Acts for rail transportation	
1965	the passage of “the High Speed Ground Transportation Act” (HSGT)
1970	the passage of “the Rail Passenger Service Act”(RPSA)
1971	“the National Railroad Passenger Corporation” (Amtrak) establishment
1991	the passage of “Intermodal Surface Transportation Efficiency Act” (ISTEA), “the Transportation Infrastructure Finance and Innovation Act” (TIFIA) , “the High-Speed Rail Transportation Act”
1994	“the High-Speed Rail Development Act”(HSRDA)
California HSR project	
1992	Working papers for California high-speed train by University of California (Route Selection, Technology Comparison, Usage and Revenue Forecast)
1993	“Intercity High-Speed Rail Commission” established by the State
1996	The commission reported “Summary Report and Action Plan” “California High-Speed Authority” established by the State
2000	The authority adopted “High-Speed Rail System Business Plan”
2004	Referendum postponed to 2006 Environmental Impact (EIR)

4.2.1 Route Plan

California HSR will connect Los Angeles and San Francisco via the Central Valley with extensions to Sacramento and San Diego. All proposed routes are electrified double-track and dedicated to HSR. No conventional passenger train or freight train will use the rights-of-way. Figure 4.12 shows the proposed lines.

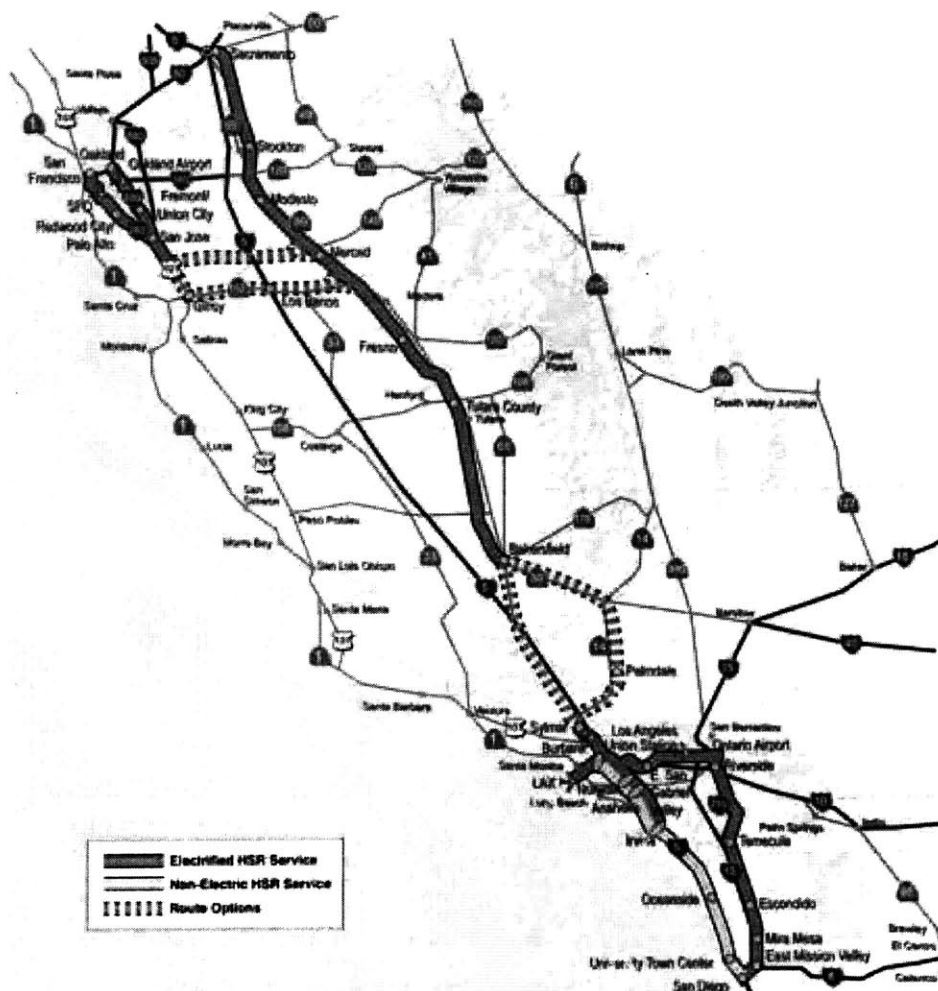


Figure 4.12 the Proposed Route for the California High-Speed Train
 Source: California High-Speed Rail Authority

The Central Valley route, which is flattest and densest in population, is the best route for HSR. The route of HSR has been discussed since the working papers of University of California in 1992. The Coastal route along Pacific Ocean and Valley route via Central Valley area are two major routes. However, from construction expense and accessibility to riders, the Central Valley route is more feasible.

In the Central Valley, the HSR selected the route along the California State Highway 99, which is on the east side of the Central Valley. Another option is along Interstate 5, which connects Los Angeles and Sacramento on the west side of the Valley, but there are no major

cities along the route. On the Pacific Coast, California State Highway 1 connects Los Angeles and San Francisco, but this corridor is relatively low density and hilly.

Mountain crossings are another focus of route planning. The business plan had some options to the north of Los Angeles, the connection between Bay Area and Central Valley, and the San Diego extension. For the north of Los Angeles, there were two mountain crossing options in the final business plan. One had 28 miles of tunnels; the other had only 11 miles of tunnels, but was 41 miles longer. Finally, the authority selected the latter, which took 10 minutes more, but served dense areas including Palmdale.

In addition, branch line routes in the East Bay area and in the Orange Country area were proposed. The East Bay branch is to Oakland. The Orange Country branch connects Los Angeles and San Diego along the Pacific Coast. The economic feasibility study in the final business plan, which was intended to be least expensive, does not include these branch lines.

Additionally, the goal of the business plan has airport connections in both Los Angeles and San Francisco areas. In the Los Angeles area, the authority intended to construct an extra feeder branch line to Los Angeles International airport (LAX). In the San Francisco area, the plan intent to construct San Francisco International airport (SFO) station on the route. Similar to the other branch lines, the economic analysis of the business plan does not include the LAX branch line.

The distance from Los Angeles to San Francisco is 442 miles. (See Table 4.8.) The extension from Los Angeles to San Diego is 151 miles, and the other extension to Sacramento from Merced (between Los Angeles and San Francisco) is 110 miles. Total length is 703 miles.

The plan proposes to run electric train at a maximum speed of 220 mile per hour, and connect Los Angeles and San Francisco in two and half hours. Figure 4.13 shows the expected maximum speed in sections. The HSR reduces speed in urban areas and in the mountains. The authority has not chosen the rolling stock type, but the existing rolling stock technology, such as Shinkansen, TGV or ICE, would likely be adopted to lessen technological risk.

As a result, the proposed HSR route between Los Angeles and San Francisco is along the Metrolink route to Santa Clarita in the Los Angeles area, Amtrak San Joaquin Route in Central Valley from Bakersfield to Merced, and Caltrain route in San Francisco area from Gilroy. For the main HSR line between Los Angeles and San Diego, no passenger rails are along the route. For the branch line between those two cities along the Pacific Coast, Metrolink and Coaster runs along the route.

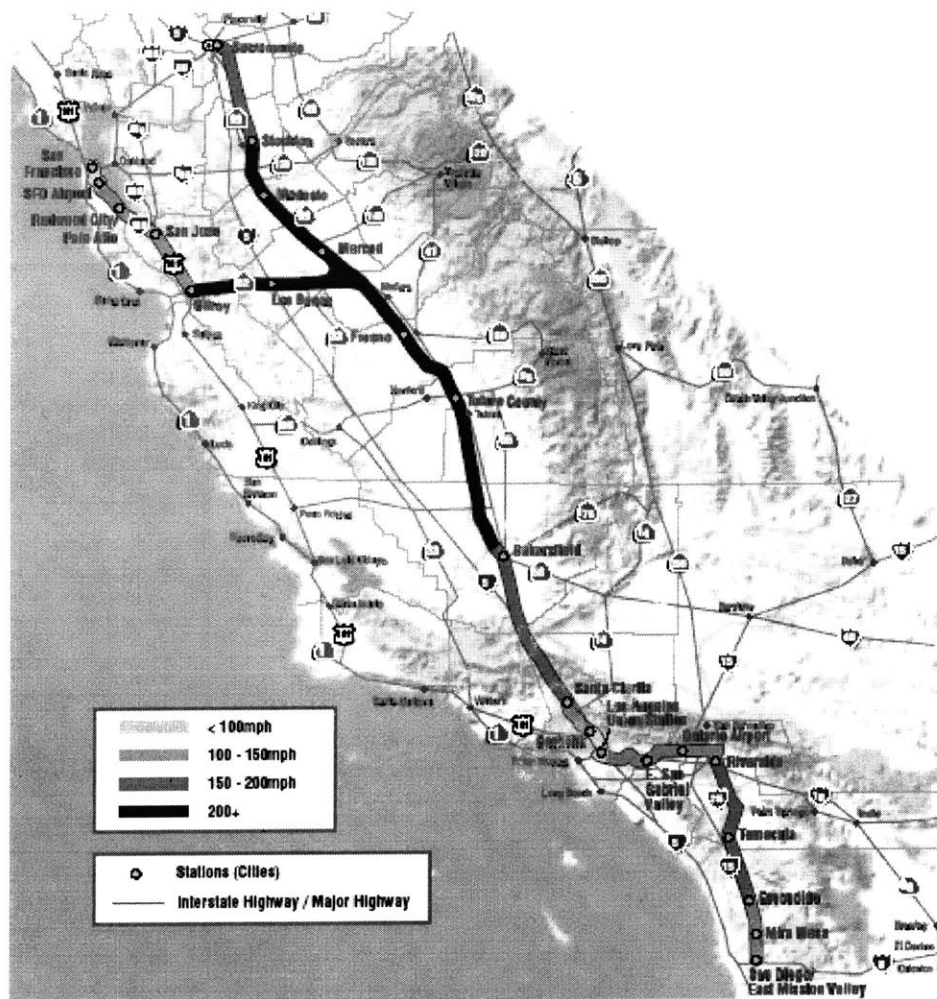


Figure 4.13 The Proposed Operating Speed for the California High-Speed Train
 Source: California High-Speed Rail Authority

4.2.2 Financial feasibility and resource

The initial investment in the plan is 30 billion dollars, including rolling stock, track and other supporting facilities. Table 4.8 shows expenses for each rail segment. Compared with

Japan, the average cost per mile is low. In Japan, the Nagano Shinkansen project (Takasaki-Nagano, 73 miles, opened on October 1, 1997) cost 110 million dollars per mile³¹. However, as the California High-Speed Rail line has almost no tunnels, the relatively low unit cost is possible and similar to the unit cost of the Metro Blue and Green lines in Los Angeles³². Even north of Los Angeles, Interstate 5 has no tunnels. From Los Angeles to San Francisco, there are no tunnels and a small portion of elevated roads.

Table 4.8 Expense for Each Rail Segment

Segment	Length (Miles)	Capital Cost (Billions \$,	Average Cost / Mile (Millions \$, 1999)
Los Angeles- Bakers Field	110	4.4	40.0
Bakers Field- Merced	160	2.3	14.4
Merced- San Jose	129	4.5	34.8
San Jose- San Francisco	43	2.5	58.1
Merced- Sacramento	110	3.0	27.3
Los Angeles- Riverside	59	2.7	45.7
Riverside- San Diego	92	4.1	44.5
Subtotal	703	23.5	33.4
Vehicle & Support Facilities		1.5	
Total		25.0	35.6

Source: California High-Speed Rail Authority

Table 4.9 shows the overall California State Budget in 2005-2006. California will spend a total of 86 billion dollars, but only 380 million dollars for business, transportation and housing, from the general state fund. To give a sense of scale, the initial expense for the California HSR is 35% of the State's total annual general budget. However, transportation has other financial resources, such as fuel taxes. Overall revenue is approximately \$18.9 billion in 2005-2006. Figure 4.14 shows the details of transportation financial resources.

³¹ Ministry of Land, Infrastructure and Transportation, Japan

³² See table 4.6.

Table 4.9 California Governor's Budget 2005-2006

General Fund Revenues and Expenditures				
2004-05 Revised vs. 2005-06 Proposed				
(Dollars in Millions)				
REVENUES	Revised 2004-05	2005-06	Dollar Change	Percent Change
Revenues	\$77,903.9	\$83,227.5	\$5,323.6	6.8
Transfers	315.2	544.0	228.8	72.6
Totals, Revenues and Transfers	78,219.1	83,771.5	5,552.4	7.1
New Economic Recovery Bonds	2,012.0 ¹¹	1,682.8	-329.2	-16.4
Total	\$80,231.1	\$85,454.3	\$5,223.2	6.5
EXPENDITURES				
NON-PROPOSITION 98:				
Governor's Office	\$18.4	\$18.3	-\$0.1	-0.5
Remaining Executive	793.2	759.8	-33.4	-4.2
Legislature	297.7	309.9	12.2	4.1
Judicial	1,763.7	1,928.2	164.5	9.3
State and Consumer Services	534.9	563.4	28.5	5.3
Business, Transportation and Housing	376.6	380.3	3.7	1.0
Resources/Environmental Protection	1,140.8	1,338.7	197.9	17.3
Health and Human Services	25,518.6	26,689.2	1,170.6	4.6
Youth and Adult Correctional	6,896.9	6,979.7	82.8	1.2
Non-Proposition 98 Education	7,911.8	8,589.3	677.5	8.6
STRS Contribution	1,148.8	581.4	-567.4	-49.4
Labor and Workforce Development	87.2	87.2	0.0	0.0
General Government	1,682.5	980.1	-702.4	-41.7
Total - Non-Proposition 98	\$48,171.1	\$49,205.5	\$1,034.4	2.1
PROPOSITION 98:	\$34,123.8	\$36,532.3	\$2,408.5	7.1
TOTAL - ALL EXPENDITURES	\$82,294.9	\$85,737.8	\$3,442.9	4.2

¹¹ For the purposes of this table, this amount is included in General Fund resources to provide better comparability. It was budgeted as a reduction in expenditures in the 2004 Budget Act.

Source: California Department of Finance website <http://www.dof.ca.gov>

As the FRA did not approve the HSR operation on conventional railroads for safety reasons, it is necessary to construct new dedicated tracks for HSR. The authority does not expect to recover the initial investment by HSR fares, and intends to recover only operation expense from fares

To provide resources, the authority intends to seek a rise in the State's sales tax or gas tax in the business plan, but finally, the general obligation bond was adopted.

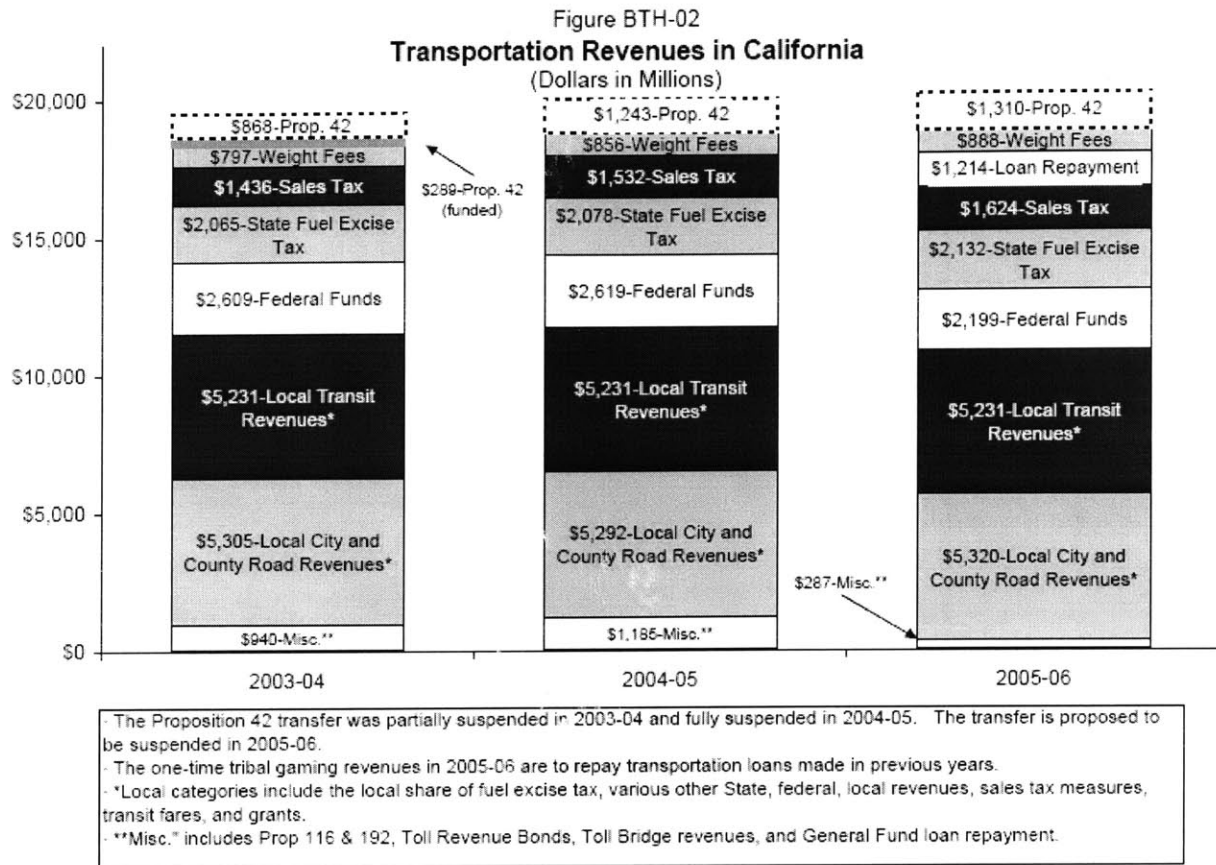


Figure 4.14 Transportation Revenue in California

Source: California Department of Finance website <http://www.dof.ca.gov>

In addition to state funds, the authority intends to acquire grants from federal government. The authority will not depend on local government funds, but local segments might make some investment in a station location with the authority with their own funds.

The cost estimation includes a contingency of 25 percent of the construction costs, and an additional 3 percent of construction costs as an allowance for environmental impact mitigation. Sixty two percent of capital costs are for construction, 16% is for design, also 16% is for program implementation, and only five percent is for rolling stock.

Chapter 697, Statutes of 2002, set about \$10 billion general obligation bond on the November 2004 ballot to fund the California HSR project, but the Governor proposed 2004-05 budgets with a repeal of Chapter 697, because of the State's severe financial condition. Finally, the ballot was postponed to 2006.

4.2.3 Schedule

The project's expected revenue start date is July 2020. The authority expects a total of 16 years for the environmental impact report, the preliminary design, and the construction.

Table 4.10 Schedule

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Development of Program Level EIR/EIS																
Project-Specific Environmental Analysis, Preliminary Design																
Final Design and Construction																

4.2.4 Competitors and Revenue forecast

The authority expects 32 million intercity passengers annually, as well as 10 million commuters with \$900 million revenue and more than \$300 million surplus. Expected revenue per passenger is about \$23. However, the initial investment repayment is impossible from passenger fares. Table 4.11 shows average fare and usage forecast in the business plan. Table 4.12 shows expected initial investment sources and usage breakdown.

Table 4.11 Average Fare and Usage Forecast in 2020

	Average Fare(\$)	Usage		Revenue (Million \$)
		Year	Daily	
Intercity	27.7	32,100,000	87,945 (70%)	888 (93%)
Commuting	7.2	9,600,000	37,500 (30%)	69 (7%)
All	22.9	41,700,000	125,445 (100%)	957 (100%)

Table 4.12 Source and Use of Funds in Final Business Plan 2000

Source of Funds	Million \$	%
1/4-cent Statewide Sales Tax Revenue	18,564	70%
Sales Tax Bond Net Proceeds	3,739	14%
Commercial Paper Net Proceeds	999	4%
Other Funding Sources	723	3%
Interest Earned on Cash Balances	2,577	10%
TOTAL	26,602	100%

Use of Funds	Million \$	%
Capital Costs	24,974	94%
Sales Tax Bond Principal and Interest Payments	1,627	6%
Ending Cash Balance	1	0%
TOTAL	26,602	100%

Table 4.13 Proposed HSR Fare in Final Business Plan 2000

	Average Business (ONE-WAY)	Fare Non-Business (ONE-WAY)
Downtown Los Angeles –Downtown San Francisco	\$42	\$24
Merced –Downtown San Francisco	\$33	\$18
Fresno –Downtown Los Angeles	\$35	\$20
Downtown Los Angeles – San Diego	\$32	\$18
Bakersfield –Sacramento	\$37	\$21
Burbank –San Jose	\$40	\$22
Sacramento – San Jose	\$35	\$20

Table 4.13 shows proposed HSR fare. Comparing with Japanese HSR, the fare of which is about \$40 for about 60 mile trip³³, these fares are low. In the Japanese case, HSR ticket price is always the same. The one month advanced purchase price and the price purchasing just before the departure are same. Commercial airlines and automobiles are two major competitors for the California HSR. The airlines will fight this HSR system politically. The plan set the HSR fare with a consideration of competitors' pricing. Commercial airlines connect between these cities within two hours. As there is tough competition between commercial airlines in California, airline fares are relatively low. For example, in January 2005, a sample round trip fare from Los Angeles to San Francisco is about \$150.

Appendix 1 shows Southwest Airline's Top 25 Carrier Market in third quarter 2003. SouthWest Airline is currently the largest domestic air carrier in the US and top low fare carrier. The airline's most popular segment was between Oakland, near San Francisco, and Los Angeles. The airline carried an average 1,584 passengers per day, with an average fare of \$66.3. In addition, 17 of the top 25 carrier markets of the airline are California origin or destination.

The second competitor is automobiles. Traveling by automobiles between those four cities takes a long time. For example, it takes over seven hours from Los Angeles to San Francisco. However, it is the cheapest way. Only gas and toll for road are necessary, and these are relatively cheap in the US.

³³ Table 3.1

The authority set the HSR fare as 50-60% of the present commercial airlines' fare. For example, business traveler sample fare from Los Angeles to San Francisco is \$42, and non-business traveler sample fare for the same ride is \$24.

In some cases, highway buses are competitors for HSRs. However, for over 300 miles intercity travel, highway buses have a relatively small market share.

As intercity transportation for California, the operating cost of HSR project is over the fare revenue, as long as the capital cost is provided by state grants. However, one of the most important transportation problems for cities is daily traffic congestion. From considerations of HSR operation in other countries, HSR can contribute toward commuting travels. In the next section, we will discuss commuter use benefit of California high-speed rails.

4.3 Case Study: the Benefit from HSR Commuting

4.3.1 The Commission's HSR Commuting³⁴

HSR commuting is not a new idea for the California HSR project. The Intercity High Speed Rail Commission submitted the final report, High Speed Rail Summary Report and Action Plan, on December 13, 1996. This report mentioned HSR commuting between Los Angeles and Palmdale with a distance of about 60 miles. To attract many existing automobile commuters, the report set the HSR commuting fare relatively low, \$6, which included \$2 boarding charge and 6.4 cents per mile charge. Thus, the report recommended public subsidizing and operation by public operators, such as Metrolink or BART. The number of estimated HSR commuters in 2015 was large, between 2.7 million and 3.7 million combined with Los Angeles and Bay Area in a year. As the commission report's main subject was high-speed inter city passenger transportation, the report did not mentioned HSR commuting in detail.

³⁴ High-Speed Rail Summary Report and Action Plan, The Intercity High Speed Rail Commission, December 1996, Chapter 4.7 Commuter Patronage Potential

Table 4.14 Estimated HSR Commuter in the Commission Report, Year 2015

	Annual Ridership (millions)	Annual Revenue (\$millions)	Revenue Per Rider (\$)	Inbound End-to-End Market
1 Bakersfield to Los Angeles via I-5	2.7	15	5.56	69%
2 Bakersfield to Los Angeles via SR 14	3.7	23	6.13	61%
3 Giloy to San Francisco	2.8	11	3.74	24%
4 Stockton to San Francisco	3.0	13	4.20	33%

Source High-Speed Rail Summary Report and Action Plan, Intercity High Speed Rail Commission, 1996, pp4-33

4.3.2 The Authority’s HSR Commuting

The authority is also considering the HSR commuting idea for the California project. In the business plan, the authority mentioned HSR commuting. The authority set \$5.00 per ride plus 6.2 cents per mile for commuting usage charge, and expected daily 37.5 thousands users, which was equal to 9.6 million annual users. In the business plan, the authority expected four trains per hour in weekday peak hours. The authority intended to use the same infrastructures for both intercity and commuting, but did not mentioned whether the same rolling stock would be used.

4.3.3 Introducing Japanese Style HSR Commuting

In this section, we will discuss the benefits from introducing Japanese base HSR commuting to California. The Japanese based HSR commuting use the same track and rolling stock for HSR commuting, while the commission’s and authority’s HSR commuting plan did not mentioned whether those HSR commuter trains use the same rolling stock as intercity service.

First, by introducing the Japan Style HSR commuting, we can acquire both intercity and commuter rail transportation with relatively a small amount of additional investment for commuters. Generally, most of the expense for a HSR project is for infrastructures. For example, in the California HSR project case, 20 billion dollars are for civil and other surface infrastructures for 700 miles of track, which is 80% of the total.

Even if it is necessary for minor modifications for commuting use of HSRs, it costs a relatively small amount comparing with other infrastructure expense. In the California HSR project, less than 5% of total initial investment is for rolling stock³⁵. Therefore, sharing surface infrastructures, such as rights-of-way, tracks, catenaries, signal systems, and others are essential for efficient rail transportation.

Second, we can provide commuter service for a larger metropolitan area than at present. As HSRs run faster than conventional commuter trains, the commuting area of HSR is wider than that of conventional commuter rails. In addition, the number of HSR commuter trains can be more than present conventional commuter trains.

In the north of Los Angeles, the HSR will parallel the Metrolink Antelope Valley Line. In the east of Los Angeles, the HSR will parallel the Metrolink Riverside Line. Table 4.15 shows the timetable of Metrolink Antelope Valley Line to Los Angeles on weekdays. The number of trains is only twelve, and trains take more than one and half-hours from Palmdale to Los Angeles. HSR train connects these cities within one hour. The authority's HSR timetable example³⁶ includes 64 local trains stopping at Santa Clarita and Riverside.

³⁵ See Table 4.8.

³⁶ The authority's final business plan p.58

Table 4.15 Metrolink Antelope Valley Line Weekday Schedule to Los Angeles

TO LOS ANGELES	READ DOWN	200	202	204	206	208	X	212	214	216	218	X	222
							210					220	
LANCASTER		4:00a	5:10a	5:50a	6:23a	6:55a	-	9:00a	11:27a	1:40p	-	-	5:50p
PALMDALE		4:09a	5:19a	5:59a	6:32a	7:04a	-	9:09a	11:36a	1:49p	-	-	5:59p
VINCENT GRADE / ACTON		4:20a	5:30a	6:10a	6:43a	7:15a	-	9:20a	11:47a	2:00p	-	-	6:08p
VIA PRINCESSA		4:52a	6:02a	6:42a	7:15a	7:47a	8:47a	9:52a	12:19p	2:32p	3:17p	-	6:49p
SANTA CLARITA		4:58a	6:08a	6:48a	7:21a	7:53a	8:53a	9:58a	12:25p	2:38p	3:23p	5:15p	6:55p
NEWHALL		5:05a	6:15a	6:55a	7:28a	8:00a	9:00a	10:06a	12:33p	2:45p	3:30p	5:22p	7:02p
SYLMAR / SAN FERNANDO		5:18a	6:28a	7:10a	7:41a	8:13a	9:13a	10:19a	12:46p	2:58p	3:43p	5:35p	7:19p
SUN VALLEY		5:25a	6:35a	7:17a	7:48a	8:20a	9:20a	10:26a	12:53p	3:05p	3:50p	5:42p	7:26p
DOWNTOWN BURBANK		5:31a	6:41a	7:23a	7:54a	8:26a	9:26a	10:32a	12:58p	3:11p	3:55p	5:48p	7:32p
GLENDALE		5:37a	6:47a	7:29a	8:00a	8:32a	9:32a	10:38a	1:04p	3:17p	4:01p	5:54p	7:38p
L.A. UNION STATION		5:53a	7:03a	7:45a	8:16a	8:48a	9:50a	10:54a	1:20p	3:33p	4:19p	6:10p	7:50p

Source: Metrolink website

X: Trains do not operate on Thanksgiving Friday, Martin Luther King Day, and Presidents' Day.

In the San Francisco area, the HSR parallels Caltrain. Table 4.16 shows the time schedule of Caltrain. Caltrain runs more trains than Metrolink, but it takes almost one and half hours from San Jose to San Francisco, but the HSR would take less than 50 minutes³⁷.

Table 4.16 Caltrain Time Table

GILROY / SAN JOSE to SAN FRANCISCO - Northbound	Weekdays																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
	111	113	215	117	219	221	223	225	227	229	231	233	235	237	239	241	243	245	247	249	251	253	255	257	259	261	263	265	267	269	271	273	275	277	279	281	283	285	287	289	291	293	295	297	299	301	303	305	307	309	311	313	315	317	319	321	323	325	327	329	331	333	335	337	339	341	343	345	347	349	351	353	355	357	359	361	363	365	367	369	371	373	375	377	379	381	383	385	387	389	391	393	395	397	399	401	403	405	407	409	411	413	415	417	419	421	423	425	427	429	431	433	435	437	439	441	443	445	447	449	451	453	455	457	459	461	463	465	467	469	471	473	475	477	479	481	483	485	487	489	491	493	495	497	499	501	503	505	507	509	511	513	515	517	519	521	523	525	527	529	531	533	535	537	539	541	543	545	547	549	551	553	555	557	559	561	563	565	567	569	571	573	575	577	579	581	583	585	587	589	591	593	595	597	599	601	603	605	607	609	611	613	615	617	619	621	623	625	627	629	631	633	635	637	639	641	643	645	647	649	651	653	655	657	659	661	663	665	667	669	671	673	675	677	679	681	683	685	687	689	691	693	695	697	699	701	703	705	707	709	711	713	715	717	719	721	723	725	727	729	731	733	735	737	739	741	743	745	747	749	751	753	755	757	759	761	763	765	767	769	771	773	775	777	779	781	783	785	787	789	791	793	795	797	799	801	803	805	807	809	811	813	815	817	819	821	823	825	827	829	831	833	835	837	839	841	843	845	847	849	851	853	855	857	859	861	863	865	867	869	871	873	875	877	879	881	883	885	887	889	891	893	895	897	899	901	903	905	907	909	911	913	915	917	919	921	923	925	927	929	931	933	935	937	939	941	943	945	947	949	951	953	955	957	959	961	963	965	967	969	971	973	975	977	979	981	983	985	987	989	991	993	995	997	999	1001	1003	1005	1007	1009	1011	1013	1015	1017	1019	1021	1023	1025	1027	1029	1031	1033	1035	1037	1039	1041	1043	1045	1047	1049	1051	1053	1055	1057	1059	1061	1063	1065	1067	1069	1071	1073	1075	1077	1079	1081	1083	1085	1087	1089	1091	1093	1095	1097	1099	1101	1103	1105	1107	1109	1111	1113	1115	1117	1119	1121	1123	1125	1127	1129	1131	1133	1135	1137	1139	1141	1143	1145	1147	1149	1151	1153	1155	1157	1159	1161	1163	1165	1167	1169	1171	1173	1175	1177	1179	1181	1183	1185	1187	1189	1191	1193	1195	1197	1199	1201	1203	1205	1207	1209	1211	1213	1215	1217	1219	1221	1223	1225	1227	1229	1231	1233	1235	1237	1239	1241	1243	1245	1247	1249	1251	1253	1255	1257	1259	1261	1263	1265	1267	1269	1271	1273	1275	1277	1279	1281	1283	1285	1287	1289	1291	1293	1295	1297	1299	1301	1303	1305	1307	1309	1311	1313	1315	1317	1319	1321	1323	1325	1327	1329	1331	1333	1335	1337	1339	1341	1343	1345	1347	1349	1351	1353	1355	1357	1359	1361	1363	1365	1367	1369	1371	1373	1375	1377	1379	1381	1383	1385	1387	1389	1391	1393	1395	1397	1399	1401	1403	1405	1407	1409	1411	1413	1415	1417	1419	1421	1423	1425	1427	1429	1431	1433	1435	1437	1439	1441	1443	1445	1447	1449	1451	1453	1455	1457	1459	1461	1463	1465	1467	1469	1471	1473	1475	1477	1479	1481	1483	1485	1487	1489	1491	1493	1495	1497	1499	1501	1503	1505	1507	1509	1511	1513	1515	1517	1519	1521	1523	1525	1527	1529	1531	1533	1535	1537	1539	1541	1543	1545	1547	1549	1551	1553	1555	1557	1559	1561	1563	1565	1567	1569	1571	1573	1575	1577	1579	1581	1583	1585	1587	1589	1591	1593	1595	1597	1599	1601	1603	1605	1607	1609	1611	1613	1615	1617	1619	1621	1623	1625	1627	1629	1631	1633	1635	1637	1639	1641	1643	1645	1647	1649	1651	1653	1655	1657	1659	1661	1663	1665	1667	1669	1671	1673	1675	1677	1679	1681	1683	1685	1687	1689	1691	1693	1695	1697	1699	1701	1703	1705	1707	1709	1711	1713	1715	1717	1719	1721	1723	1725	1727	1729	1731	1733	1735	1737	1739	1741	1743	1745	1747	1749	1751	1753	1755	1757	1759	1761	1763	1765	1767	1769	1771	1773	1775	1777	1779	1781	1783	1785	1787	1789	1791	1793	1795	1797	1799	1801	1803	1805	1807	1809	1811	1813	1815	1817	1819	1821	1823	1825	1827	1829	1831	1833	1835	1837	1839	1841	1843	1845	1847	1849	1851	1853	1855	1857	1859	1861	1863	1865	1867	1869	1871	1873	1875	1877	1879	1881	1883	1885	1887	1889	1891	1893	1895	1897	1899	1901	1903	1905	1907	1909	1911	1913	1915	1917	1919	1921	1923	1925	1927	1929	1931	1933	1935	1937	1939	1941	1943	1945	1947	1949	1951	1953	1955	1957	1959	1961	1963	1965	1967	1969	1971	1973	1975	1977	1979	1981	1983	1985	1987	1989	1991	1993	1995	1997	1999	2001	2003	2005	2007	2009	2011	2013	2015	2017	2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041	2043	2045	2047	2049	2051	2053	2055	2057	2059	2061	2063	2065	2067	2069	2071	2073	2075	2077	2079	2081	2083	2085	2087	2089	2091	2093	2095	2097	2099	2101	2103	2105	2107	2109	2111	2113	2115	2117	2119	2121	2123	2125	2127	2129	2131	2133	2135	2137	2139	2141	2143	2145	2147	2149	2151	2153	2155	2157	2159	2161	2163	2165	2167	2169	2171	2173	2175	2177	2179	2181	2183	2185	2187	2189	2191	2193	2195	2197	2199	2201	2203	2205	2207	2209	2211	2213	2215	2217	2219	2221	2223	2225	2227	2229	2231	2233	2235	2237	2239	2241	2243	2245	2247	2249	2251	2253	2255	2257	2259	2261	2263	2265	2267	2269	2271	2273	2275	2277	2279	2281	2283	2285	2287	2289	2291	2293	2295	2297	2299	2301	2303	2305	2307	2309	2311	2313	2315	2317	2319	2321	2323	2325	2327	2329	2331	2333	2335	2337	2339	2341	2343	2345	2347	2349	2351	2353	2355	2357	2359	2361	2363	2365	2367	2369	2371	2373	2375	2377	2379	2381	2383	2385	2387	2389	2391	2393	2395	2397	2399	2401	2403	2405	2407	2409	2411	2413	2415	2417	2419	2421	2423	2425	2427	2429	2431	2433	2435	2437	2439	2441	2443	2445	2447	2449	2451	2453	2455	2457	2459	2461	2463	2465	2467	2469	2471	2473	2475	2477	2479	2481	2483	2485	2487	2489	2491	2493	2495	2497	2499	2501	2503	2505	2507	2509	2511	2513	2515	2517	2519	2521	2523	2525	2527	2529

the round trip time of rolling stock is short.

Finally, by sharing the same rolling stock, tracks, and signal system, we can acquire a simple and safe rail transportation system. A complicated system often causes accidents. System operation might be complicated. For example, not all train need to stop all intermediate stations. Several trains should pass some stations for express service. However, the system itself should be simple and elementary.

4.3.4 The Area Study: HSR Commuting Potential in North Los Angeles Area

In this section, we discuss in detail the commuting potential in north Los Angeles area. Figure 4.15 shows current highway route map. In North Los Angeles area, the proposed HSR take a route from Los Angeles to Palmdale via Burbank and Santa Clarita along Interstate 5 and State Road 14.

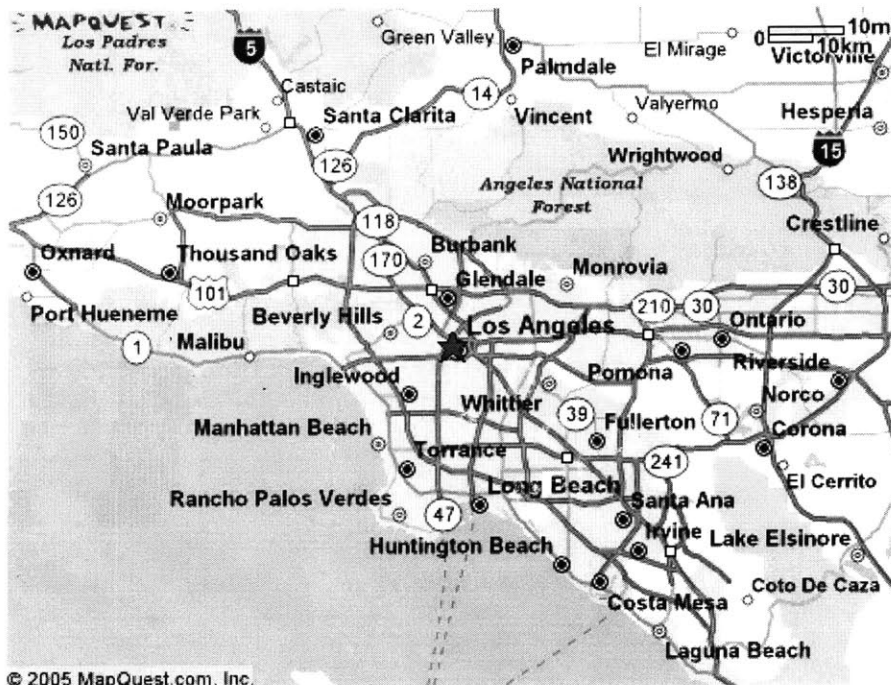


Figure 4.15 Highway Route Map
Source: Mapquest <http://www.mapquest.com>

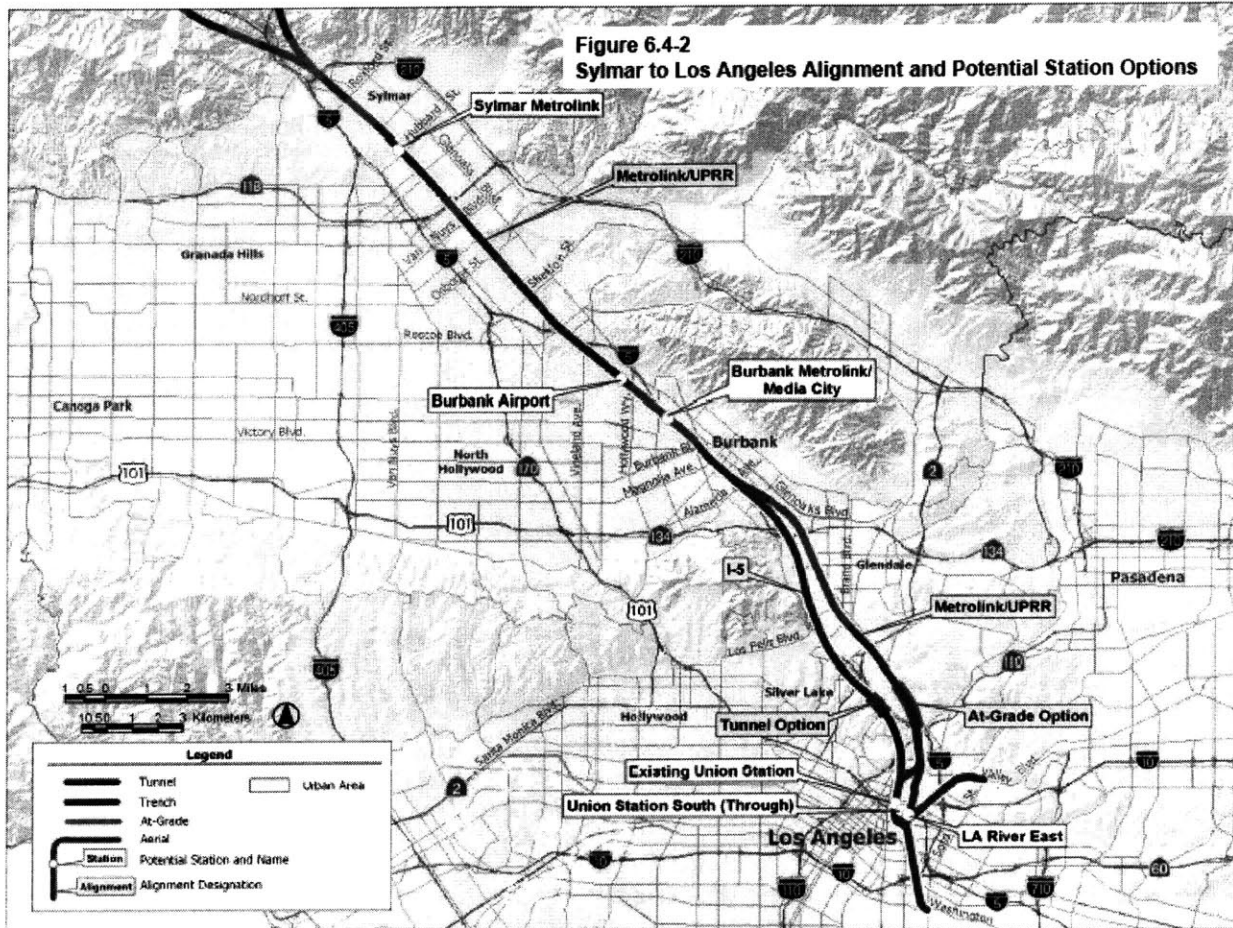


Figure 4.16 The proposed HSR route from Los Angeles to Sylmar
 Source: The California High-Speed Rail Authority website staff recommendations

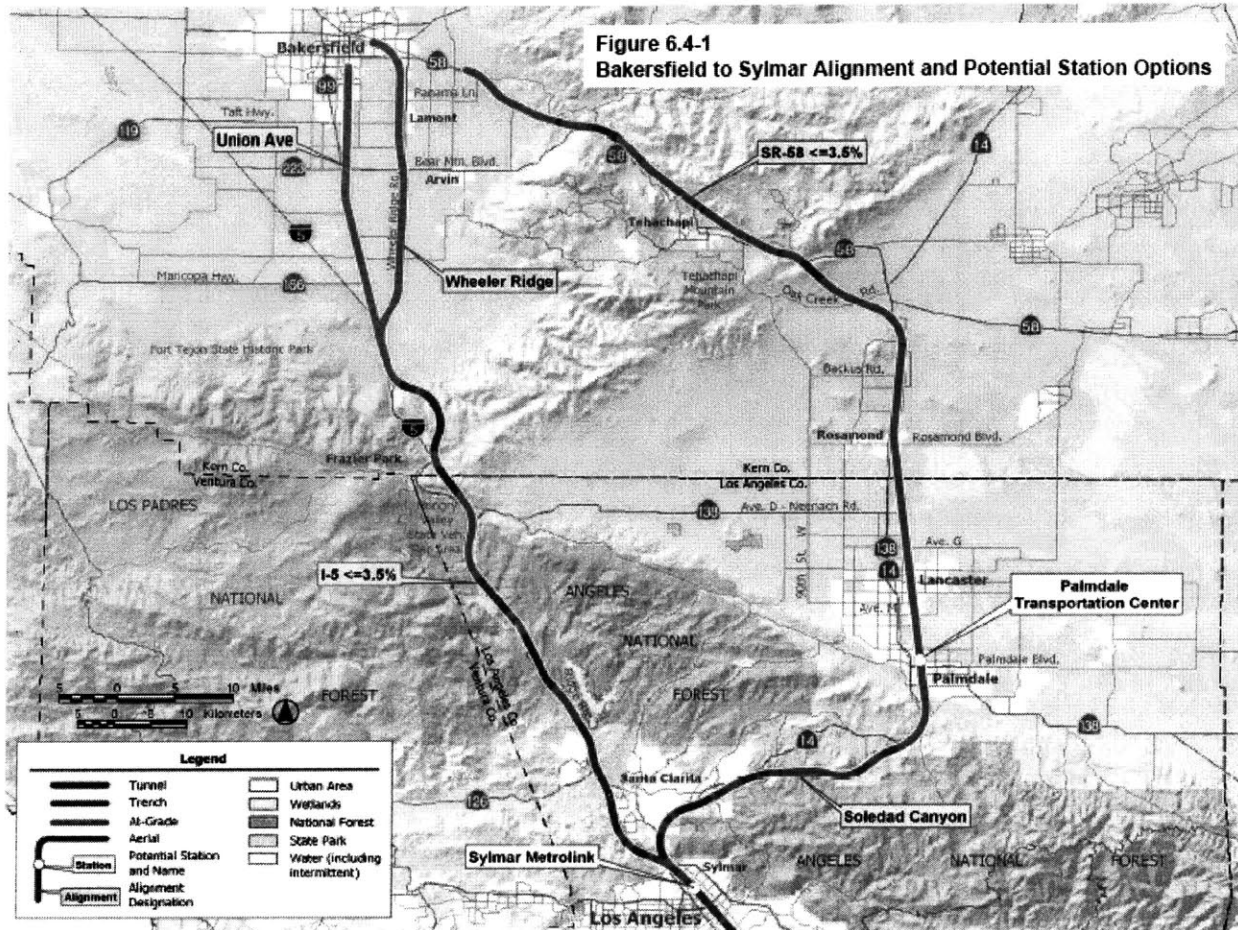


Figure 4.17 The proposed HSR route from Sylmar to Bakersfield
Source: The California High-Speed Rail Authority website staff recommendations

From Los Angeles to Lancaster, automobile takes 72 minutes in general via Interstate 5 and State Road 14 with a distance of about 73 miles³⁸, while the Metrolink commuter trains runs at the same route in about two hours.

In the suburbs of Los Angeles, the population grows more than the downtown. Lancaster and Palmdale’s population growths from 1990 to 2000 are more than 20% while the Los Angeles city and the Burbank city ‘s population growths are both about 6-7%.

The annual average daily traffic (AADT) of State Road 14 at Palmdale was 159,000 cars per day³⁹ and eastbound peak traffic was 7,200 cars per hour in the same period, while an average of 6,817 passengers used the Metrolink Antelope Valley Line in 2004. The peak fare of

³⁸ Search Result of Mapquest. <http://www.mapquest.com>

³⁹ Caltrans, The Traffic and Vehicle Data Systems Unit, in 2003

Metrolink from Lancaster or Palmdale to Los Angeles Union Station is \$8.75⁴⁰.

Table 4.17 Population and Housing Unit Price in the North of Los Angeles

Name	Population in 2000	Increase from 1990	Median House Unit
Los Angeles	3,694,820	6.0%	\$221,600
Burbank (city)	100,310	7.1%	\$256,400
Santa Clarita (city)	151,088	22.2%	\$229,200
Palmdale (city)	116,670	50.9%	\$116,400
Lancaster (city)	118,718	20.6%	\$103,700
California All State	33,871,648	13.6%	\$211,500

Source: U.S. Census Bureau, <http://quickfacts.census.gov>

Table 4.18 Metrolink Antelope Valley Line Statistics

Stations	10
Route Miles	76.6
Trains*	24
Daily Ride*	6,817
Average Speed	42mph

Source: Metrolink Website, 2004, Weekdays

Six trains do not serve for Lancaster and Palmdale

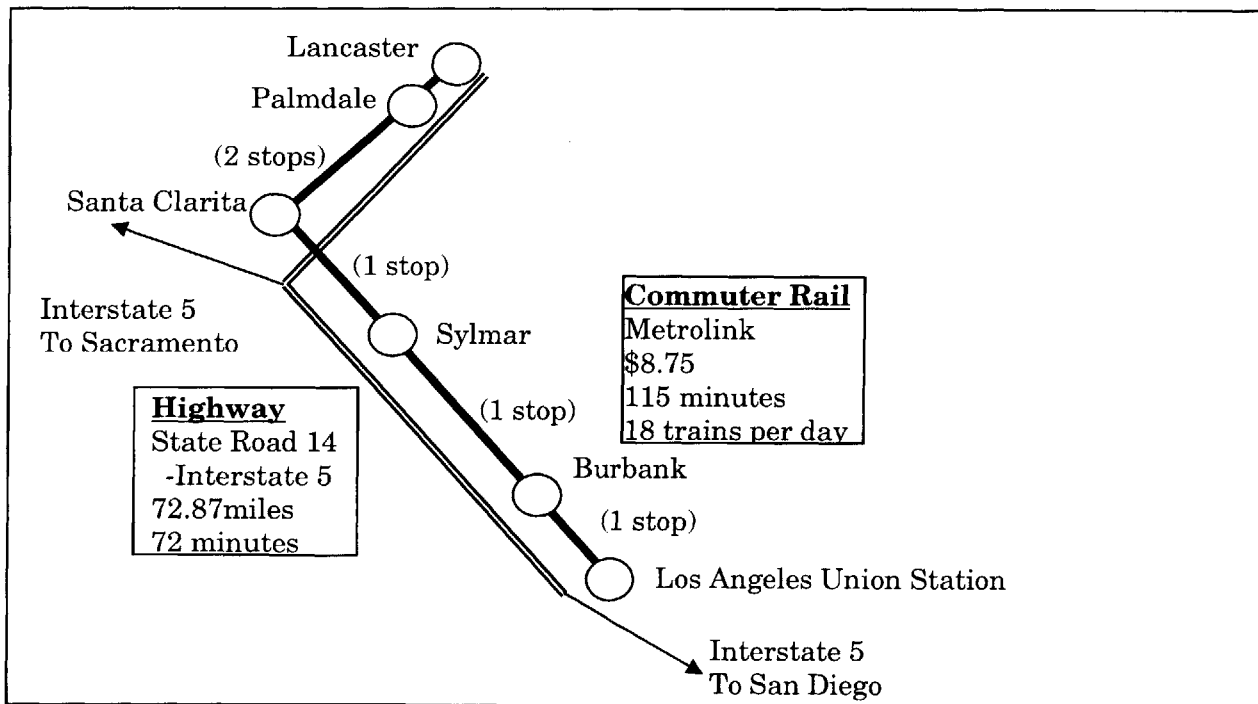


Figure 4.18 Existing Major Rail and Road from Los Angeles to Lancaster

Figure 4.19 shows expected HSR commuting stations, time, fare, and the number of

⁴⁰ Five zones at peak hours. Source: Metrolink website

trains. The authority's business plan in 2000 selected the route along Interstate 5 from Los Angeles to Bakersfield, but currently, the route changed to via Palmdale, which had fewer tunnels. The authority did not mention clearly the construction of Santa Clarita and Lancaster stations, but we assume that for effective HSR commuting, these stations are necessary. Commuting fare is based on the assumption of the authority, \$5 boarding charge plus 6.2 cents per mile ride. From Los Angeles to Lancaster (about 70 miles,) the projected fare is \$9.50. It is relatively low, comparing with double HSR price to conventional rails in Japan. However, as the first attempt to HSR commuting in the US, this pricing is a possible option. The number of HSR commuting trains is that of local trains in the business plan timetable example. By the assumption of average speed of 150 mph⁴¹, it takes about a half hour.

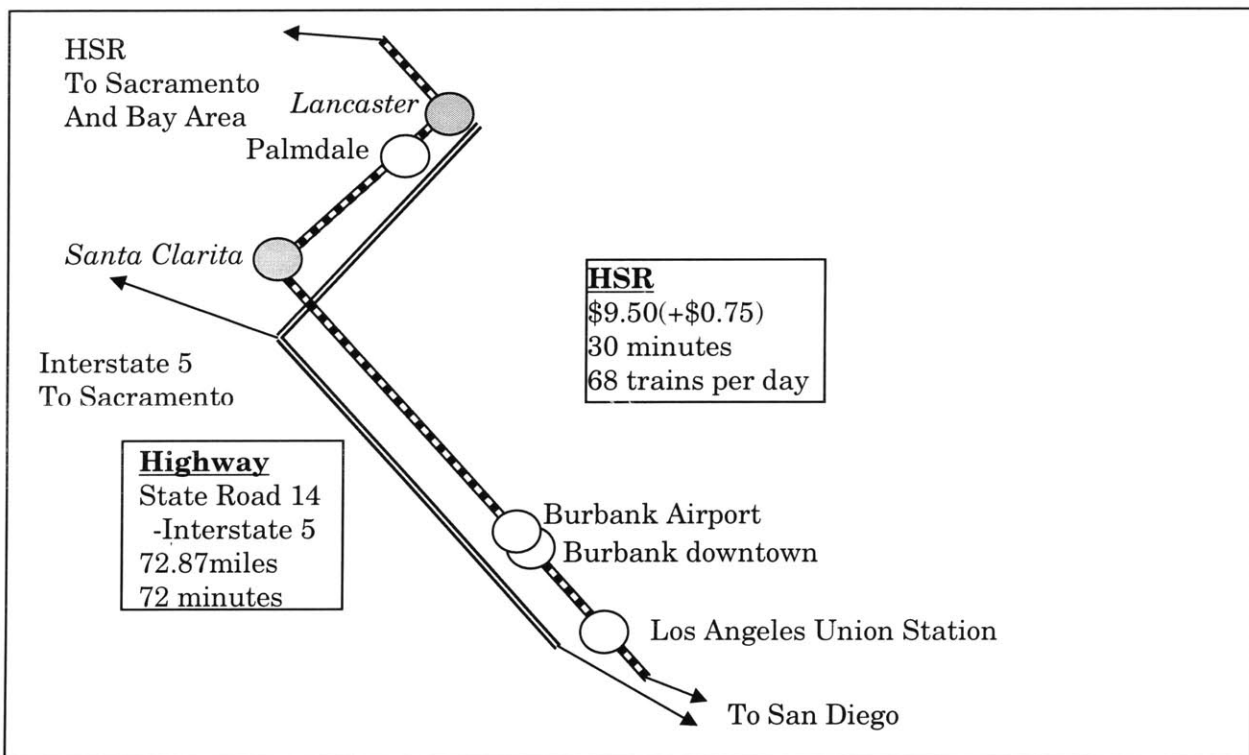


Figure 4.19 Future HSR Commuting and Highway from Los Angeles to Lancaster
 HSR commuting fare and time is from Los Angeles Union Station to Lancaster.

HSR commuting usage forecast is 17,100 passengers per day in the area with four trains

⁴¹ Figure 4.13

per hour in peak hours⁴².

Table 4.19 shows unit costs and unit revenues of expected HSR commuting and current commuter rails in California. HSR operating unit revenue is expected to exceed its unit expense. The unit revenue of current commuter rail, Metrolink, is lower than the expense.

Table 4.19 Operating Revenue and Expense (HSR and Conventional Rail) in California

	HSR	Conventional
Operating Expense (\$millions)	50	111
Operating Revenue (\$millions)	70	60
Revenue/Expense	140%	54%
Unit Expense (\$/mile)	0.07	0.30
Unit Revenue (\$/mile)	0.15	0.16
Unit Income (\$/mile)	0.08	-0.14

Source: HSR: The Final Business Plan, June 2000

Conventional: Metrolink website, Weekday Riders:38,774, Average Trip: 36.2 miles

Revenue/Expense: 54%, Calculated Annual Passenger Miles: 366,344,507

Assumption: One year = 261 weekdays

Table 4.20 shows the comparison of cost and revenue between HSR and conventional commuter rail, Metrolink with the assumption of same number and distance commuters. Expected HSR and current conventional rail revenues are same, but the cost of HSR commuting is relatively low, as the total HSR transportation scale is large. While the income of conventional commuter rail is in deficit, HSR commuting would generate surplus.

Table 4.20 Comparison of Cost and Revenue between HSR and Conventional Rail Commuting in California

	HSR	Conventional	Difference
Cost Daily (\$thousands)	84	364	-280
Cost Yearly (\$millions)	22	95	-73
Revenue Daily (\$thousands)	174	196	-22
Revenue Yearly (\$millions)	46	51	-6
Income Daily (\$thousands)	91	-168	259
Income Yearly (\$millions)	24	-44	67

Source: Table 4.19

Assumption: 10,000 commuters per weekday, average 60 mile distance commuting, one year = 261 week days

⁴² Independent Ridership and Passenger Revenue Projections for High Speed Rail Alternatives in California, January 2000. Table 4.10 also refers the Commission's HSR commuting forecast.

Figure 4.20 shows HSR commuting benefit for the operator in California. As the initial infrastructure expense is large, commuting HSR (**Case B**) cannot operate without deficit.

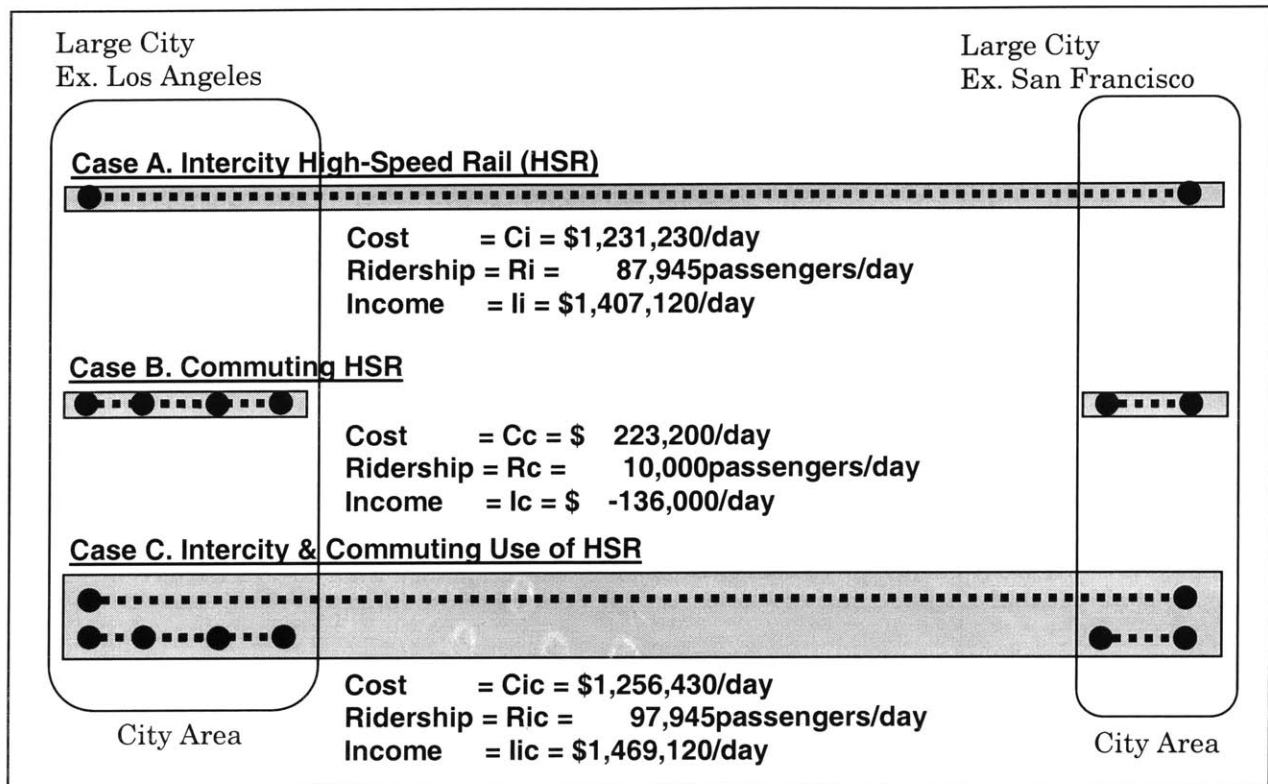


Figure 4.20 HSR Commuting Benefit for the Operator in California

Legend: See Figure 3.8

Source: Intercity: Table 4.11, Inner city: Table 4.20, HSR commuting Revenue: Section 4.3.2, Assumption: Average commuting distance =60 miles, Average intercity trip = 200 miles Cost for inner city HSR, including the redemption of 60 miles dedicated track, 35.7 million dollars per mile, for 30 years, no interest, from Table 4.8

$$\begin{aligned} \text{Intercity \& Commuting Use of HSR Ridership} &= R_{ic} = R_i + R_c \\ &= 87,945 + 10,000 = 97,945 \text{ passengers/day} \quad (9) \end{aligned}$$

$$\begin{aligned} \text{Intercity \& Commuting Use of HSR Revenue} &= V_{ic} = V_i + V_c = U_i \cdot D_i \cdot R_i + V_c \\ &= 0.15(\$/\text{mile}) \cdot 200(\text{miles}) \cdot 87,945(\text{passengers/day}) \\ &+ (\$5 + \$0.062/\text{mile} \cdot 60 \text{ miles})(\$/\text{mile}) \cdot 10,000(\text{passengers/day}) = \$2,725,550/\text{day} \quad (10) \end{aligned}$$

- Vic: Revenue in the commuting use of HSR case (\$/day)
- Vi: Revenue from HSR inner city service (\$/day)
- Vc: Revenue from HSR commuting service (\$/day)
- Ui: Unit Revenue from HSR intercity passengers (\$/mile)
- Di: Average HSR intercity ride distance (miles)

$$\begin{aligned}
 &\underline{\text{Intercity \& Commuting Use of HSR Cost}} = \text{Cic} < \text{Ci} + \text{Cc} \\
 \text{Cic} &= \text{Ei} * \text{Di} * \text{Ri} + \text{Ec} * \text{Dc} * \text{Rc} = 0.07(\$/\text{mile}) * 200(\text{miles}) * 87,945(\text{passengers}/\text{day}) \\
 &+ 0.042(\$/\text{mile}) * 60(\text{miles}) * 10,000(\text{passengers}/\text{day}) = \$1,256,430/\text{day} \\
 \text{Ci} + \text{Cc} &= \text{Ei} * \text{Di} * \text{Ri} + \text{Ecp} * \text{Dc} * \text{Rc} = 0.07(\$/\text{mile}) * 200(\text{miles}) * 87,945(\text{passengers}/\text{day}) \\
 &+ (\$0.372(\$/\text{mile}) * 60(\text{miles}) * 10,000(\text{passengers}/\text{day})) = \$1,454,430/\text{day} \quad (11)
 \end{aligned}$$

$$\begin{aligned}
 &\underline{\text{Intercity \& Commuting Use of HSR Income}} = \text{lic} = \text{Vic} - \text{Cic} > \text{li} + \text{lc} = (\text{Vi} - \text{Ci}) + (\text{Vc} - \text{Cc}) \\
 \text{lic} &= \text{Vic} - \text{Cic} = \$1,469,120/\text{day} > \$1,271,120/\text{day} = \text{li} + \text{lc} \\
 &= \$1,407,120/\text{day} + \$-136,000/\text{day} \quad (12)
 \end{aligned}$$

As is shown in Formula 12, HSR commuting benefits the operator in the California case. Intercity & commuting use of HSR income exceed the total income from separately HSR intercity and commuting service. As the HSR commuting proportion is relatively small, the total income from separately HSR intercity and commuting service is still surplus. However, it is better to provide HSR intercity and commuting service by sharing infrastructures.

HSR commuting is fast and not too expensive. In addition, HSR commuting benefits the operator by generating surplus, while current conventional commuting services are in deficit. However, the problem is feeder transportation facility. In Japan, most of HSR commuters in metropolitan areas are switching from conventional rails, so it is needless to provide extra feeder transportation facilities. However, in California, most of expected HSR commuters are current automobile commuters. It is necessary to provide feeder transportation, such as parking lots and feeder buses. Depending on automobiles as feeders, it is necessary to construct HSR commuting stations within relatively small distances from expected HSR commuters' houses.

HSR commuting benefits commuters by fast and low cost commuting service, but HSR commuting also benefits the operator in California. HSR intercity operators can provide commuting service with a relatively small amount of extra expense. Extra rolling stock and ground infrastructures are unnecessary. If the operator construct rolling stock yard in Lancaster, where the land price is relatively lower than downtown Los Angeles, the operator can provide HSR commuting trains by deadhead train from the yard to Los Angeles before intercity

operations.

In this chapter, we examined the California HSR project as the most feasible one in the US. The project is projected to be self-sufficient once constructed; however, by introducing HSR commuting, the HSR project acquire one more financial resource and can help solve inner city traffic congestion problems. We will summarize the findings and draw conclusions in the next chapter.

Chapter 5 Conclusion

In this chapter, we conclude by listing the principal findings in order from the previous chapters. Finally, we will present the major conclusion.

5.1 Findings

1) Each nation or region has peculiar transportation inclinations, and rail passenger transportation is a potential option for the US.

Each nation or region has peculiar transportation inclinations. In the US, major passenger transportation method is airlines and automobiles, and rail transportation is mostly for freight transportation. However, the congestion of airports and roads are increasing and another transportation option is necessary.

Rail passenger transportation is less energy consuming and is an environmentally effective mode. For the sustainable development of the US without the expansion of more energy consuming and less environmental effective modes, such as airlines and automobiles, the HSR is a potential option.

In other countries, such as Japan, French and Germany, there are successful HSRs. However, as basic transportation modes and social backgrounds are different, the direct application of unfamiliar transportation mode, such as HSRs for the US, is difficult. Risk reduction is essential for any kinds of projects. By introducing another successful technology, such as Shinkansen or TGV, technological risk would be lessening. However, the deliberate consideration of economical and social circumstance is necessary.

2) HSRs are primarily for intercity transportation, and dedicated tracks are necessary for HSR.

To be competitive with other passenger transportation modes, such as airlines and automobiles, dedicated tracks for HSRs are necessary to achieve necessary level of service. In addition, dedicated tracks provide safe transportation without the conflict of road crossings, heavy weight freight trains, and conventional passenger rail traffic. However, as dedicated HSR tracks costs more than incremental HSRs, financial resources are necessary. All the successful HSR cases in this thesis are with dedicated tracks.

From successful HSR examples in Japan, French and Germany, the primary purpose of HSR is intermediate distance intercity passenger transportation. Meanwhile, in the US, there are no HSR by the definition. There are several statewide HSR projects in the US, but none has been constructed.

3) The most difficult hurdle for HSR projects in the US is financial resources

There are several HSR transportation potential corridors, in which large cities are in intermediate distances. In the US, as the whole country is large, nation wide, coast to coast HSR is not effective, but there are still HSR transportation potential regional corridors in Florida, California, Texas, Chicago, and other regions⁴³. However, competing modes, such as airlines and automobiles, are advantageous in time or cost. As the former HSR project, such as Texas TGV⁴⁴, shows, for HSR project in the US, public investment is necessary. However, as the amount of the project cost is huge, the approval of this public investment is most difficult hurdle for HSR projects in the US.

⁴³ Professor Joseph Sussman, WBUR Radio Interview, April 20th, 2005
http://www.publicbroadcasting.net/wbur/news.newsmain?action=article&ARTICLE_ID=763274

⁴⁴ Ibid 10

4) HSR commuting is another potential financial resource, and needs no large additional investment.

From the Japanese case, HSR commuting benefits commuters but also HSR operators. In the Japan case, conventional commuter trains take twice as long as or longer than Shinkansen HSR for commuting. In the East Japan Railway Company's case, more than 25,000 people bought HSR commuting passes.

In addition, HSR commuting is an additional revenue resource. In the East Japan Railway Company's case, 21.4 billion yen (206 million dollars) income was from HSR commuting pass sales in FY 2003. Compared with intercity passenger transportation volume, the Japanese HSR commuting transportation is relatively small, but has sufficient ridership and revenue. HSR commuting has potential to relieve inner city traffic congestion as well.

As commuting and intercity travel are complementary behavior, additional fundamental investments, such as extra tracks and rolling stock, are not necessary. Therefore, HSR commuting is possible with a small amount of extra investment.

5) For effective HSR commuting, there are additional considerations

For effective HSR commuting, several extra considerations, such as monthly commuter passes, coupling function, and shifting seat configuration, are necessary. HSR commuting has to use the same infrastructures as much as possible for low cost operation, but HSR commuting need special operation methods.

6) The reconstruction of public rail transportation is on going in the US.

As is shown in California four big city cases, Los Angeles, San Francisco, San Diego, and Sacramento, the reconstruction of public rail transportation, such as subway systems and LRTs, is ongoing in the US.

7) HSR commuting is a potential option for California, and the US.

HSR commuting is a potential option for California, and the US. As the large cities in California, such as Los Angeles and San Francisco have large population, HSR commuting would be effective relief for inner city automobile congestions. However, feeder transportation mode is different from Japan where conventional trains and buses provide access; in California, providing access for HSR commuters will be more difficult. Automobile parking lots would be necessary in California.

5.2 Conclusion

HSR commuting benefits not only passengers, but also HSR operators. HSR commuting provides fast travel for passengers, but also it is a potential revenue source for intercity HSR projects and operators. In addition, HSR commuting is a possible option for inner city traffic congestion relief.

HSR is an ideal mass transportation mode in intermediate distance, up to 500 miles. There are several successful cases in the world, but the US has not had any. There are some HSR potential states in the US, and the motivation of these states is high. The most severe barrier for HSR projects is financial resources.

Providing commuting service via HSR is a potential option for inner city and intercity traffic congestion in the US. The primary purpose of HSR is intercity passenger travel, but by introducing the concept of HSR commuting, HSR become a potential option for inner city congestion relief. As the geographical and social backgrounds in the US are different from the countries which have successful HSR, a deliberate policy initiative for HSR is necessary.

This thesis has suggested several options for HSR commuting in the US. This alone is not enough to solve both HSR financial resource problem in the US and inner city traffic congestion in the US. However, the author hopes that this thesis is going to be helpful for future investigators and executives considering this option.

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Appendix

Top Carrier Markets Southwest Airlines

4th Quarter 2003

Source: US DOT Database 1A

Southwest airline is the top domestic carrier in the US. Within top 20 market of Southwest airlines, 15 market' origin or destination is in California. California is the large revenue resource for Southwest airlines and the airline will object the HSR project politically.

Carrier Market Rank	All Markets Rank	Market / Carrier	Non- Stop Mileage	Pass Per Day	Revenue Per Day	Market Share (%)	Avg. Yield (cents)	Revenue per Pass (\$)	
1	18	Los Angeles CA	334	1786	118415.8	100	19.67	66.3	
		Oakland CA							
		Southwest Airlines		1584	99235.8	88.69	18.59	62.6	
		United Airlines		111.7	8678	6.25	23.13	77.7	
		Other Locals		90.4	10437.2	5.06	34.16	115.5	
2	13	Dallas/Fort Worth TX	234	2029	144923.7	100	30.66	71.4	
		Houston TX							
		Southwest Airlines		1484.1	103410.5	73.15	29.52	69.7	
		Continental Airlines		268.9	21052.8	13.25	35.27	78.3	
		American Airlines		221	16058.2	10.89	31.73	72.7	
		Other Locals		53.9	4212.8	2.65	33.26	78.2	
Off-line Connects	1	189.4	0.06	0	189.4				
3	33	Oakland CA	448	1298.7	99480.4	100	17.17	76.6	
		San Diego CA							
		Southwest Airlines		1289.2	98756	99.27	17.17	76.6	
		Other Locals		9.5	775.1	0.73	15.93	81.6	
4	42	Burbank CA	325	1215.8	83040.8	100	21.02	68.3	
		Oakland CA							
		Southwest Airlines		1215.8	83040.8	100	21.02	68.3	
5	35	Las Vegas NV	255	1277.7	67470.7	100	20.71	52.8	
		Phoenix AZ							
		Southwest Airlines		1044.9	52000.1	81.78	19.44	49.8	
		America West Airlines		231.3	15288.9	18.1	25.72	66.1	
		Other Locals		1.2	115.6	0.1	27.5	96.3	
Off-line Connects	0.3	66	0.02	0	220.0				
6	22	Los Angeles CA	238	1583.5	100497	100	27.01	63.5	
		Las Vegas NV							
		Southwest Airlines		990	56137.2	62.52	24.13	56.7	
		America West Airlines		315.6	22809.6	19.93	30.62	72.3	
		United Airlines		150.4	13114.8	9.5	36.94	87.2	
		American Airlines		124	8132.1	7.83	27.91	65.6	
		Other Locals		3.4	282.3	0.21	35.5	83.0	
Off-line Connects	0.2	20.9	0.01	0	104.5				
7	65	Oakland CA	361	952.4	56571.9	100	16.5	59.4	
		Ontario CA							
		Southwest Airlines		950.1	56341.3	99.76	16.43	59.3	
Other Locals	2.3	218.5	0.24	22.3	95.0				
8	66	Burbank CA	226	945.9	54247.7	100	25.95	57.4	
		Las Vegas NV							

		Southwest Airlines			908.4	52551.7	96.04	26.18	57.9
		Other Locals			37.5	1689.2	3.96	20.29	45.0
9	74	San Diego	CA	472	917.3	66870.4	100	15.16	72.9
		Sacramento	CA						
		Southwest Airlines			902.4	65604.4	98.38	15.15	72.7
		Other Locals			14.8	1276.1	1.61	16.18	86.2
		Off-line Connects			0.1	0	0.01	0	-
10	57	Las Vegas	NV	407	1007.9	84319.6	100	20.26	83.7
		Oakland	CA						
		Southwest Airlines			856.8	72239.1	85.01	20.66	84.3
		America West Airlines			77.4	6575.1	7.68	20.02	84.9
		Aloha Airlines			50.9	3751.7	5.05	18.17	73.7
		Other Locals			22.4	1703.1	2.23	12.69	76.0
		Off-line Connects			0.3	50.6	0.03	0	168.7
11	38	Los Angeles	CA	372	1232	76138.3	100	16.66	61.8
		Phoenix	AZ						
		Southwest Airlines			850	41991.8	68.99	13.32	49.4
		America West Airlines			230.3	16464.1	18.69	19.17	71.5
		Unduplicated Commuter			143.9	16852.2	11.68	31.65	117.1
		Other Locals			7.4	725.1	0.6	23.82	98.0
		Off-line Connects			0.4	105.1	0.04	0	262.8
12	100	Baltimore/Wash Intl	MD	328	807.3	49404.5	100	18.72	61.2
		Providence	RI						
		Southwest Airlines			790.1	47915.9	97.87	18.55	60.6
		Other Locals			17.2	1490.4	2.13	22.49	86.7
		Off-line Connects			0.1	0	0	0	-
13	49	Oakland	CA	373	1097.4	72650.9	100	17.84	66.2
		Santa Ana	CA						
		Southwest Airlines			754.2	50907.5	68.72	18.19	67.5
		Alaska Airlines			341.7	21615	31.14	17.05	63.3
		Other Locals			1.5	123.7	0.13	14.72	82.5
		Off-line Connects			0.1	4.7	0.01	0	47.0
14	88	Las Vegas	NV	258	870.1	56381.7	100	25.12	64.8
		San Diego	CA						
		Southwest Airlines			750.8	48204.5	86.3	24.98	64.2
		America West Airlines			113.5	7765.6	13.05	26.41	68.4
		Other Locals			5.7	390.3	0.66	19.65	68.5
15	64	San Diego	CA	419	964.6	75529.7	100	18.78	78.3
		San Jose	CA						
		Southwest Airlines			741.8	55935.3	76.91	18.08	75.4
		American Airlines			222	19477	23.01	21.14	87.7
		Other Locals			0.8	108.6	0.08	19.76	135.8
		Off-line Connects			0.1	8.8	0	0	88.0
16	122	Ontario	CA	380	726.6	51877.2	100	18.45	71.4
		Sacramento	CA						
		Southwest Airlines			724.8	51712.9	99.75	18.39	71.3
		Other Locals			1.8	182.1	0.25	18.58	101.2
17	120	Baltimore/Wash Intl	MD	377	734.6	45105.2	100	16.29	61.4
		Manchester	NH						
		Southwest Airlines			711.3	43459.9	96.83	16.21	61.1
		Other Locals			23.3	1664.2	3.17	18.09	71.4
		Off-line Connects			0.1	0	0	0	-
18	73	Phoenix	AZ	301	921	50745.9	100	18.18	55.1
		San Diego	CA						
		Southwest Airlines			708.6	36458.1	76.94	16.98	51.5
		America West Airlines			191.8	11975.3	20.82	20.34	62.4
		Other Locals			20.5	2287.7	2.22	36.03	111.6

19	125	Burbank	CA	349	713	50483.5	100	19.83	70.8	
		Sacramento	CA							
		Southwest Airlines				691.1	49101.7	96.92	19.9	71.0
		Other Locals				22	1369.9	3.08	17.21	62.3
20	134	Las Vegas	NV	344	694.5	45140.3	100	18.73	65.0	
		Reno	NV							
		Southwest Airlines				675.7	43817.1	97.29	18.8	64.8
		Other Locals				18.7	1317.7	2.7	16.88	70.5
21	87	Dallas/Fort Worth	TX	242	878.8	60349	100	27.69	68.7	
		San Antonio	TX							
		Southwest Airlines				666.1	43998.6	75.81	26.63	66.1
		American Airlines				161.1	11892.2	18.34	30	73.8
22	68	Los Angeles	CA	305	941.8	73513.7	100	25.42	78.1	
		San Jose	CA							
		Southwest Airlines				662.5	46308.9	70.34	22.69	69.9
		American Airlines				137.3	11291.5	14.58	26.62	82.2
23	78	Unduplicated Commuter			133.6	15221.7	14.19	36.98	113.9	
		Other Locals			8.3	682.7	0.87	26.53	82.3	
		Off-line Connects			0.2	8.9	0.02	0	44.5	
		Houston	TX	319	905.1	77605.6	100	28.2	85.7	
New Orleans	LA									
Southwest Airlines			631.7		51008	69.79	26.56	80.7		
Continental Airlines			271.1		26348.6	29.96	31.86	97.2		
24	161	Other Locals			2.3	226.4	0.26	18.86	98.4	
		Santa Ana	CA	396	617.1	45697.4	100	18.33	74.1	
		Sacramento	CA							
		Southwest Airlines				602.7	44386.4	97.66	18.28	73.6
Other Locals			14.3		1266.2	2.33	18.98	88.5		
25	137	Off-line Connects			0.1	44.7	0.01	0	447.0	
		Albuquerque	NM	322	679.3	36037.1	100	16.27	53.1	
		Phoenix	AZ							
		Southwest Airlines				591.3	29976.5	87.04	15.55	50.7
America West Airlines			87.9		6046.6	12.94	20.98	68.8		
		Other Locals			0.1	14.6	0.02	41.01	146.0	
		Off-line Connects			0.1	0	0	0	-	