Transformation of High-Speed Rail Stations to Major Activity Centers: Lessons for California

Paper prepared for
World Conference on Transportation Research, 2010

Cornelius Nuworsoo*

Associate Professor
California Polytechnic State University, San Luis Obispo
*Corresponding Author
1 Grand Avenue
San Luis Obispo, CA 93407
Tel.: (805) 756-2573
Fax: (805) 756-1340
Email: cnuworso@calpoly.edu

Elizabeth Deakin
Professor of City and Regional Planning
228 Wurster Hall
Berkeley, California 94720-1850
Tel: (510) 642-4749
Email: edeakin@berkeley.edu

Revised May 23, 2010

Word Count
Abstract (249) + Main body + References = 5955
4 figures * 250 = 1000
Total = 6955

Contents

List of Figures

Abstract

This paper presents findings from domestic and international case studies of developments around high-speed rail stations and derives from these findings some lessons for station area development for California's high-speed rail system. The paper reviews the case for high-speed rail as a complement to air and highway systems in addressing congestion and providing needed additional services as the population of the State continues to grow. Review of domestic and international experiences reveals that well-planned station-area developments can result in desirable impacts on the communities served including: a) good intermodal connections – convenient access and ease of transferring between local and regional transport systems and modes, facilitated by the creation of multi-modal stations; b) physical improvements – increased and/or upgraded development of residential, retail, work and cultural land uses within walking distance of station areas; c) economic improvement – generation of economic activity and benefit as agglomeration economies take place; and d) social improvement – creation of vibrant activity centers or hubs for social interaction and recreation. Together these changes would result in significant reduction in negative environmental impacts, locally and beyond. These desirable impacts may be harnessed in planning for high-speed rail stations in California through the creation of activity hubs with coordinated transportation and land use, urban design, and multimodal access and circulation. Designs would be similar to transit-oriented development but also accommodate travelers arriving or departing stations by auto (including rental cars). This synthesis of lessons for California should also be widely applicable for more sustainable and environmentally friendly transportation systems.

Key Words:

high-speed rail; station-area development; intermodal connections; activity centers; improvement; physical; economic; social

1.0 Introduction

As the prices of petroleum-based fuels sky-rocket, many travelers find it cost effective to switch to more fuel efficient vehicles, including shared modes in high-capacity vehicles. Public transit use, carpooling and vanpooling, for example, increase when fuel prices are high. For longer-distance trips, where both air and auto modes are impacted by high fuel costs, rail systems can be an attractive alternative. The limitation of conventional rail is that it often is too slow to compete with air travel, especially for trips in the 300- to 1000-kilometer range. High-speed rail – trains traveling at 200 to 560 kilometers per hour – can offer a competitive alternative in this range and need not depend on petroleum fuels.

Can high-speed rail also compete over shorter distances, e.g. 80 to 320 km? What conditions are needed for high-speed rail to be competitive in this distance range? In particular, Can station area planning help increase rail use for such shorter distances and improve the station's overall performance? Can it also help improve conditions in the cities and towns served? This paper addresses these issues, drawing on cases from the literature as well as an analysis of their lessons for California, where a high-speed rail system is being proposed.

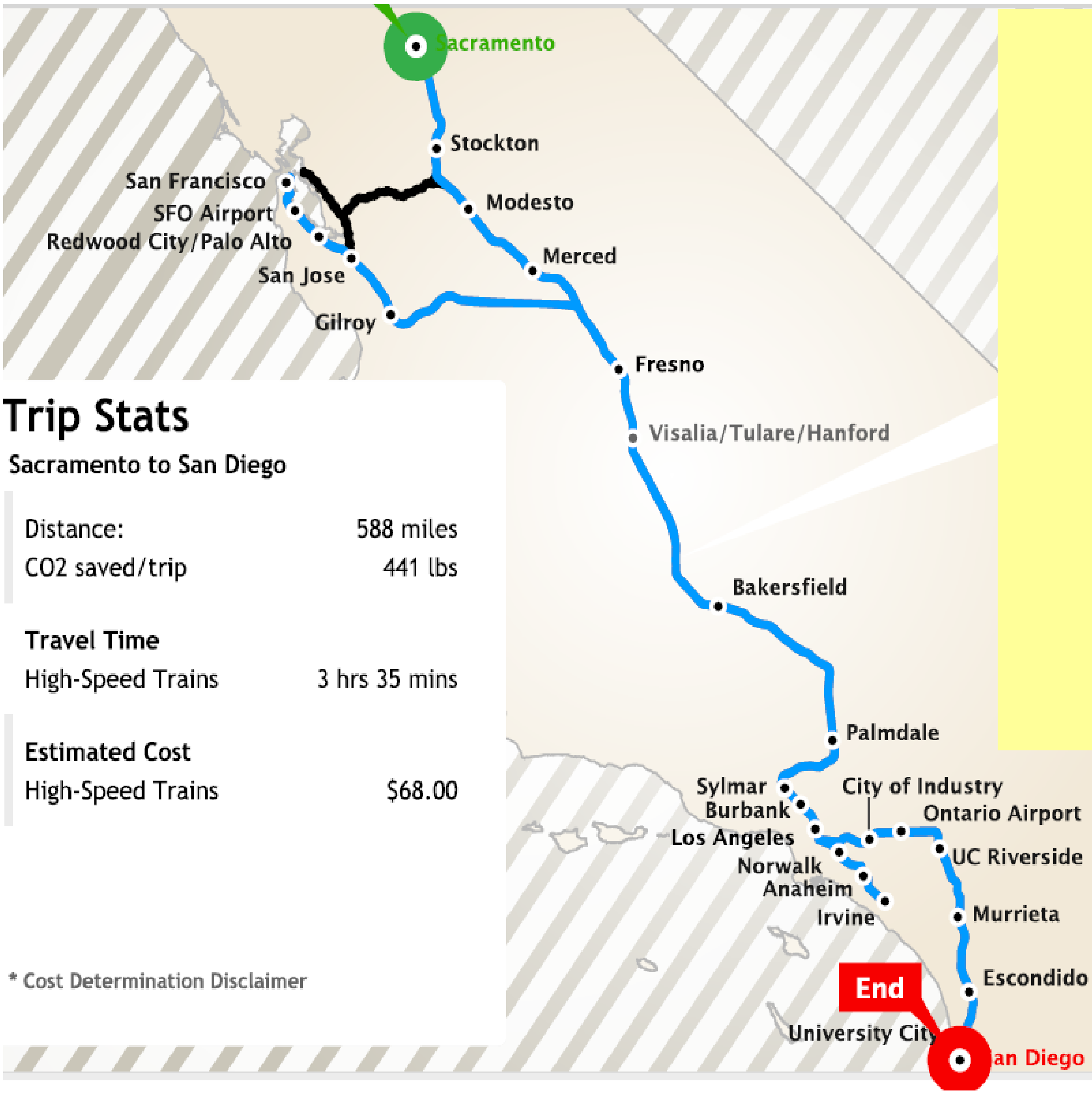
This paper provides a review of domestic and international cases on the station planning issue, drawing upon a wide literature, and extracts key lessons from these cases that could apply not only to California cities and towns but more generally.

2.0 Background: California's Proposed HSR System

In 1996, the California High-Speed Rail Authority was established and charged with planning, designing, constructing and operating a state-of-the-art high-speed train system across the state. With the November 2005 certification of a program-level Final Environmental Impact Report (EIR) & Environmental Impact Statement (EIS), California high-speed rail (HSR) became ready to move into the implementation phase. The 2006-2007 state budget included $14.3 million to allow the Authority "to begin project implementation". This funding was to be used primarily for project-specific environmental work, preliminary engineering, and right-of-way preservation and acquisition. (California High-Speed Rail Authority website). On November 4, 2008, California voters approved a bond measure to raise US$9.95 billion for the project.

The proposed HSR system would be approximately 1290 km (800 miles) long. See Figure 1. It would connect Sacramento and the San Francisco Bay Area in the north with Los Angeles and San Diego in the south, traveling through the Central Valley of California, a rich agricultural area containing a number of smaller cities with limited air service. The HSR system would not only connect these major population centers and smaller cities, but would also link them to existing air, rail and highway systems. Much of the HSR system would share rail alignments with freight lines, requiring safety, operations and design improvements to joint facilities, including grade separation. Overall, however, as currently proposed, the HSR system would provide a predominantly separate transportation system.

Figure 1: Proposed California High-Speed Rail Network



Source:

California High-Speed Rail Authority website: http://www.cahighspeedrail.ca.gov/about/, accessed July 1, 2008

As envisioned by the California High-speed Rail Authority, trains would operate at speeds up to 350 kilometers-per-hour (kph) (220 mph), with express services traveling between downtown San Francisco and Los Angeles in 2 ½ hours. Between California's major, longer-distance intercity markets, door-to-door travel times could be comparable to air transportation and less than half as long as automobile travel times. For trips of intermediate length, HSR trips could be quicker than either air or automobile transportation, taking into account total travel times including check-in and waiting. Fares could be competitive or lower than the costs of travel by auto or air especially under today's high fuel prices.

Riders are anticipated to include business travelers, tourists, and leisure travelers as well as commuters for city pairs such as Los Angeles and Anaheim, Palmdale and Los Angeles, Riverside and San Diego, and Central Valley cities and the Bay Area. In addition, the HSR system is envisioned to offer both interregional and intraregional travelers convenient connections to airports and to regional transit services. Forecasts are for 42 to 68 million passengers per year by 2020. The HSR system could also carry light-weight, high-value freight. (California High-Speed Rail Authority website: http://www.cahighspeedrail.ca.gov/about/)

3.0 Benefits and Costs of a California HSR System

High-speed rail has been popular and successful in the European Union and in Asia, but it has not yet taken hold in the United States. Whether it can succeed in California has been the subject of considerable discussion both in the academic literature and in popular media.

Some academics, e.g. Charles Lave, have questioned the benefits of new rail systems, arguing that when the costs of construction are considered, net benefits are questionable (Lave, 1977). However, when the comparison is construction of new roads or new airports, costs are not necessarily higher. A mid-1990s study of the proposed California high-speed rail system analyzed its cost competitiveness relative to highway and air transportation (Levinson et al, 1996), and found it least costly in terms of social costs alone, but not in terms of total costs. The study concluded that California HSR would be most effective if treated as an alternative to highway use and a complement to air transportation.

A subsequent study (Brand et al, 2001) assessed that the benefits of the California high-speed rail system would outweigh its costs by a factor of two. The study considered both user and non-user benefits in the calculations.

Studies that have addressed the proposed California high-speed rail system's feasibility, alternative alignments, and ridership projections include Parsons Brinckerhoff et al, 1999; Charles River Associates, 1999, and Cambridge Systematics, 2006. The studies have found that a California HSR system would provide a reasonable modal alternative to air or auto travel for long distance trips, and that diversion of trips to HSR would reduce pressures for costly road and airport expansion. HSR also is expected to improve mobility and accessibility to several parts of the state that are not well served by air or conventional rail transportation.

The rationale for implementing a high-speed rail system among available options presented in these studies is as follows:

- *Population* – California's population is projected to increase from 37 million (2005) to 59.5 million by the year 2050 (California Department of Finance, July, 2007). The projected population increase necessitates finding practical options to accommodate intercity travel needs that are sustainable, efficient and economically viable.

- *Highways* – Portions of the road network in the state of California currently rank among the most congested in the nation. In 2005, for instance, the Texas Transportation Institute designated Los Angeles as the number one congested very large city and the Los Angeles-Long Beach-Santa Ana area as the number one congested very large urban area in the country. To the extent that economic prosperity and quality of life are dependent upon the efficiency of the transportation network, they may be in jeopardy as population and attendant human activity and travel continue to grow. Cost-effective transportation system investments will be needed to enable the state to sustain its economic vitality and quality of life.

- *Airports* – The airport system in California is a key component of the state's transportation network and an essential element for the facilitation and promotion of economic growth (Twomey & Tomkins, 1995). However, major airports in Los Angeles (LAX) and San Francisco (SFO) are consistently busy and prone to delays. Recent expansion plans for LAX were dropped in an agreement between the City of Los Angeles and neighbors of the aviation facility opposed to the new plan. San Francisco International airport also had to drop plans for a new runway in the Bay because of the damage to fisheries it would cause. Opposition to airport expansion has led transportation officials in several parts of the state to call for new alternatives and complements to air transportation. The Southern California Association of Governments (SCAG), for instance, proposed the use of maglev technology (a form of high-speed rail transportation) to connect area airports as a solution to future transportation needs of Southern California (SCAG, 2004).

- *Energy Cost & Consumption* – Comparative energy use measured in "energy intensity", that is, energy consumption per passenger-kilometer shows that rail alternatives, which ranged from 655 kJ (1000 Btu per passenger-mile) to 1575 kJ, outperformed transportation by both passenger car at 2295 kJ and air at 2230 kJ in 2004 (Bureau of Transportation Statistics, 2006). Compared to air transportation particularly, which is dependent on fossil fuels, HSR could run on electricity that may be generated from more sustainable sources of energy.

- *Air Pollution* –Assuming that the electricity for HSR is generated from clean sources, HSR running on electricity will emit far less pollution into the atmosphere than automobiles and aircrafts running on fossil fuels. The Japanese Ministry of Transport reported that carbon dioxide emissions per passenger-kilometer was 12 grams by rail in 2007, which was one-sixth the emissions by air and one-ninth the emissions by the private automobile (MLIT, 2010). The electric generation mix in CA is already relatively clean, and state greenhouse gas legislation requires that utilities include renewables and reduce emissions over the next two decades, accounting for purchased as well as produced power. As a result it is likely that emissions will remain low even as it is likely that electricity for HSR would be purchased and would include a higher than California-average share of coal-generated power.

4.0 Harnessing the Potential of a High-Speed Rail System

The implementation of HSR is a very large capital expenditure - a mega public works project that needs to be harnessed to benefit the State. Public works projects have traditionally served as catalysts for economic development (Forkenbrock, 1990; Boarnet, 1995), but they also can be money sinks (Altshuler and Luberoff, 2003; Flyvbjerg et al., 2003). It is therefore desirable to undertake careful planning to maximize benefits; see, for instance, Nash (2009).

As described earlier, the California HSR proposal is a hybrid, intended to serve both as a complement and alternative to air and highway travel. It further is a hybrid in its aims to serve long distance as well as middle-distance trips. The latter trips would include, for example, commute trips of over 80 kilometers in length as well as business and recreation trips in the 80-320 kilometer range.

One strategy for maximizing benefits is development of urban and intercity transport station areas. For urban transport systems, this is a widespread phenomenon in the US and abroad, undertaken to increase the effectiveness of the transport system by increasing ridership as well as to capture the value created by the increased accessibility the transport services provide. In the urban public transit sector, such developments are often called transit-oriented developments (TOD), and are found on urban heavy rail, urban light rail, commuter rail, and intercity rail lines.

Outside the US, station area development is also found along long distance commuter and intercity travel lines. Many examples of high-speed rail station area developments exist in Europe, for example, at stations in Lille and Lyon in France and in Asia. In Curitiba, Brazil, station area development exists at major stations along the bus rapid transit network. Indeed station area developments are also found in the vicinity of airports. An entirely new community is being developed on the land side approach to the new Hong Kong airport.

International comparisons shed light on what could make HSR successful. For example, in a study of the state-of-the-art in high-speed rail and airport connections in Europe, López-Pita and Robusté (2004) noted increasing intermodal collaboration. The authors pointed out the logic of rail-air intermodal connections that would shift short distance air travel to rail, thereby freeing up the short haul air slots for long distance air travel in increasingly congested air spaces. The authors assert that European airports and airlines view the high-speed rail as complementary rather than competition. In contrast, airlines have been among the key opponents of high-speed rail in past efforts to begin its development in the US (Itzkoff, 1991)

Both the US and international cases suggest that successful station area developments meet several objectives:

- Intermodal connections: Convenient access and ease of transferring between local and regional transport systems and between modes, facilitated by the creation of a multi-modal station;
- Physical improvement: Increased and/or upgraded development within walking distance of the station area, creating a vibrant activity center or hub for social interaction and entertainment. land uses include residential, retail, work and cultural activities;

- Economic improvement: Generation of economic activity and benefit as agglomeration economies take place;
- Social improvement: Creation of a vibrant activity center or hub for social interaction.

4.1 Intermodal Connections

HSR stations in Yokohama, Japan and Massy, France and urban rail terminals such as Union Station, Washington, DC and Grand Central Station, New York illustrate the potential for intermodal connections at proposed California HSR stations.

The Union Station in Washington, DC, for instance, accommodates intercity rail, commuter rail, urban rail (Metro), intercity bus, transit bus, tour buses and trolleys and rental car. However, the Hong Kong airport is introduced as a modern example of a multi-modal station area planning to illustrate the trend and the potential for bringing several different transportation modes together to complement each other at one station.

Hong Kong has a relatively new International Airport that opened for operations on July 6th, 1998. It operates as the 5th busiest international passenger airport in the world. As a "station area" it is developed with: (a) one of the longest airport terminals in the world at 1.3 kilometers (km) long; (b) four underground tunnels; (c) a six lane highway; (d) railway line; (e) five bridges; and (f) an adjacent small city of 260,000 residents.

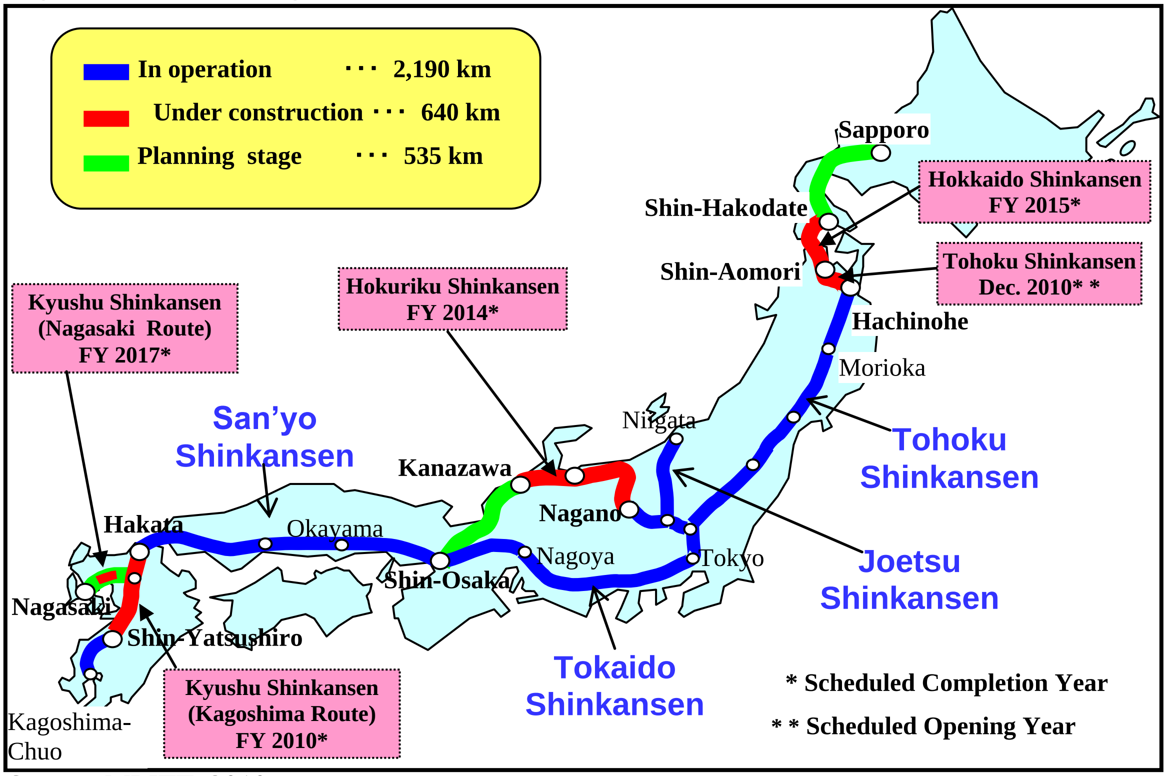
The airport was designed to function around a centrally located rail terminal. It is truly multi-modal as it is connected to the transit network comprising rail, bus, and ferry services. It has a four-story Ground Transportation Center, which provides an airport interface point for the Airport Express trains, buses, tour coaches, taxis, hotel limousines and private cars. Adjacent to the terminal is SkyPier, which provides passengers with ferry access to and from the airport.

California's proposed HSR is primarily a spine along the north-south length of the state. Stations are not provided for every single community along the route. Intermodal connections will provide the feeder services for passenger flow and connectivity with off-line communities. The presentation of other cases under the other themes of this discussion shed further light on the importance of intermodal connections to HSR stations.

4.2 Physical Improvement

The physical improvement potential of a high-speed rail system is achievable through the application of *land use planning* and *urban design* principles to the station areas and the larger communities in which they exist. Two cases from Japan illustrate changes that can be accomplished with the California system. Japan is credited as pioneer of high-speed rail and continues to operate the busiest rail network in the world. In 2009, Japan Railways (JR) carried 8.64 billion riders (compared to 5 billion in Indian at second place). Today, the Shinkansen, which covers about 2,190 kilometers on five lines, 640 kilometers of extensions are under construction and 535 kilometers are planned (MLITT, 2010).   Japan's HSR network represents a spine with spurs, similar to the network proposed for California; see Figure 2. Considerations that led to successful developments of station areas in Japan can guide implementation of the California system.

Figure 2: Japan's High Speed Rail Network

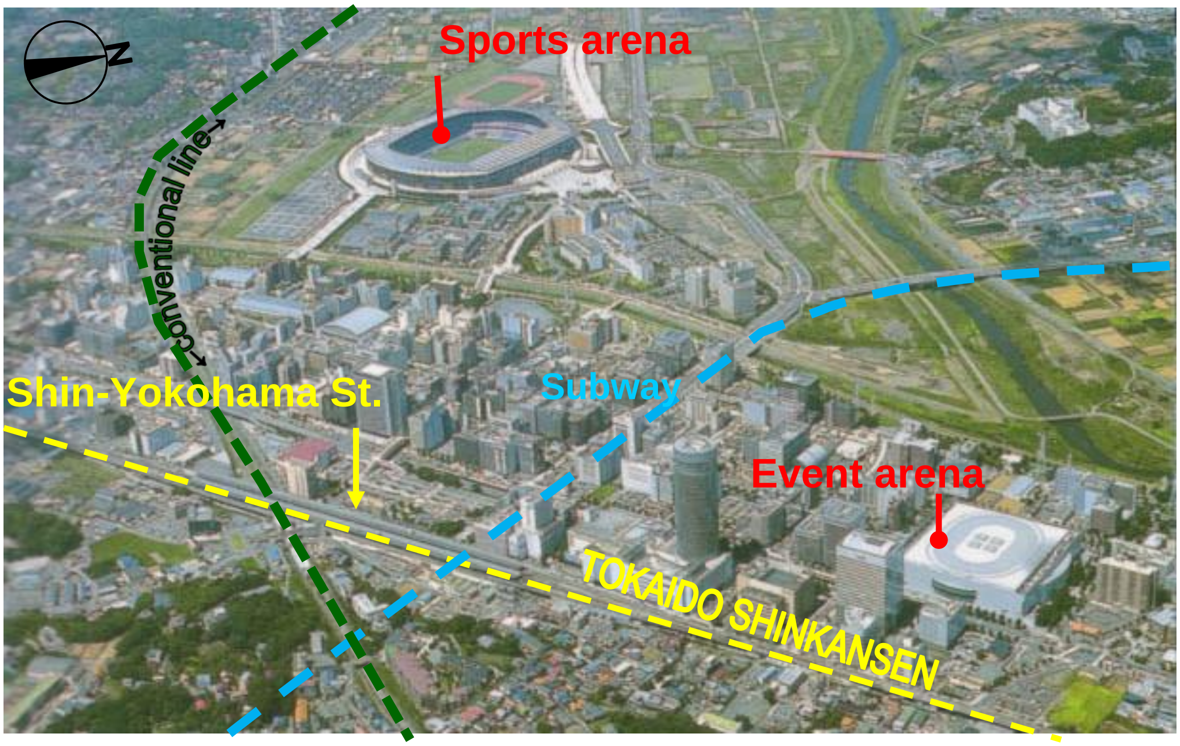


Source: MLITT, 2010

Yokohama City is a sister city of San Diego and had a 2009 population of 3,574,443. The Shinkansen station, Shin-Yokohama, is located 5 kilometers from the center of the city and about 30 kilometers from Tokyo Station. The station opened in 1964, as part of the original Tokaido Shinkansen line from Tokyo to Osaka. At that time, the surrounding area was completely rural, but the site was selected because it was the intersection of the Tokaido Shinkansen tracks with the existing JR line.

From the first year of opening the Shinkansen station, land development commenced around the station area and continued slowly till 1985 when the station was connected to Yokohama City by means of the Yokohama Municipal Subway system. The area around the Shinkansen station experienced a massive influx of buildings, population and economic development. The improved connectivity made possible by shorter travel times to Nagoya and Osaka, prompted mid-sized companies and firms to move their offices there. The arrival of new companies turned this area into a new business district. This development was soon followed by the construction of the largest new event and sports arenas in Japan. The latter housed the FIFA World Cup in 2002. The Shin Yokohama Station soon turned into a vibrant and thriving front entrance of Yokohama City. Over a period of 40 years, the area around Shin-Yokohama station became a newly developed city center of Yokohama. See Figure 3.

Figure 3: Development Around Shin-Yokohama Station



Source: MLITT, 2010

Saku City (Sakudaira) Station is located 165 kilometers from Tokyo and 1.5 kilometers from the city center on the Hokuriku line, one of the more recent additions to the Shinkansen network. The Hokuriku line from Tokyo to Nagano was completed in 1997 in time for the 1998 Winter Olympics in Nagano. Like the Shin-Yokohama Station, the 60 hectares (ha) area surrounding the Sakudaira station was originally rural, but the site was selected because of the cross connection with the conventional rail line operated by JR.

The Saku City local government implemented a massive urban development program around the station area. Within five years after the opening of Sakudaira Shinkansen station, the city government completed the development of roads, parks, open space, paid parking, and other services and facilities necessary for a new urban center. The city's involvement of public and private partnerships in the planning of the station area was crucial for its economic success. The private sector continues development of commercial establishments, apartments, condos, and paid parking, etc. The concentration of development around the station resulted in a 20 percent growth in its population within a decade even though population growth in the Nagano Prefecture as a whole was only marginal.

The Japanese case studies revealed certain lessons for California. In both cases, the high-speed rail stations enabled vacant areas to become new thriving urban centers. In the first case, Yokohama City, the Shinkansen station was located on the undeveloped outskirts of one of the largest cities in Japan. This case would be an appropriate example of the nature of development that could occur in major urban centers like San Diego or San Francisco. In the second case, Saku City, the Shinkansen station was located in an undeveloped area within a smaller city. The Saku City case would be an example of the nature of development that could occur at such secondary cities in the Central Valley as Sacramento, Stockton, Merced, Fresno, or Bakersfield following construction of high-speed rail stations. Like the Central Valley Cities, Saku is located in a rural area that lacked convenient connections to major cities. The Shinkansen enabled Saku City to become "close" to major centers and hubs by decreasing travel times. Shinkansen's connectivity triggered a rejuvenation of the city's economy. High-speed rail in California's Central Valley can have similar effects if planned correctly. In both case studies, ridership, population, and economic growth, were all highly dependent on two factors. One is the provision of good quality transportation links to the new station especially rail transportation from the existing urban centers if the station is not already located in the city center. The other factor is local government policies regarding growth and transit-oriented development.

4.3 Economic Improvement

The economic improvement potential of a high-speed rail system lies in the premise that if well-planned and implemented it can contribute toward the *economic development* of areas. This is achievable through the consolidation of activities at the station areas thereby facilitating links between activity centers in the larger region in which they exist. The potential of HSR to generate economic gains through development of its station area may be illustrated with several examples of metro rail, intercity rail and multimodal stations in the US and abroad. The development of several metro rail stations in Washington D.C. into major employment and activity centers has been touted as exemplary for the US (Cervero et al, 2004). Many downtown train stations are similarly developed around the world as exemplified by stations on the New York, San Francisco and London subway systems, among others. Greengauge21, a non-profit organization researched the development and regeneration effects of high-speed rail on cities (Harman, 2006). The study has two conceptual premises about the effect of transportation investments on areas served and their importance for both economic and spatial planning. The premises are:

1. Transportation investments affect the way the transportation system is used, which under conditions of efficiency would affect income gained and return on investment;
2. Transportation investments affect the way activity patterns evolve and consequently the economy and structure of the areas.

While European case studies have been carried out for high-speed rail in Belgium, Germany, Italy, Netherland, Portugal and Spain, the Greengauge21 Study paid particular attention to the two case studies of Lyon, where high-speed rail was first implemented in Europe, and Lille, both in France. Figure 4 shows the locations of Lyon and Lille within the TGV network of France.

Lyon is one of the largest cities in France and is located in its southeastern area**.** It was the first city to be linked with Paris via the French TGV line. Existing rail service lines operated through the central area of historic Old Lyon, which is located on a peninsula and is thus physically constrained. City officials began the development of a major commercial area east of the central area. With implementation of TGV service, a major new station was built adjacent to the emerging commercial area. This new station became the focus of most new trains serving the city which spurred further commercial development. The public transportation system was reconfigured to facilitate access between the TGV station and most of the metropolitan area. Many companies decided to move their offices from elsewhere in the city to the premises of the new station in order to benefit from the easy access to TGV. Agglomeration economies set in further attracting many new activities including hotels. The station area of the TGV station therefore became a major center of economic activity and a cornerstone of the economic expansion of the city.

Figure 4: TGV Network of France Showing Locations of Lyon and Lille

Source: Project Mapping <http://www.projectmapping.co.uk/index.html> Accessed 5/23/10

Lille, located in northern France, was traditionally an industrial city. Its economy slowed down considerably in the face of competition with cheaper imports from other parts of the world. With strong political leadership and a long term vision and practical action, the city was revived through redevelopment activities. These activities included the building of a new TGV station on a former military barracks site near the existing rail station. The remainder of the site was then developed into a major mixed-use center that includes offices, a retail center, hotels, public housing, a large conference center and events hall, and a public park. A program of metropolitan area-wide adaptive reuse of facilities resulted in major reorganization of land uses and activity locations. These developments took decades, however, to be fully implemented.

The case study evaluation extracted the following lessons:

- High-speed rail is likely to exert the most impact if service sector activities are primary in the area served. In that case the high-speed rail becomes a catalyst for further growth.
- Site selection for the high-speed rail station is critical and must be implemented as part of a larger master development plan.
- Strong political leadership is essential and must be combined with consistency of strategy over a sustained period of time
- It is critical that surrounding areas are tied to the station area through available transportation options.

It is worth noting that not all TGV station areas have turned into successful development sites. Some stations (e.g. Le Creusot and Haute Picardie) are located on the TGV line just outside the cities served, with the aim that they would be accessible by car and public transit. The lack of existing business activity at these locations became a deterrent for others to come and the visions for local activity centers did not materialize. These examples emphasize the need for careful site selection and planning for the California HSR stations if it economic benefits are to be realized.

4.4 Social Improvement

The social improvement potential of a high-speed rail system lies in the premise that if well-planned and implemented high-speed rail can help improve the social well-being of a community. This is achievable through the application of *smart growth* principles of compact, mixed-used and transit oriented development at the station areas to reduce motorized travel, increase non-motorized travel, shorten trips, and reduce air pollution, thereby promoting healthier living.

Lille redeveloped and reorganized land uses due to the TGV station. In 2004, Lille gained recognition as European City of Culture. Programs run year-long to highlight what was achieved gave impetus to additional initiatives.

A commuter rail TOD station in suburban Chicago may be used to illustrate some aspects of the social effects of good station area planning. See Cervero et al., 2004.

Elmhurst is 24 km west of Chicago on Metra’s Union Pacific West line. In 2000, its population was 43,000 residents. In the 1970s and 1980s the downtown infrastructure was in need of repair. At-grade railroad crossings obstructed traffic. Shops were leaving for nearby malls and stores and streets became vacant.

City officials undertook a downtown redevelopment plan that included: (a) allowing mixed uses; (b) orienting retail stores to directly front pedestrian streets; (c) mandating street level windows in shops; (d) reducing required parking for mixed uses; (e) offering a facade assistance program; and (f) improving landscaping.

The outcome of these efforts includes the addition of 300 more residential units and 13,000 sq meters of commercial space to the downtown. $17 of private money was invested for every $1 of public investment made. The developments included the construction of several mid-rise (three to five story) buildings. And as a result, the transit station has become the small city's main social hub.

Concluding lessons include the following:

- Strategic placement of rail stations can contribute to effectiveness of urban redevelopment schemes. However, reviving ailing downtowns or redevelopment areas requires public investment in urban planning and development, not just the presence of a new high speed rail station.
- Adaptive reuse of existing real estate can be an important ingredient in revitalization efforts.
- Having strong leadership and continuity by professional staff is necessary for success for projects that take a long time to be realized.

5.0 The Accessibility Factor in Successful Station Area Planning

The case studies reviewed make it clear that multimodal accessibility is a major factor in successful station area planning. Important ingredients include:

(a) The availability of alternative modes to access the station. These include non-motorized modes for trips with origins and destinations in close proximity to the station and both transit and private modes (taxi, rental car, private auto) for trips of longer distances.
(b) Priority placement of high ridership access modes at the station area. The stops for modes with the highest occupancy would locate closest to the station platform or center and stops for modes with lower occupancy would be placed farther away from the platform.
(c) The relative placement of land uses (commercial vs. residential) in the broader area would centralize uses that require frequent use of the high speed rail and place others successively farther away from the station platform.
(d) Gradation in development density is appropriate, declining with distance from the station area.
(e) Mixed use corridors along axes that radiate from the station center can provide additional amenities both to travelers and to station area workers, residents, and visitors.

Factors that contribute to station area success can be further sorted into two groups: (a) those related to the broader "station area", say 0.5 km to 1.5 km radius and (b) those related to "station layout". The two groups may be outlined in terms of "accessibility" as follows:

(a) Broader area – Efficient accessibility affects the degree of integration of the station into its surroundings and consequently the level of patronage by those in its vicinity.

Availability of parking and integrated bus network connections will facilitate station use by those in both the immediate area and slightly distant areas. Auto access and parking should not, however, be allowed to dominate the station area, and therefore parking structures are preferred over surface parking.

(b) Station layout: – Efficient accessibility especially in terms of pedestrian access results in ease of flows and convenience of station use. The layout would place higher occupancy modes closest to the station platform and lower occupancy modes successively away from the platform. That would result in minimized ingress and egress times for users and encourage use of alternatives to the automobile in accessing the station.

The sum of these development features echo the principles of new urbanist and neo-traditional neighborhood design. The station effectively becomes the central focus of a neighborhood that is designed according to principles of new urbanism. However, unlike at least some new urbanist proposals, where the automobile has at best an uneasy place in the overall design, the cases suggest that cars need to be accommodated, while recognizing their lower passenger productivity in considering access and pricing.

6.0 Applying the Lessons to Station Area Development in the Central Valley of California

California's Central Valley cities are nothing like Hong Kong, Chicago or Lyon, in size, layout, density, economy, or outlook. The largest of the cities along the Central Valley portion of the high speed rail system is the state capitol, Sacramento, with just over 2 million people in the metropolitan area. Sacramento is somewhat larger than Lyon (1.8 million metro pop.) but outside the moderately dense downtown, urban development in Sacramento is spread over more than four times the amount of land consumed in Lyon. About 270 km farther south is Fresno, with a metropolitan population just under one million, and 180 km south of Fresno, at the southern end of the Valley, is Bakersfield, with a metropolitan population of about 800 thousand. Both of these metro areas are somewhat lower density than Sacramento. Other likely high-speed rail stops (Stockton and Merced between Sacramento and Fresno, Visalia/Tulare/Hanford south of Fresno) would be located in cities or urban agglomerations with current populations of 80,000 to about 300,000.

Centrally located station areas proposed for Sacramento and Fresno nevertheless could apply many of the lessons from experiences abroad. Sacramento could use the rail station as a new multimodal activity center, well connected to the central city and the larger region by existing and planned light rail and bus systems. Fresno could use the downtown station as a catalyst for revitalization, adding easy connections via public transit as well as hotel, bus and rental car services for recreational travelers.

While Sacramento and Fresno are magnets for in-commuting and the Visalia area is largely self-contained, two of the cities might also be transformed by high speed rail's changing accessibility for commuters. Consider, for example, the proposed high-speed rail stations for Merced and Stockton, cities with populations of 80,608 and 289,927 respectively as of January 2008 (California Department of Finance). The two cities offer lower housing costs than the San

Francisco Bay Area and now house a high percentage of commuters traveling over 80 km one way to work each day. The commute is strenuous, with highly unpredictable travel times due to congestion and incidents.

For these two small cities, the proposed high-speed rail station would be located adjacent to the downtown or possibly, for Merced, at a proposed tech center at a former air force base. In both cities, the ideas extracted from the cases – that strong intermodal connections can be used as the backbone for urban development that produces economic, social betterment and improved environmental performance – resonate with city officials..Both Merced and Stockton have downtowns with significant buildings and land uses, and the downtowns are built at densities that could support walking and biking to a HSR multimodal station. Both downtowns also have many underutilized parcels and buildings that could be redeveloped or restored. City officials in both locations are seeking to improve conditions in the downtowns, and HSR may be the reason and the incentive to do just that High-speed rail thus could be a catalyst for infill, redevelopment, and renovation, resulting in more efficient and sustainable land use and higher levels of HSR use as well.

With complementary urban revitalization activities, would high-speed rail attract long-distance commuters from these cities? Costs would be a deterrent under current pricing proposals - a ticket for the 1 hour trip would be $32, according to the CHSRA website (accessed 5/24/2010) whereas driving the 170 km distance would cost only $12-15 in fuel costs at current US prices, or about $20 in direct user costs including wear and tear if no parking, tolls, or other mileage based expenses are included. However, the costs would be competitive if the extra hour by car were considered and the commuters' value of time was on the order of $12, well below 50% of the average wage rate of California workers today (a value of time that would not account for additional benefits of reliability and ability to use time on the train for other purposes.) A bigger issue might be the feasibility of reaching the final destination within reasonable time and cost limits, and here is where station area land use and access planning would be a critical factor.
In particular, the interventions would require a new focus on:

1) Offering variety of housing choices to both existing and newly attracted residents that include transit oriented living in a compact environment in the station areas that would mimic living in a compact city such as San Francisco. The amount of housing should be sufficient to support a mix of uses so that many daily needs can be met by walking.
2) Improving local access by foot, bicycle, and public transit in and around the station area so that these modes of travel are comfortable and convenient as well as utilitarian.
3) Managing auto use so that cars do have access to the station, but without disrupting the station area itself.

The HSR then would provide relatively quick access to employment as well as to the many social and cultural attractions of the larger urban areas; in turn, urbanites could get out into the countryside via HSR and could take local transit or a rental car to their destinations. Merced has two advantages it could build upon. One is its proximity to Yosemite National Park. The new station in Merced could be the gateway to Yosemite, offering shuttles, tour buses, and rental cars. Merced's other advantage is the new University of California campus located to the North of downtown. A bus rapid transit link between the campus and the centrally located high-speed rail station would provide convenient access to the HSR itself but also would attract shopping and social-recreational trips from the campus to the downtown. Stockton also has an advantage: an existing commuter rail service to the Bay Area. The proposed location of the HSR station integrates its operations with the commuter rail service in opposite corners of one city block, thereby offering additional access and linkage benefits that would contribute to the success of the transit oriented development.

7.0 Conclusion

Major urban centers in the State of California experience recurring levels of air and highway congestion. Projected increases in the State's population make it critical to plan for additional transportation systems to augment and complement the existing systems. The rationale for implementing a high-speed rail system among available options lies in its advantages in terms of relatively high travel speed, low energy consumption, environmental friendliness, and high person-carrying capacity. However, HSR is a very large capital expenditure, and it behooves the state to take steps to capture all potential benefits to make the project cost-effective. The HSR project would provide opportunity to harness physical, economic and social improvements in the communities and regions served by the HSR system and in the State as a whole.

Development of transportation station areas is historically a widespread phenomenon in the US and abroad. Review of domestic and international cases revealed that well-planned station-area developments can result in desirable impacts on the communities served that include: (a) consolidation of economic activity and overall improvement in economic health; (b) improvements to and increased attractiveness of the built environment; and (c) positive ridership gains in the use of public transportation and reduction in negative environmental impacts. These desirable impacts can be harnessed in planning for proposed high-speed rail stations in the State through the creation of activity hubs with coordinated transportation and land use, urban design, and multimodal access and circulation in the station areas in line with the concept of transit-oriented development. Central to the transformation of station areas to major activity hubs is the notion of accessibility which underlies groups of factors that contribute to station area success. These factors relate to treatment of both the broader station area and the station layout. While the lessons synthesized here are meant for the development of the California high-speed rail program, they are widely applicable elsewhere toward a more sustainable and environmentally friendly transportation system.

Acknowledgment
This paper was produced in part for a project conducted by the UC Berkeley Global Metropolitan Studies Program with funding from the California High-speed Rail Authority. The opinions expressed in this paper are those of the authors and do not necessarily reflect the views or policies of the California High-speed Rail Authority.

References
Altshuler, Alan A. and David E. Luberoff, (2003) *Mega-Projects The Changing Politics of Urban Public Investment*, Brookings Institution Press and Lincoln Institute of Land Policy

Boarnet, Marlon G., (1995) 'New Highways and Economic Growth: Rethinking the Link', *Access* Fall 1995, pp. 11-15

Brand, Daniel, Mark R. Kiefer, Thomas E. Parody, and Shomik R. Mehndiratta, (2001) 'Application of Benefit-Cost Analysis to the Proposed California High-Speed Rail System', *Transportation Research Record: Journal of the Transportation Research Board*, No.1742, TRB, National Research Council, Washington, D.C., 2001

Bureau of Transportation Statistics, (2006) 'Transportation Energy, and the Environment', *National Transportation Statistics Annual Report*.

California High-Speed Rail Authority website: http://www.cahighspeedrail.ca.gov/about/; Accessed July 1, 2008

Cambridge Systematics, (2006) *Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study*

Cervero, Robert et al. (2004) *Transit-Oriented Development in the United States: Experience, Challenges, and Prospects*, Transit Cooperative Research Program, TCRP 102, Transportation Research Board.; Accessible online at: http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_102.pdf

Charles River Associates, (1999)*Express Commuter Ridership and Revenue Forecasts on HSR Alignments.* Charles River Associates, Boston, Mass., June 1999.

Flyvbjerg, Bent, Nils Bruzelius, and Werner Rothengatter, (2003) *Megaprojects and Risk: An anatomy of Ambition*, Cambridge University Press

Forkenbrock, David J., (1990) 'Putting Transportation and Economic Development into Perspective', *Transportation Research Record: Journal of the Transportation Research Board*, No. 1274, TRB, National Research Council, Washington, D.C., pp. 3-11.

Harman, Reg, (2006) "High Speed Trains and The Development and Regeneration of Cities", Greengauge 21, London, June, 2006; Accessed August 8, 2007 at: http://www.greengauge21.net/assets/European_Regeneration_Experience.pdf

Hong Kong International Airport, SkyCity Brochure; Accessed online 8/15/07 at: http://www.hongkongairport.com/eng/aboutus/scbrochure.html

Itzkoff, Donald M., (1991) 'If you build the trains, people will come - development of high speed ground transportation still faces various obstacles', *Railway Age*, July, 1991

Lave, Charles A. (1997) 'The Negative Energy Impact of Modern Rail Transit Systems', *Science*, February 11, 1977. Vol. 195, pp. 595-596

Levinson, D., D. Gillen, A. Kanafani, and J. M. Mathieu, (1996) *The Full Cost of Intercity Transportation—A Comparison of High Speed Rail, Air and Highway Transportation in California*, University of California at Berkeley, June 1996

López-Pita, Andrés and Francesc Robusté, (2004) 'High-Speed Line Airport Connections in Europe: State-of-the-Art Study', *Transportation Research Record: Journal of the Transportation Research Board*, No. 1863, TRB, National Research Council, Washington, D.C., pp. 9–18.

Los Angeles World Airports (2004), *LAX Master Plan*, Los Angeles

Ministry of Land, Infrastructure, Transport and Tourism; Accessed online 2/9/2010 at: http://www.cahighspeedrail.ca.gov/about/default.asp?topic=boardArchive&year=2010&month=1

Nash, Chris, (2009) When to Invest in High-Speed Rail Links and Networks? Discussion Paper

No. 2009-16, University of Leeds, United Kingdom, December 2009, Accessed online May 23, 2010 at: http://www.internationaltransportforum.org/jtrc/DiscussionPapers/DP200916.pdf

Parsons Brinckerhoff Quade & Douglas, (1999) *California High-Speed Rail Corridor Evaluation*, Final Report, California High-Speed Rail Authority, Sacramento, Dec. 30, 1999

Southern California Association of Governments, (2004) *Regional Aviation Plan*, Los Angeles

State of California, Department of Finance, (2007) *Population Projections for California and Its Counties 2000-2050, by Age, Gender and Race/Ethnicity,* Sacramento, California, July 2007.

Texas Transportation Institute, (2005) *Urban Mobility Report*, College Station, Texas A&M University; Accessed online August 15, 2007 at: http://mobility.tamu.edu/ums/congestion_data/tables/los_angeles.pdf

Twomey, Jim. & Judith Tomkins, (1995), 'Development effects at airports: A case study of Manchester Airport', In D. Banister (Ed.), *Transport and Urban Development* (pp. 187-211). New York: E&FN Spon.